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Sustainability in Transforming Societies

PROCEEDINGS

of the 26th Annual Conference of the International Sustainable Development Research Society

15-17 July 2020, Budapest, Hungary

Sustainability in Transforming Societies

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Proceedings of abstracts and papers

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Welcome Message by the Conference Chair

It is my great pleasure to present you the Proceedings of the 26th Annual Conference of the International Sustainable Development Research Society at the Budapest University of Technology and Economics.

The special topic of this year's conference, namely 'Sustainability in Transforming Societies' has been chosen to reflect upon the most important trends in today's societies all around the world and their implications for the notion of Sustainable Development, which entered the scientific discourse more than thirty years ago.

These trends, including, but not limited to shifts in demographics and the polarization evident in many societies; the impacts of rapid technological innovation including the digitisation of the economy; the shifting centres of economic power and the spread of new business models, as well as resulting changes in lifestyles raise many questions.

Are the underlying principles of Sustainable Development still valid? Are the tools developed over these years still adequate? Have the problems themselves changed over the years? What have we achieved and can we now foresee a better future?

We have stressed the timeliness and importance of these questions more times than one can count. And change we can see: businesses question their core competencies, governments implement innovative policy tools and more and more people turn to sustainable lifestyles. But are these changes enough? Can we preserve what is good and repair what is flawed? Can we build a prosperous future for everyone in the long run?

As scientists, our task is to ask and re-ask these questions until we find the right answers to them. We have to discuss and debate, to prove and persuade for which we need platforms such as the annual conferences of ISDRS.

I hope that the 2020 conference will provide another successful platform, which can take us closer to answer at least some of these questions.

Prof. Gyula Zilahy

Full professor, Head of Department
Department of Environmental Economics
Faculty of Economic and Social Sciences
Budapest University of Technology and Economics

Keynote addresses – Opening Plenary, 15th July, 2020

Prof. Pauline Deutz, University of Hull
President of ISDRS

Prof. Pauline Deutz is full professor of the Department of Geography, Geology and Environment at the University of Hull and the president of the International Sustainable Development Research Society. Her research interests are focused on the political and economic aspects of environmental issues, especially examining how the latter interrelate with the functioning and organisation of the capitalist economy.

A particular interest is the building, and implications, of a Circular Economy (i.e., maximising the value from resources and minimising waste). Her research in this area includes multi-disciplinary collaborations with colleagues in environmental sciences, chemical and systems engineering.

Prof. Gyula Zilahy, Budapest University of Technology and Economics, conference chair

Prof. Gyula Zilahy is a full professor of business sustainability and head of the Department of Environmental Economics of the Budapest University of Technology and Economics. He also acts as the vice dean for scientific and international affairs at the Faculty of Economic and Social Sciences.

He received his Ph.D. degree in 2003 analysing the management aspects of energy efficiency measures within corporations. His research interests include corporate environmental management, the implementation of the principles of cleaner production and industrial ecology in an industrial setting, sustainability communication and sustainable business models. His practical experience includes work with SMEs and multinational corporations in the fields of Environmental Management Systems and sustainability reporting. His special interest bridging his academic and administrative positions is the promotion of responsible business education and the introduction of the principles of Sustainable Development in higher education.

Prof. János Józsa, Rector of the Budapest University of Technology and Economics

Prof. János Józsa is the Rector of the Budapest University of Technology and Economics (BME) and professor of the Department of Hydraulic and Water Resources Engineering. He is a corresponding member of the Hungarian Academy of Sciences.

His main research interest and field of teaching is the hydrodynamics of surface waters including interface processes, measuring and modelling wind-induced lake currents and sediment motion, measuring and modelling flow, mixing and sediment transport in rivers with compound channel, modelling floodplain inundation, deterministic and stochastic modelling of turbulence.
Computer modelling and simulation have always been important elements throughout his research and teaching career.

His current research interests are measurement and 3D CFD modelling of flow and morphological changes in large rivers, measurement and adaptive numerical modelling of wind-induced flows and transport processes in shallow lakes.

Ferenc Hizó, Deputy State Secretary for Public Service Development, Ministry for Innovation and Technology, Hungary

Ferenc Hizó graduated in 2004 as an economist from the College of Modern Business Studies, later went to the Corvinus University of Budapest and graduated as a political scientist and economist in 2009. He is the Deputy State Secretary for Public Service Development in the State Secretariat for Construction, Infrastructure Environment and Sustainability of the Ministry of Innovation and Technology.

His professional management activities include the topics of domestic sustainability, waste and public utility water services.

Prof. Rolf Wüstenhagen, University of St. Gallen, Switzerland

Dr. Rolf Wüstenhagen, Full Professor for Management of Renewable Energies at the University of St. Gallen, left one of the leading European energy venture capital funds in 2003 to embark on his academic career. Visiting faculty positions at UBC Vancouver, CBS Copenhagen, NUS Singapore and Tel Aviv University. 2008-2011 lead author of IPCC special report on renewable energy and climate change. 2011-2015 member of Federal government's advisory board for Swiss Energy Strategy 2050. He is the Academic Director of the University of St. Gallen's certificate programme Managing Climate Solutions (MaCS-HSG), Co-Founder of the CEMS Model UNFCCC and the Executive Education Programme Renewable Energy Management (REM-HSG).

Ms. Wenyan Yang, UN Department of Economic and Social Affairs

Ms. Wenyan Yang, Chief of Global Dialogue on Social Development Branch, Division for Inclusive Social Development of UN Department of Economic and Social Affairs. She is the Division's focal point coordinating support to the UN Commission for Social Development and the preparation of the *World Social Report*. An economist by training, she also serves as DESA's Principle Focal Point for Gender.

Prof. Philip J. Vergragt, SCORAI

Prof. Philip J. Vergragt, Ph.D. is a founding executive Board member of SCORAI, the Sustainable Consumption Research and Action Initiative; Professor Emeritus at Delft University of Technology, The Netherlands; and Research Professor at Marsh Institute, Clark University, Worcester, MA. He is also a local climate activist in Newton, MA. His main research interests are sustainable consumption and production; sustainable cities; and technology assessment of emerging technologies.

Prof. Sándor Kerekes, professor emeritus, Corvinus University of Budapest

Prof. Sándor Kerekes is the founder of the Department of Environmental Economics and Technology at the Corvinus University of Budapest. He introduced Environmental Education at the university in the early 1990's and his interest turned to the promotion of preventive environmental practices in the region. He led nation-wide research projects evaluating the EU accession of Hungary from an environmental point of view. He was the vice rector of Corvinus University of Budapest. He is the head of the Doctoral School for Management and Business Administration of Kaposvár University.

Keynote addresses – Closing Plenary, 17th July, 2020

Dr. Péter Kaderják, State Secretary for Energy and Climate Policy

Dr. Péter Kaderjak is the Minister of State for Energy and Climate Policy, in the Ministry for Innovation and Technology. He is Ph.D. in Management and Business Administration and MSc in economics, both from Corvinus University of Budapest, Hungary. He has been the the Director of REKK, the Regional Centre for Energy Policy Research at the Corvinus University of Budapest from 2004 to 2018. Formerly he had several positions in public administration. Among others, he served as the President of the Hungarian Energy Office and as a member of ACER's Board of Appeal (2011-16). He is directing a postgraduate program in Energy Economics at Corvinus and training director for the Energy Regulators Regional Association.

Prof. Don Huisingh, professor emeritus, University of Tennessee

Prof. Don Huisingh was awarded his BS from the University of Minnesota in 1961 in Science Specialization, Economics and Horticulture and his PhD from the University of Wisconsin in 1965 in Biochemistry and Plant Pathology.

He taught and did research at North Carolina State University in Raleigh North Carolina for 23 years and then moved to Europe 1987. Since then he has taught full-time or part-time at Erasmus University in The Netherlands and in Lund University, in Lund, Sweden. Since 2018 he is teaching and performing research part-time at Sapienza University in Rome, Italy, and at Linköping University in Linköping, Sweden.

He was the Co-Founder of the "Erasmus International Off-Campus Ph.D. Programme on Cleaner Production, Cleaner Products, Industrial Ecology and Sustainable Development'. He is the Founder and was Editor-in-Chief of Elsevier's Journal of Cleaner Production (JCLP) from 1992 to 2015. He is Editor-in-Chief, emeritus of the JCLP, and is the Co-Editor-in-Chief of the new World Scientific Journal, titled: "International Journal of Data Mining for Global Warming."
He has lectured in more than 120 universities in 80 countries. He has worked on helping corporate leaders implement Cleaner Production in more than 200 companies and organizations. He has advised governmental agencies on sustainable development-related policies and programs.

Dr. Joachim H. Spangenberg, vice-chair, SERI

Dr. Joachim H. Spangenberg is research coordinator at the Sustainable Europe Research Institute SERI Germany in Cologne. Previous positions include the Helmholtz Centre for Environment Research UFZ, Germany, Université UVSQ, France, SERI, Vienna, the Wuppertal Institute, and the Institute for European Environment Policy.

With a PhD in economics, but an academic background in biology and ecology, he is an inter- and transdisciplinary researcher by education and dedication.
He works on sustainable development strategies, limiting resource consumption, degrowth, sufficiency, sustainable consumption, biodiversity conservation by pressure reduction, ecosystem services and their valuation.

Prof. Peter Dobers, Södertörn University
Vice-president of ISDRS

Peter Dobers is currently professor in Business Studies at Södertörn University (Stockholm, Sweden) after 10 years on the Chair of Business
Studies and Sustainable Development at Mälardalen University (Västerås, Sweden) in 2005-2015. He is the dean of the Faculty Board at Södertörn University and was guest professor at the Royal Institute of Technology (Stockholm, Sweden) in Sustainable Collaboration during 2015-2016.

He has published more than 35 articles in well respected journals such as Sustainable Development, Business Strategy and the Environment, Progress in Industrial Ecology and Corporate Social Responsibility and Environmental Management, but also in mainstream management journals such as Scandinavian Journals of Management, and in mainstream organization journals such as Organization and Journal of Organizational Change Management. He has edited and co-edited seven special issues in some of the above mentioned journals and has published about ten books and many book chapters. Since 1999, Dobers is on the editorial board of Business Strategy and the Environment (now Principal Editor) and Corporate Social Responsibility and Environmental Management, and recently on Business Strategy and Development.

He has served as Treasurer of ISDRS for six years and is currently vice-president of the Society.

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Research Methods and Methodologies

Developing grounded survey method to improve the understanding of energy-conscious behaviour

Prof. Maria Csutora [1], ***Dr. Gábor Harangozó*** [1], ***Prof. Ágnes Zsóka*** [1]

1. *Corvinus University of Budapest*

The international struggle to cope with climate change and the national efforts to maintain a sustainable energy policy aim at better understand household energy consumption patterns to develop more effective policies to improve energy efficiency. Both qualitative and quantitative techniques are used in this field, however, these methods are usually applied either independently from each other or in an additive way. The purpose of our research was to develop an integrative method where even the survey part is grounded, while neither parts are subordinate. The research was based on the ENABLE-EU project, including five case study countries (Germany, France, Spain, Ukraine and Hungary), 24 focus groups and a survey with 5006 respondents.

Quantitative tools (e.g. surveys) on the one hand provide a basis for statistical analysis and higher validity for decision making. However, question blocks related to household consumption surveys usually follow similar patterns mainly related to socio-economic and technical factors of households, but fail to properly cover behavioral factors. Only a very small proportion of surveys rely on qualitative behavioural research, and the latter generally do not follow strict standards. Thus, surveys are not properly grounded. Qualitative research on the other hand – including focus group discussions, mind or system mapping as forms of participatory or grounded theory research – aims at understand the drivers of sustainable consumption and helps highlight the ideas of stakeholders directly. However, validity may be low, and it is difficult to base policy instruments on those results.

This paper aims at develop a grounded theory based integrated approach. An intermediary step called pattern analysis is invented that serves as a link between qualitative and quantitative research. Pattern analysis is based on repeated focus group observations and it identifies recurring links between categories on focus group PSM maps. Thus it helps in building up theory and construct variables needed for the survey. Focus group participatory research shed light on some understudied issues of behavioural factors related to energy consumption. Based on common patterns resulted from comparing the outcome of mind maps at national and international levels, assumptions were formulated and tested quantitatively as survey questions. Beyond including new aspects into the energy-related household surveys, the aim of using the pattern analysis as midway technique was also to test whether those common patterns as qualitative findings can be generalised or remain assumptions of the specific focus groups. The survey helped to check the validity of focus group based insights, while the insights gained from the focus groups helped to interpret the findings from the survey.

Contrasting the qualitative assumptions with the quantitative results provided several lessons. The main lesson is that research results of each method would have led to wrong conclusions separately, without applying the midway technique. The pattern analysis drew attention to some issues that need and can be effectively integrated into further research. Awareness of the recommended room temperature, heating and cooling related health impacts, environmental impacts of our energy-related behavior, direct and indirect impacts of behaviour change are some topics that are expected to contribute to deeper understanding and an effective policy making. The qualitative, participatory research provided useful insights for local decision making and the formulation of community-based programs, while results of the representative surveys in five countries gave useful munition to national and regional energy policy making.

Early Stage Researcher embarking on Transdisciplinary Research – Opportunities, Challenges and Lesson Learnt

Mr. Kaustubh Thapa [1], ***Prof. Walter J. V. Vermeulen*** [2], ***Dr. Pauline Deutz*** [3]

1. *Copernicus Institute of Sustainable Development, Utrecht University,* ***2.*** *Utrecht,* ***3.*** *University of Hull*

Dealing with the seemingly insurmountable environmental problems needs both critical and transformative understanding from researchers across disciplines. One way to generate transformative knowledge in academia is transdisciplinary (TD) research, which emphasises knowledge co-creation where researchers work with the society in a reflexive, recursive, transparent and equal manner. The process-oriented transdisciplinary approach to research often referred to as Mode 2 or post-normal science aims at knowledge co-creation together with society for its transformation. This presentation focuses on one such transdisciplinary project on electronics and electric waste (e-waste) in two different geographic contexts (China and Nigeria) in the broader context of the circular economy. Although e-waste is a popular research topic, there are very few TD researches in the field . A TD approach to e-waste aim towards a solution-oriented understanding of the problem which is co-created with the stakeholders. This paper aims to highlight the opportunities and, more so, the challenges of an Early Stage Researcher (ESR) during the initial phase of the research. The scoping fieldwork focused on observation and on building relationships that would ideally enable TD research. Apart from the obvious challenge of socio-cultural and political differences having a significant influence on the research process, the biggest obstacle was often to explain the idea of TD to other researches and other participants . Building trust is key to "transdisciplinary epistemic community", which is the launching platform for TD research. This work concludes with reflections on challenges towards building such communities from this fieldwork and shares lessons learned. Further, the relevance of TD research, its limitations, opportunities, lessons learnt, and practical insights are presented form an ESR perspective. This work is aimed to be a conversation starter and also an invitation for other TD researchers to share their experiences to enrich the community.

Evidence-Based Planning for creating Social Value of Energy: Implementing the Ecosystem Approach in Sierra Leone

Mr. Saurabh Biswas [1], ***Dr. Clark Miller*** [1], ***Dr. Nalini Chhetri*** [1], ***Dr. Netra Chhetri*** [1], ***Dr. Mary Jane Parmentier*** [1]

1. *Arizona State University*

Energy and sustainable development have a nuanced relationship beyond a simplistic 'energy access drives socio-economic growth' truism. Considerable research has identified the ability of users to translate energy access to outcomes as a critical variable in the success of energy systems, in terms of its social, psychological, infrastructure, economic, and environmental impact. Thus, the value proposition of energy use in its entirety - benefits, burdens, risks and consequences; collectively termed as the *social value of energy,*is an indispensable characteristic for sound policy and projects that can navigate a just, equitable and sustainable energy transition. This is especially crucial for places where universal access to electricity is absent, creating a supply side bias in national policy decisions.

The ongoing research project titled *'Improving the Social and Economic Impact of Energy Investments in Sierra Leone: through Enhanced Social Value Creation, Capacity-Building, and Decision Support'*, aims to overcome gaps in typical techno-economic planning, by creating a scientific basis and capacities for policy makers and project designers to imagine holistic energy systems that drive sustainable futures for Sierra Leonean communities. Across four phases of implementation and five study sites, the research is developing opportunity maps for energy infrastructure to be harmonized with sustainable development goals for each of the socio-economic demographic being investigated. Site selection, research design and data analysis are done in participatory settings to facilitate a stepped uptake and capacity building among various stakeholders.

The project adopts a novel methodological approach called the *Ecosystems Approach*for constructing social value of energy pathways. The ecosystem approach draws from scholarship in the capabilities approach, user-centered design, productive uses of energy and socio-technological systems. It conducts a multi-level, mixed methods investigation of *actors*, the *spaces* they inhabit and the *relationships* that link the two; probing the mechanisms that create social value using energy. A three tiered inquiry process: (1) explores the dynamics of creation of social value via energy use and the energy services necessary to achieve it, (2) maps the corresponding socio-technical systems through the energy value chain, and (3) maps the broader policy and innovation ecosystems that support energy systems development and operation. The toolkit draws from participatory rural appraisal (PRA), transformational sustainability research, complex systems mapping, futures visioning and co-production practices.

Initial results in Sierra Leone indicate that thriving energy futures are a function of energy systems overcoming current deficits in well-being (restorative value) as well as continued well-being creation in the future (thriving value). It also brings to light a set of cultural and process lock-ins among institutional actors that prevents effective communication, coordination, consequences and burdens identification. The lack of coordination is endemic to research in the policy domain as well, where 'shelved research reports' are a phenomenon across government departments.

Sustainable energy transitions research has underscored the need for grounded investigative approaches and the ecosystem approach contributes by presenting an evolving methodological approach, with a focus on the user's ability to translate forms of energy access into meaningful and valuable outcomes, at individual, occupational and communal levels.

Four ‘tastes’ of transdisciplinary research on sustainable development issues: Historical, systematic review and mapping of the methodological discourse

Prof. Walter J. V. Vermeulen [1], ***Dr. Sjors Witjes*** [2]

1. *Copernicus Institute of Sustainable Development, Utrecht University,* ***2.*** *Institute for Management Research, Radboud University*

Background.
Sustainability science itself emerged as an interdisciplinary field of research addressing the complex nature-society metabolism: human society exploiting social and ecological resources without precautionary attention for the direct, indirect and long term impacts of this (Vermeulen 2018). As such collaboration between disciplines and integration of theory and practice-based knowledge have been at its heart from the start. Transdisciplinarity (TD) goes beyond intra-science collaboration and acknowledges close collaboration with societal stakeholders. We will discuss the framing of the concepts of multi-, inter-, and transdisciplinary shortly and look at some more recent conceptualisations even going beyond transdisciplinarity.
Justification/aim.
In practice the concept of TD is used in very diverse ways. For researchers and students in the field an overview of the diverse discourse is not available. As an introduction on an edited book on the topic of TD practice and stakeholder collaboration we developed this paper to illicit some of the crucial choices to be made in research design by researcher applying TD.
Findings.
In this paper we show the history of the concept of TD. First in a wider perspective, seeing it emerge in various disciplines, and secondly in the field of sustainability science We then discuss the main discourses around the given justifications for going beyond interdisciplinarity in the context of sustainability. We observe that there are various partly overlapping, but also partly conflicting assumptions behind it, constituting various tastes of TD, with each their own implications for the design and execution of such research.

Knowledge co-production

Dr. Joachim Spangenberg [1]

1. *Sustainable Europe Research Institute SERI Germany*

Co-creation of knowledge in transdisciplinary research processes is increasingly being discussed as a necessary approach to address complex, in particular interacting wicked real-world problems. Consequently, a growing number of research projects carry a transdisciplinarity mandate. However, the results of transdisciplinary work have often fallen short of the expectations. A better understanding of the challenges of first interdisciplinary, and then transdisciplinary work can help avoiding such disappointments. As complex problems are linked to different real-world dimensions which are the research domain of different (albeit partly overlapping) disciplines, interdisciplinarity is a condition sine qua non for developing strategies adequately dealing with such challenges. However, any such approach is confronted with two key challenges: different disciplines have diverging epistemologies (and in the case of irreconcilable ontologies, not common epistemology can be defined). Secondly, integration of results is only possible if disciplines abstain from making assumptions already falsified by another discipline in charge of the respective issue (the “Basic Law of Interdisciplinarity”). Transdisciplinarity adds another challenge: results are expected to be not only scientifically solid, but also socially robust and thus suitable as the basis for applicable solutions. This challenges traditional attitudes and identities of science regarding its relation to decision making: concepts like “Truth Speaks to Power” with science claiming a truth monopoly have to be replaced by the post-normal approach of considering lay participants as “Extended Peer Community”. Furthermore, the self-definition of science as neutral and objective, despite a variety of insights contradicting it, still prevails in particular in natural sciences. However, in real-world transdisciplinary research, it cannot survive, like that or not. If research results are to support applicable solutions, the scholars producing them necessarily are influencing the often disputed options under consideration. Every bit of information, put in a social context, becomes supercharged with values and interests, and is treated accordingly by the stakeholders involved. Thus projects become stakeholders in their own right as they interfere with local decision processes. From a project point of view it appears better to actively shape such a role, rather than ignore the social processes and leave the definition of the role as a stakeholder – which will inevitable take place – to others, who will do so along the lines of their own interests. As a consequence, projects should from the outset be aware of this challenge, reflect on and clearly define their role, and openly communicate it to all stakeholders. This may include ethical standards, scientific norms, the finding conditions of the respective donor, and other aspects shaping the project performance. Jointly negotiating objectives (as far as possible under the funding conditions), clarifying, defining, and communicating them together with the given restrictions and the usually limited time period a project will be active ((i.e. defining an exit strategy) will reduce misperceptions and misguided expectations, but not necessarily overcome criticism and opposition. One important condition for being able to implement such communication strategies is a prior and ongoing reflection amongst scholars regarding their own – often implicit – expectations: reflecting the underlying objectives of stakeholder involvement can help to develop more efficient interaction strategies and reduce wrong expectations on the side of the academic participants.

Methodological Agility for Sustainability Transitions in the Context of the Anthropocene

Dr. John van Breda [1]***, Ms. Zhen Goh*** [2]***, Prof. Dave Snowden*** [3]

1. *Centre for Complex Systems in Transition,* ***2.*** *Cognitive Edge,* ***3.*** *Cogn*

The concept of the Anthropocene has some far-reaching ontological, epistemological, ethical and methodological implications for our intellectual/academic endeavours. Never before in human history have we been required to face the consequences of our own human actions on a global scale. In view of the overwhelming empirical evidence of the anthropogenic causes of climate change and global warming, the historical assumptions about the immutability of all natural laws and processes are no longer necessarily valid. Not only has it now become quite plausible to accept that human actions are responsible for interfering with and indeed changing some of the earth's four-billion-year-old natural processes – such as, for example, the earth's temperature self-regulating mechanisms – but also that this interference and these changes have occurred to such an extent that we can no longer speak of them as purely 'naturally' occurring processes. In the Anthropocene it no longer suffices to produce knowledge on or about nature that is concerned only with the understanding (Verstehen) and explaining (Erklärung) of the anthropogenic causes of the Anthropocene; we are also, at the same time, challenged to produce practical knowledge that can contribute to changing (Verändern) our thinking and actions responsible for (causing) the Anthropocene in the first place.

This implies co-producing transformative knowledge for undertaking sustainability transitions in different socio-ecological contexts across the world. However, transformative knowledge is not just about co-producing strategic knowledge of how to practically navigate said sustainability transitions. Inextricably linked to this are ethical questions related to the way we should act appropriately, fairly and justly in the context of the Anthropocene today – with no action arguably being the most unethical response. In short, this means co-producing theoretical, practical and normative knowledge which addresses the complex challenges facing us in said sustainability transitions in the context of the Anthropocene today.

Dealing with these complex challenges at the ontological-epistemological-ethical interface has far-reaching methodological implications, warranting a range of trans-disciplinary responses. However, there is an inherent risk in presenting such trans-disciplinary approaches as a methodological panacea. It is much better to imagine trans-disciplinarity as one amongst a number of context- or domain-relevant methodological responses – including mono-, multi- and inter-disciplinarity – on the understanding that trans-disciplinarity is much more specifically focussed on and interested in tackling societal challenges that are considered too complex to be addressed strictly from within single disciplinary boundaries. The methodological agility that this implies should not, however, be confused with the much more onerous Kuhnian notion of 'paradigm switching', which is simply too arduous an undertaking for the nimbleness required when facing ever-changing problem situations in the Anthropocene today.

In light of the above, the fundamental focus of this presentation / talk is on developing such an agile trans-disciplinary methodology – with an explicit interest in contributing to the understanding of facilitating said sustainability transitions in the context of the Anthropocene today.

On transdisciplinary tools for sustainable development research: posing methodological features and principles

Dr. Sjors Witjes [1]***, Prof. Walter J. V. Vermeulen*** [2]

1. *Institute for Management Research, Radboud University,* ***2.*** *Utrecht*

Transdisciplinary (TD) research in the field of sustainability science entails a complex system of knowledge integration, addressing the persistency of wicked societal problems and of empowerment in the light of urgent transformational challenges. Merging knowledge from different actors creates a higher understanding of the societal problems and challenges necessary for strategic decisions to start a process of change contributing to the societal transition at hand. The exposure to different sources of knowledge requires researchers with an open and fresh mind, who also coordinate the change process that TD research entails. The methods applied for TD research also address the process of organizing the network of necessary knowledge carriers and the strategic choices that lead to a contribution to societal developments of the TD research project, portfolio of the TD researcher or TD research institute.

Transdisciplinary research partnering with vulnerable and marginalized people in the developing world: Promoting societal transformation toward sustainable futures through community-based innovations

Prof. Tetsu Sato [1]

1. *Faculty of Collaborative Regional Innovation, Ehime University*

Vulnerable and marginalized people under poverty conditions in rural areas of developing countries heavily depend on various natural resources to sustain and improve their livelihood and well-being. These resources are also critically needed as affordable food resources for people living under poverty conditions in these countries. In the "Transdisciplinary Study of Natural Resource Management under Poverty Conditions Collaborating with Vulnerable Sectors" (TD-VULS project, 2017-2019) funded by Research Institute of Science and Technology for Society (RISTEX), Japan Science and Technology Agency (JST) and subsequent "Establishment of a Sustainable Community Development Model based on Integrated Natural Resource Management Systems in Lake Malawi National Park" (IntNRMS project, 2020-2025) funded by JST and Japan International Cooperation Agency (JICA), we have conducted transdisciplinary research together with these vulnerable people as a genuine partner of research. We especially focused on visualizing real-world challenges facing them and innovative practices emerging among them to tackle with these challenges in complex social ecological systems. We have developed a transdisciplinary methodology of dialogue and deliberation with vulnerable people (Dialogic Deliberation in Living Spheres (DIDLIS)) in Malawi, East Africa, and applied it at 9 rural communities in 7 countries in total. This methodology aimed to co-design research agenda, co-produce integrated knowledge and skills, and promote collective actions to achieve sustainable resource management and improve livelihood and well-being of people through in-depth dialogue and collective thinking. It was carefully designed to build trust and facilitate mutual learning among vulnerable people and transdisciplinary scientists by eliminating power disparities and filling gaps in knowledge and culture. This methodology successfully facilitated integration of rich local and practice-based knowledge and scientific knowledge derived from diverse research domains to co-create transformative narratives on various imminent challenges and visions of solutions. We have further succeeded in identifying many innovators among farmers, fishers, and practitioners related to forest, tourism and other indispensable natural resources, and various innovative practices performed by these innovators to improve quality of life and well-being of vulnerable people. These innovations included long-lasting community-driven management of fishery resources using seasonal lacustrine protected areas in Lake Malawi with effective enforcement mechanisms, small-scale irrigation and conservation agriculture to support pre-school educations and feeding programs for children, community-based tourism promoted by tour-guide association emerged among villagers, and innovative societal mechanisms of fair distribution of irrigation water to the most downstream farmers. We have made comparative analyses of these transformative narratives, and identified timeline of causal processes, linkages between innovative practices and human well-being, and potential leverage points for transformation toward sustainable and equitable futures of the communities. These findings indicated significant potentials of knowledge and skills emerging among innovative local practitioners, importance of transdisciplinary dialogue to facilitate mutual learning to co-produce integrated knowledge, and significance of detailed analyses of innovative local practices to understand mechanisms of emergence of transformative processes among vulnerable people. We have been applying these methodologies of dialogue and collective thinking combined with leverage point analysis to establish integrated management systems of diverse natural resources which are essential for livelihood and well-being of vulnerable people. The outcomes of this transdisciplinary research will contribute to better understanding of societal transformation mechanisms toward sustainable futures, and to co-create diverse collective actions to improve livelihood and well-being of marginalized and vulnerable people under poverty conditions in developing countries.

Visions and Visioning for transforming Societies to Sustainability: overview of methods and cases

Dr. Jaco Quist [1]

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Visions are important in transitions and transformations of Society to Sustainability. Their role, functions and use needs further study, both conceptual and empirical, including relevance for governance and transdisciplinary and transformative practices. A distinction can be made between (i) visions in long-term developments and transitions, also used to explain socio-technological change, (ii) generating visions through interactive learning and interaction among groups (of actors) and transdisciplinary contexts, and (iii) assessing visions through vison assessments to explore possible value conflicts and other value-driven and interest-driven differences among actors and stakeholders in emerging transitions. This paper will focus on methods for making visions. Two major approaches for making visions are backcasting and transition management, though other participatory visioning approaches can be found too.

The paper will first review recent developments of vision-based approaches through an overview of the literature and building on research work and projects of the author. This will followed by an inventory on methods and cases using these methods how visions can be made, supported by examples in various domains but all aiming at sustainability and include SCP, Renewable Energy, Circular Economy and Zero Waste, Water Management, Sustainable Lifestyles, and Cities and Communities. The inventory of visioning methods includes: (i) creativity methods, such as brainstorming, in combination with clustering, which is illustrated for the future of repairing and circularity in the furniture industry (ii) problem structuring approaches, as often used in transitions management, which is illustrated for urban agriculture in the city of Rotterdam and for sustainable lifestyles in the Rotterdam-The Hague region (iii) elaboration of visions start via setting targets, (iii) Morphological analysis, in the sense of creating diversity for different dimensions of the system under study, illustrated for sustainable waste management in the Indian city of Ahmadabad, (iv) Q- methodology, a method from social sciences that is applied to study diversity in viewpoints; it can also be used to generate future perspectives and may yield up to five or six future perspectives, which is illustrated for sustainable gas futures in the Netherlands, and.(v) Making narratives and imaginaries.

The paper consists of an introduction, a literature overview of visioning approaches, a section describing main visioning methods, a discussion section developing a framework for methodological characteristics and criteria for application before drawing conclusions.

Assessing Sustainability - Part 1

Assessing circularity and sustainability: a survey-based analysis of companies with circular economy practices

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The circular economy (CE) concept has become a major trend among companies, promising new business opportunities and a decrease in harmful environmental impacts. Though research on circular business models has recently increased, only few scholars have investigated whether CE practices also yield the sustainability results they promise. Therefore, establishing the empirical *status quo* of circularity and sustainability assessments provides a way forward and enables targeted improvements of applied assessment approaches with academic findings. This paper presents the results of an empirical analysis conducted through a qualitative survey in the Netherlands and Italy, where the major part of research on the nexus of circularity and sustainability assessments has been produced. The survey was distributed online to over 800 representatives of companies. Purposive sampling was employed to target only firms associated with national and international CE networks, assuming these companies already implement and assess CE best practices at varying levels of maturity. They thus can be defined as "front-running CE businesses". Within a three months' timeframe, 155 companies provided information on their understanding of the CE concept, its relationship with sustainability, as well as the assessment approaches used for the monitoring and reporting of CE and sustainability aspects. The survey answers show that companies view CE as one of the tools to achieve sustainable development improvements, particularly in the environmental domain. Yet, the respondents are ambiguous towards the question of whether CE can also provide economic benefits to firms. Furthermore, self-developed sustainability indicators were the most frequent assessment approach on a company level, while Life Cycle Assessment related methodologies prevailed on a product level. Given the qualitative nature of the survey, the observed tendencies are to be scrutinised through semi-structured interviews in a next step. Further research advancements will also include the survey distribution in other European and non-European countries to enable regional comparisons.

Guiding tools measuring and reducing food waste: A review of standards, protocols and methods

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Food loss and waste represents a global threat to food security, has detrimental environmental effects, and costs billions of dollars per year. In 2018, it was estimated that 1.6 billion tonnes of food went to waste, representing one third of the world's food production at an estimated cost of US$1.2 trillion. This figure is projected to rise to 2.1 billion tonnes by 2030 if the issue is not addressed.

One problem in remedying food loss and waste is that it is difficult to accurately quantify. Accurate estimates or measurements of the quantity of food loss and waste produced are necessary if society is to transform food systems to be more sustainable. This is necessary not only to assess progress against targets set by organizations, but also to quantify the cost and potential savings in taking action to mitigate waste.

This paper documents a review of current related global standards, protocols and methods, in light of various groups developing tools to help food supply chain actors reduce food loss and waste (including the Australian based Fight Food Waste Cooperative Research Centre, the World Resources Institute, and EU based REFRESH). Our primary contribution lies in analyzing global standards, protocols and methods in relation to such tools are being developed or enhanced.

We achieve this by mapping the current food loss and waste standards, protocols and methods through a review of existing literature and 10 expert stakeholder interviews. We then refer to an existing resource food loss and waste tool currently being enhanced by the research team, as a way of organizing our results. By taking this approach we ground our review in a real tool development project as a framework to assess the relevance of existing food loss and waste standards, protocols and methods, via our multi research methods.

Results show that important food loss and waste tool features are; measurement of the true financial cost of waste, not just waste management costs; linking the true cost of waste to business costs such as food purchase (raw materials), energy, labour, and transport; inclusion of equivalency measures such as waste cost per bin or per meal; differentiating between avoidable and unavoidable portions of total waste; using efficiency ratios for business to better understand their supply chains; alignment to the recently released global Food Loss and Waste Standard; modularity with business systems; mapping across whole supply chains to reveal upstream / downstream issues, including effects of change; mapping the food loss and waste measurement process for specific sectors / industries to help them find relevant data; as well as represent other measured outcomes such as greenhouse gases saved, calories wasted, and material mass lost.

We conclude by discussing areas for future research, with a focus on implications for teams developing or improving food loss and waste tools, as well as suggestions for future global standards, protocols and methods. This has particular implications for both policy makers and organizations that are looking to reduce the global food loss and waste problem.

Indicators System of Intermunicipal Sustainability: a case study in rural areas, Beira Baixa, Portugal

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It is essential and urgent to seek social cohesion and quality of life of citizens, namely quality public spaces, energy efficiency, employment, economy, integration and social inclusion, among others, through policies (global or local), while respecting the specificity of each region. Indeed, in order to change the municipalities' planning policy, it is essential to incorporate sustainability criteria and their measurement. In particular indicators are a useful tool for communication and to support decision. The intermunicipal communities, as a cluster of neighbour municipalities, have an essential role in the promotion of territorial policies as a key factor for European territorial cohesion. The case study presented is about the Beira Baixa region in the interior of Portugal. Its population represents 0.8% of the resident population of Portugal. This region holds the country's 3rd and 4th largest municipalities in terms of area (Castelo Branco and Idanha-a-Nova), but with the lowest populational densities (18 inhabitant/km2). The main objective of this study is to present the results of the themes and calculate an index to determinate the key areas of a questionnaire survey applied to a representative sample of the resident population of Beira Baixa, Portugal, over 18 years of age. The survey aims the support of the development of a participative Indicators System (IS) for Intermunicipal Sustainability assessment. The objectives of the questionnaire were to inquire the population's perceptions and awareness about sustainability concepts, main sustainability themes and self-assessment of the local sustainability. The data that resulted was analysed using adequate multivariate statistical techniques, in particular to merge the more relevant sustainability domains and respective themes. The results show a statistically significant association between "Have you heard of the term "Sustainable Development (SD)"?" and "municipality". Specifically, we can see that in the rural municipalities the percentage of the population that has never heard of SD is higher. Besides, there is an imbalance between the four dimensions associated with the concept of SD (environment, economy, social and governance/institutional), in the community as well as in each municipality. In the question that relates to the Themes of the IS the environmental and social ones were identified as the most relevant. The exploratory factorial analysis on the presented subjects revealed six "components": the first one is strongly related with the "Environmental", the second with the "Economical", the third with the "Social", the fourth with the "Rural", the fifth with the "Immaterial" and lastly the "External Aspects". The research revealed also the low involvement of the population in public decisions and in questions related to the environment. It is essential to involve the population in order to put pressure on the government and local authorities to diminish social inequalities and assume their responsibilities for commitments to society, namely regarding local sustainability.

Integrating CE assessment in public sector organizations: drivers and barriers for implementation

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In response to interrelated sociotechnical challenges such as resource depletion, increasing emissions and waste, circular economy (CE) is seen as a key strategy to sustainable development. However, to seize its potential, CE should be integratedin organizational practice. Public sector organizations account for around 40% of economic activity in OECD countries and thus need to co-lead the transition from a linear to a circular economy by improving their own organizational circularity. There are different ways of increasing CE activity in organizations; nevertheless, academics, industrialists and politicians share the understanding that assessment can drive organizational change through simplified information exchange and understanding. In this context, a range of CE assessment approaches have been developed in recent years. The majority of these efforts focus on the design of assessment approaches and not on their implementation by the organizations. Consequently, public sector organizations to date have little guidance on how to integrate CE assessments. This leads to many organizations still struggling to implement, use and improve CE assessment.

Therefore, it is the aim of this article to bridge the gap in the literature and answer the questions of why is CE performance currently not assessed in many public sector organizations, what are the factors that drive and prevent the integration of CE assessment approaches as well as what are concrete steps for a successful integration of CE assessment, especially in the context of existing assessment efforts. Following a transdisciplinary approach, the research is conducted in collaboration with the Portuguese Circular Economy Coordination Group which consists of CE experts from different Portuguese ministries. The research involves two main methods. To contextualise, analyse the status quo and derive learnings from other academic fields an extensive literature review including multiple scientific fields such as public management, sustainability assessment and circular economy assessment is conducted. This is complemented by semi-structured interviews to explore and understand current drivers and barriers of CE assessment integration.

The expected findings of this article are an analysis of the drivers, such as simplicity of assessment approaches, synergies between existing assessments or involvement of staff, as well as the barriers, such as complex data requirements, missing differentiation to existing sustainability assessment or lack of assessment culture in public sector organizations. Moreover, this article seeks to provide recommendations on how to implement CE performance assessment in public sector organizations. This research contributes to a deeper understanding of CE assessments and advances the integration of CE principles in public sector organizations.

Self-assessment questionnaires of component suppliers – a way towards sustainability?

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The automotive industry is characterized by complex value chains and networks as well as deep structured supplier bases. In 2014 the automotive OEMs launched a joint sustainability self-assessment for suppliers in order to assess the sustainability performance of suppliers in the automotive sector. The main areas of the self-assessment comprise the supplier performance on sustainability issues, like CSR, environmental matters, sustainability engagement in supplier management, business conduct and compliance, etc. The main goal was to avoid duplication and increase efficiency for both, the OEMs and their suppliers.

According to Hacking and Guthrie (2008) sustainability assessment can be embedded in impact assessment practices designing a framework focusing on strategicness (level of accentuating strategy), comprehensiveness (direct and indirect effects of sustainability issues, e.g. dimensions concerning triple-bottom-line, strategies (sufficiency, consistency, efficiency) principles, etc.), and integratedness (the way assessment techniques are used, combined and aligned).

The automotive industry is engaging in sustainability, but mainly using a very own understanding of sustainability. However, sustainability is not arbitrary, but follows clear vision, strategies, principles, criteria and indicators. So, it is of interest how the self-assessment questionnaires (SAQ) reflect sustainability effectively and progressively. In addition, it is rather unclear if self-assessment questionnaires really reflect the suppliers performance on CSR, sustainability, etc.. Moreover, it is of interest if the SAQ really improve sustainability progress or rather cause contra-productivity in an organizational and value chain sense. The main importance is to be seen in the fact that automotive OEMs might have own understandings and implementations or realization strategies towards sustainability. If so, self-assessment might mainly be a tool for backstop than advancing real sustainability progress. Final, the benefit to other members of the organization or the organization as a whole or along the value chain is not fully identified.

We analyzed SAQs, two German and six English ones, in order to understand the main foci of the questionnaires. In addition, we analyzed the concepts of the SAQs by using Leximancer software, and analyzed deviation from GRI reporting for better understanding of sustainability progress. Moreover, interviews were conducted with components suppliers in order to understand the usefulness of the SAQs.

Using Leximancer software, we did find that self-assessment questionnaires reflect main sustainability and CSR issues, e.g. company, management and service issues, working conditions, etc. However, they strongly relate to GRI standards and often duplicate indicators. Since suppliers in the automotive industry are usually forced to set up and maintain an environmental, occupational safety, health and energy management system in addition to quality management, anyway, actual added value remains largely hidden. The questionnaires are intended to ensure this. This is also a legitimate purpose. However, the SAQs tend to act as a safeguard for the OEMs, without initiating any concrete progress towards sustainability. Real innovations in the sense of sustainability are not a component. These are created with development suppliers if necessary, so that clear guidelines are given, e.g. to use certain materials. However, not all of the given innovations are really progress towards sustainability. The SAQs do more relate to quality assurance questions and standardized management systems than to subjects related to self-assessment. The SAQs are indeed capacity-absorbing, thus, lost productivity is very likely. An establishment of a risk management that helps supporting sustainability criteria or standards is not addressed and directly supported.

Stakeholder-driven selection of indicators for sustainable energy development

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One of the most critical challenges facing the world is how to provide energy to all while minimizing the associated negative environmental and social impacts and maximizing the positive ones. A transformation of current energy systems is necessary for this to be possible. This transformation is often referred to as sustainable energy development which is a complex and multi-dimensional concept. Sustainable energy development has become an international policy objective that is integral to sustainable development as evidenced by the UN's SDG7 on affordable and clean energy. Energy-related challenges facing countries vary significantly and thus tailored actions towards sustainable energy development are necessary. Similarly, a set of context-specific indicators is needed to measure progress towards this international policy objective. In a data-driven world, the significance and usefulness of sustainability indicators for policymaking and tracking progress towards policy goals is becoming generally acknowledged. Nonetheless, no standardized approach to indicator selection exists. Furthermore, current indicators for sustainable energy development have been criticized for lack of transparency, imbalanced representation of the pillars of sustainable development, and lack of involvement of stakeholders during development. The aim of this research was to develop a stakeholder-driven approach to indicator selection for sustainable energy development and apply this approach in Iceland for the development of context-specific indicators. The importance of stakeholder engagement in decision-making, policy development, and indicator selection is progressively more recognized. By involving stakeholders during indicator selection, bias in selection is minimized and it is possible to take into account diverse viewpoints thus increasing validity and comprehensiveness. Thereby, stakeholders define the thematic scope of the sustainability assessment. A stakeholder-driven approach can result in a representative and robust set of indicators that is acceptable to stakeholders which is vital to ensure its application. Stakeholders of the Icelandic energy system were engaged through semi-structured individual and group interviews with the aim of identifying the main opportunities and challenges for sustainable energy development in the country. From these interviews, the main themes of sustainable energy development in Iceland according to its stakeholders were identified recognizing what is necessary for a transformation of the Icelandic energy system. To further verify these results, two rounds of a Delphi survey were sent to interviewees. A common thread from this stakeholder engagement was a perceived lack of a comprehensive long-term energy policy in the country. This even further adds value and immediacy to the research. Six overarching sustainability themes were identified: nature conservation, socially beneficial energy system, economically efficient energy system, energy security, sustainable energy production, and sustainable energy consumption. These themes and underlying stakeholder goals were connected to established indicators to produce a preliminary set of indicators. Thereafter, the quality of indicators and their interrelations were assessed, and unsuitable and overly related indicators eliminated. In the end, a comprehensive set of 50 indicators were selected to track progress towards a sustainable energy future in Iceland. These indicators account for all of the above themes and the three pillars of sustainable development; economic, social, and environmental. The result of this process is both an identification of what a sustainable energy future might entail in Iceland as well as a comprehensive set of indicators for sustainable energy development. Therefore, these results should be useful for the development of a long-term energy policy in the country.

Strengthening early stage decision-making by process-integrated sustainability assessment in local infrastructure transitions

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Urban infrastructures are vital for the distribution and the exchange of energy, matters and information as a basis for the well-being of societies. How infrastructures are designed and managed has strong impacts on their sustainability, including performance, resilience, social justice, economic viability, resource consumption and climate mitigation. Existing infrastructures are deeply embedded in socio-technical regimes. Currently, modernisation needs, sustainability concerns and climate change as well as technological advances especially in ICT drive a transformation of such socio-technical infrastructure systems. This could open up space for improving infrastructures' sustainability and contributing to sustainability transitions, e.g. by introducing coupled socio-technical infrastructure systems.

However, such transformation does not necessarily lead to more sustainability: While sustainability gains importance in infrastructure planning, there is little empirical information on sustainability effects of coupled systems. Navigating sustainability transitions requires continuous social learning about intended actions and their effects, taking systemic synergies and trade-offs as well as diverse actors' perspectives and needs into account. Tools for a collaborative and systematic consideration of sustainability effects in early planning phases are hardly applied or discussed. Against this background, we have developed and tested a tool for in-process assessment to support sustainability-oriented decisions in early planning stages where there is still a great deal of scope for decision making. The tool is based on a sustainability concept developed for coupled infrastructure solutions and includes 26 criteria related to a) performance and resilience, b) social justice and economic viability, c) resource consumption and emissions. To verify the relevance and applicability of our assessment approach we applied and tested the tool in (i) a Delphi-based online survey and (ii) action-oriented research in local case studies, both embedded in the German context.

Our general findings show that coupled infrastructures can deliver services in a more sustainable and resilient way, e.g. by reducing or substituting primary energy demand and greenhouse gas emissions. However, not all novel solutions necessarily improve sustainability. Therefore, adapted regulations and targeted local process management that fosters collaboration with diverse actors are required to guide the ongoing transformation towards more sustainability. In real-world case applications our approach has proved to be a flexible tool to reflect on and integrate different sustainability aspects and perspectives considering short-term and long-term effects as well as the identification of critical aspects.

Hence, the proposed sustainability check can contribute to ongoing planning and discussion processes by helping local actors to elicit potentially benign and disadvantageous effects. We draw conclusions regarding the application of process-integrated sustainability assessment for informed decision making in the field of infrastructure planning and management. As such, our sustainability check provides a new process tool to facilitate collaborative and systemic reflexivity and assessment.

THE ENVIRONMENTAL IMPACT OF WINE PRODUCTION: A LCA CASE STUDY IN SICILY (ITALY)

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The wine production represents one of the most important and profitable industry in the agri-food sector. In 2019, the total world amount of wine produced, including sparkling and special wines, has been estimated for about 263 million hectolitres (mhl), highlighting a 10% reduction over 2018 (292 mhl). Worldwide, the most important wine producers are located in Italy, France and Spain which respectively contributed for about 16%, 14% and 12% to the world wine production, in 2019. Due to its specific climate characteristics and its geomorphology, Sicily is the fourth wine producer region in Italy (3,8 mhl), after Veneto, Puglia and Emilia Romagna. Despite the high importance in terms of economic revenues, the wine sector is also a higher contributor to the environmental impacts, considering, in particular, the agricultural, packaging and distribution phases, in a life cycle perspective. The growing attention of consumers towards the environmental issues, brought the wine industry in improving the production processes in order to reach more sustainable and environmental friendly products. In this context, the assessment of the whole life cycle of wine production by means of the Life Cycle Assessment (LCA) method is fundamental for obtaining a detailed picture of the related environmental concerns. LCA is a standardised method for the identification of the potential environmental impact associated with a product, process or service throughout its entire life cycle, from raw material extraction/cultivation, through manufacturing, transport, use and final disposal The aim of this study is to assess the potential environmental impacts related to the wine production processes by means of the LCA method. The study has been performed in order to support a wine company operating in Sicily (Italy) in planning environmental improvement options. The functional unit selected for carrying out the analysis is “one bottle of wine”. The system boundaries follow a “cradle-to-grave” approach, from raw material extraction to the end of life, allowing a high level of detail in the assessment of the environmental impacts. In addition, the potential environmental impacts were evaluated by using the IPCC 2013 GWP 100a in order to obtain information related to one of the most adopted impact categories for assessing this sector. The results of this study pointed out that the environmental hot-spots are mainly connected to the agricultural production phase. They allowed, on the one hand, to understand the whole environmental performance of this specific wine production process, on the other, through a sensitivity analysis, to help the company in understanding which are the phases or processes to be implemented for reducing the related environmental impacts. This study confirmed how the LCA method is a valid tool to quantitatively investigate production systems and find solutions to minimize environmental impacts.

Assessing Sustainability - Part 2

A sustainability assessment tool for Metropolitan Areas: Development in Metropolitan Region of Ribeirão Preto, Brazil

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Sustainability policies are supported by flows of information from heterogeneous sources related to economic, social, environmental and institutional processes and are monitored transparently and reliably. In the sustainability planning process of metropolitan areas, sustainability assessment tools have provided a way for local authorities to monitor, evaluate and disclose periodic and continuous reports. Despite several initiatives in developing sustainability assessment metrics, indicatively indicator-based tools, few theoretical frameworks became practical applications and there seems to be a substantial gap in the study of metropolitan areas. This research aims to develop a practical management tool supporting by indicators to assess the level of regional sustainability in the Metropolitan Region of Ribeirão Preto (MRRP), Brazil. The sustainability of the 34 municipalities in MRRP will be assessed. Sustainability Indicators (SI) involving institutional aspects, society, economy, and environment will be selected to obtain the set of applicable indicators. The proposed tool will be developed based on 17 Sustainable Development Goals (SDG) and by considering criteria including the transparency and understandability for all members of society including local government authorities. The selection process will be conducted by contributing of MRRP local governments and their relevant stakeholders whose expertise are associated with different dimensions of sustainability. A quantitative and qualitative participatory technique will be applied to extracted the primary and secondary data. A set of indicators and key guidelines on the horizon of SI use in metropolitan areas is proposed aiming of representing a critical analysis of the relevant indicators analyzed, but supported and underpinned from a crosscutting position of the SDG, represented by societal and local governments' role within a region. The preliminary results demonstrated that there are challenges and opportunities for SI selection and application for metropolitan areas, mainly for the implementation of technically oriented indicators. This can influence the level of a potential impact on society, including metropolitan local governments, different professionals and end-users. This research provides the idea of employing an element of local government inclusion in identifying SI for regional sustainability, as well as finding the best way to evaluate and use of SI. It is also pointed out an integrated view for combining the theoretical inputs and practical application within the SDG perspective, as well as the need to develop more refined routes towards sustainable development in metropolitan areas. In addition, as one of the main contributions of this research, the different findings can provide meaningful information for local and regional governments, policy-makers and planners to take suitable actions to improve the sustainability level of the metropolitan-level regions in Brazil. The method approaches developed and applied in this research can be also adaptable for the investigation of sustainability at others metropolitan areas, including their specificities.

Emergy accounting in sustainability assessment

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Emergy accounting (EmA) is a method in the "sustainability assessment toolbox", that has gained increasing interest due to several reasons: 1) it includes naturally economic flows alongside with energy and material flows (also other information flows than money can in theory be included but has yet not been done so to any larger extent); 2) EmA has interesting alternative solutions to problematic areas where the popular Ecological footprint method has gained criticism from the scientific community; 3) EmA as a complement to LCA may make it possible to develop the LCA method to assess also larger systems as cities, regions, and countries, which is not currently possible. There is currently no standard how EmA should be used in sustainability assessments. Preliminary features of a framework were presented at ISDRS 2016, and in this paper this framework is further developed and compared with ten recent emergy papers addressing sustainability. The ISDRS 2016 preliminary framework included 1) the Emergy Sustainability Index (ESI); 2) the normalizing mechanism in EmA; and 3) emergy as a network measure; in this paper is also included 4) pulsing sustainability. The results showed that all ten papers used the normalizing feature of energy, material and money. Eight of them included the possibility to capture network properties of the system investigated with indices and systems diagrams. Seven of them used the, to some extent disputed, Emergy Sustainability Index (ESI). None of the ten papers addressed the pulsing aspect of sustainability suggested by the emergy accounting originator H.T. Odum in several of his textbooks.

Meta-evaluation of environmental education projects´ assessments: limitations; benefits and challenges

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Assessing the outcomes and impacts of the implementation of sustainability strategies, programs, projects and initiatives is a decisive step towards enhancing their efficiency and effectiveness. Indicators usually play a central role in evaluation and reporting. However, although there has been a proliferation of sustainability indicator (SI) initiatives worldwide, SI initiatives face many challenges, such as: participatory evaluation; self-assessment; integration of nontraditional aspects of sustainability; governance models; among others. Practice has not yet reached a situation where methods or approaches are proven to work well. Therefore, meta-evaluation, the evaluation of an evaluation, represents a theoretical and practical framework able to systematically enhance the assertiveness of sustainability assessments. However, the implementation of a formal meta-evaluation process may be technically complex and approaches are still not well established and disseminated. Therefore this paper aimed at presenting a meta-evaluation framework developed to critically analyse environmental education project´s assessments and discussing its limitations, benefits, and challenges. A case study was implemented in the Brazilian energy sector, encompassing the meta-evaluation of seven environmental education projects' assessments. The meta-evaluation framework, based on 10 indicators, was delivered through an electronic platform. It comprehends the following dimensions: evaluation framework design; indicator selection; indicator performance; evaluation process and governance; evaluation quality and utility; and stakeholder's participation. This study confirmed that there is a great number of variables and of indicators to be considered in a meta-evaluation approach to critically analyse environmental education projects´ assessments, according to evaluation good-practices. On the other hand, results indicate that meta-evaluation can be used as a quality-control tool during the implementation of environmental educational initiatives´ assessments, enhancing its objectivity, accuracy, feasibility, utility and transparency. Structured with 20 indicators, the critically analysed environmental education evaluation model has now 13 indicators after the meta-evaluation process was implemented. Results also confirmed the relevance and usefulness of meta-evaluation approaches to enable environmental education evaluation models to be updated, being adapted to new situations and contexts systematically. Moreover, outcomes indicated the relevance and usefulness of meta-evaluation approaches to discuss and enlighten solutions regarding limitations and possibilities found in literature related do SIs. For instance, the adequate level of standardization for indicator sets versus context-specific sets; and an integrated indicators' theory applied to environmental education projects´ assessments were two issues discussed and addressed during the meta-evaluation process implemented. Besides, this research concluded that meta-evaluation approaches must be used as a participatory tool during the implementation of environmental educational initiatives' assessments, contributing to the consolidation of the participatory evaluation conception. Meta-evaluation implementation enhances stakeholder's autonomy and public policy action. Further researches must be carried out to better study governance procedures and the optimum point in the assessment cycle that meta-evaluation must be implemented.

Mine Closure and Sustainable Development: An Evaluation of Repurposing Scenarios for a Mining Facility in Colorado, USA

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Under present circumstances, where sustainable and responsible use of resources is of utmost importance, the private sector emerges as one of the actors that is expected to contribute to sustainable development. This expectation has been made official by the United Nations' explicit call on the private sector to further engage in responsible practices during the establishment of the Sustainable Development Goals in 2015. The mining industry is one of the private sector actors that has the potential to significantly contribute to sustainable development and has been making efforts to engage in more environmentally, socially, and economically responsible practices.

In a mining operation, the closure phase is the end of the operational stage when the ore has been depleted or when mining is no longer economically feasible. Although the physical closure occurs at this final phase, closure starts from the earliest stages of mining and should be planned ahead in line with sustainable development principles. Otherwise, substantial environmental legacies and costs, as well as social costs and disruption due to prematurely closed or poorly abandoned mines, would be inevitable.

Responsible mine closure and repurposing are crucial for contributing to sustainable development by ensuring successful environmental rehabilitation of the mined land and reducing the socioeconomic risks related to the departure of the mining company as an employer and economic contributor. In this paper, we argue that sustainable repurposing should: i) be unique to individual circumstances and needs of the nearby communities, ii) take into account the preferences of stakeholders, and, iii) adopt a holistic approach that addresses the associated environmental, social and economic issues rather than focusing on only one dimension.

This paper evaluates and compares three different repurposing scenarios for a tailings dam area of a molybdenum mine in Colorado that is approaching the closure phase. To do this, we employ the multi-attribute utility approach, which allows for a comparison between diverse attributes. These attributes include environmental, social, and economic indicators, which are compiled from mining-specific international organizations, reporting guidelines, and the academic literature. We use a survey methodology to examine the preferences of diverse stakeholders and integrate them into the sustainability assessment of three different repurposing scenarios, namely, organic shrimp farming, CBD and hemp production, and glass manufacturing.

Our initial findings show that the repurposing phase of the mining life cycle was not considered as much as other phases in the literature for developing sustainability indicators. We found that a small set of indicators could be selected for this study out of a large, mining-specific sustainability indicator set, and we suggest 16 new indicators to include in the final set of 30 indicators used for this study. Additionally, the initial evaluations show that each alternative has its own strengths and weaknesses in terms of environmental, social, and economic sustainability, and the ranking of alternatives changes depending on the decision maker's preferences and values.

In conclusion, this study allows us to evaluate the ways in which different repurposing scenarios can contribute to sustainable development in nearby communities, and provides an innovative method for evaluating sustainable development initiatives. We not only identify the strengths and weaknesses of each scenario but also determine which scenario would better reflect the preferences of stakeholders and result in the most economically, environmentally, and socially sustainable outcomes.

Sustainable Building Without Certification: An Exploration of Implications and Trends

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Sustainable and resilient infrastructure plays a pivotal role in meeting the United Nations Sustainable Development Goals (UN SDGs). Current information from the U.S. Environmental Protection Agency (EPA) and other credible sources indicate that buildings account for approximately 40% of total energy consumption worldwide, which leads to about 48% of greenhouse gas emissions from the building sector alone. To combat this problem, the current trend is to design sustainably, and one of the leading determinants of the metrics by which these buildings are measured is the Leadership in Energy and Environmental Design (LEED) rating system administered by the United States Green Building Council (USGBC). However, the LEED certification criteria and process have been seen by many as either cumbersome or sometimes too expensive. As a result, buildings are being constructed following LEED or other sustainable building guidelines, but without necessarily pursuing external certification. This paper takes a critical look at LEED implementation without certification through the lens of sustainable development and societal transformation and addresses three (3) questions: 1. What is the rationale behind not pursuing LEED certification? 2. When certification is not part of the objective, how are particular sustainability criteria selected? 3. With regards to criteria selection and performance evaluation, to what extent do LEED building projects that undergo certification differ from those that do not, and what are the potential implications for building performance? The results provide insights on the implications of assessment-related decisions in building design and construction as we look to transform our societies into more sustainable, healthier, and livable places, and support global goals for sustainable development.

The effects of environmental performance on competitiveness: A stochastic frontier approach

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The main inputs to economy are the environment and natural resources especially in biodiversity countries. Because of this, they are associated to the competitiveness and efficiency taking into account that natural resources are a factor for production affecting productivity and growth. Moreover, if natural resources will become scarcer, which require to anticipate this change to prevent a decrease on competitiveness. In this context, the analysis of competitiveness and its relationship with environmental performance is an important topic, especially in emerging economies with high biodiversity as a strategy to promote and prevent environmental damage and to improve competitiveness. This study evaluates the effects of environmental performance on competitiveness using a stochastic frontier approach in Colombian regions using the competitiveness index based on methodology proposed by world economy forum for global competitiveness index and different environmental variables, which allows us to understand how environmental performance plays an important role in the results of competitiveness in Colombian regions that evidence economic and social disparities. The results of this study suggest the importance of environmental performance for the increase competitiveness. Increased environmental performance should lead to an increase in competitiveness. It is important to close regional gaps through political instruments that promote adequate environmental measures that consider competitiveness and innovation to promote sustainable development and the responsible use of natural resources. The findings of this study are important to design adequate instruments that include environmental performance and competitiveness as key elements to promote sustainability, growth and welfare in Colombian regions.

Provision, Quality Of and Access to Education

Assessing Education from Space: Using satellite Earth Observation to assess pupil density in primary schools in rural areas of Nigeria

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Nigeria is a country with a rapidly growing youthful population and the availability of good quality education for all has long been a key priority for the country. An important element of this is the improvement of access to high-quality primary education in rural areas. A key indicator for achieving this is the provision of adequate classroom space for more than 20 million learners in Nigerian public schools as overpopulated classrooms are known to have a strong negative impact on the performance of both pupils and their teachers. However, it can be challenging to assess this indicator for over 60 thousand primary schools, especially in rural areas.

In this research, we evaluated the pupil density of schools in Nigeria using satellite Earth Observation (EO) data to determine the size of available teaching spaces coupled with a governmental database of school-provided data on the number of enrolled pupils between 2011 and 2014. From these data, we evaluated the area per pupil of 1900 randomly selected public primary schools in rural areas across 19 Nigerian states, spanning all regions of the country. In order to identify overcrowded schools, we used the minimum standard threshold defined by the Federal Government of Nigeria which states that schools should provide at least 1.2 m^2 of classroom space per pupil. Our analysis shows that, by this definition, 71 % of the schools examined were overcrowded. Such overcrowding can be expected to have a negative impact on educational performance, achieving universal basic education and on meeting the UN Sustainable Development Goal 4 - Quality Education.

While measuring floor area can readily be performed manually *in situ*, collecting and reporting such data for the number of rural primary schools in a large and populous country such as Nigeria is a substantial, time-consuming administrative task with considerable potential for errors and data gaps. Satellite EO data are readily available, provide accessibility in remote areas, are reproducible and is easy to update over time. This paper provides a proof-of-concept example of how such EO data can contribute to addressing socio-economic dimensions of the UN's Sustainable Development Goals framework.

Contending with Sisyphus: Pursuing Sustainable Development in a Business-as-Usual World

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In recent decades, organizations and management scholars alike have been called to consider their impact on global sustainability, and many have responded. Sustainable development recasts organizational norms, dynamics, and outcomes and their long-term impact on people, planet, and profits. Much of the research in this area has focused on how actors conceptualize, catalyze, and implement change to address sustainable development challenges. Albeit with a few exceptions, barriers to sustainability in organizations have received far less attention. Our focus is on understanding what happens when individuals experience little forward momentum in advancing sustainability–when their repeated efforts seem futile. Like Sisyphus, who was made to endlessly roll a huge boulder up a steep hill without ever reaching the top, we know little about how actors continue advancing change when they experience limited or no progress. Understanding how change agents persist in places that heavily promote the status quo are critical issues in enabling sustainable development specifically and understanding organizational change and change agents more generally speaking. In order to investigate these issues, we turn to the concept of place-based sustainability. Place-based sustainability is a relatively new and underutilized lens to study the complex and dynamic interactions between natural and built environments. It refers to how the local context, be it physical or symbolic, plays a role in whether and how an organization embeds sustainability. Until today, most studies on place-based sustainability have focused on how place contributes positively to organizational sustainability. However, we know little about how actors persist in places where they experience limited forward momentum for sustainability. In light of this lacuna, our study examines how actors willing to embed sustainability cope in organizations where the concept of place is important, but is disengaging the organization in improving its sustainability performance. Our empirical setting is a higher education institution (HEI) where sustainable development initiatives have been attempted from the early 1990s to 2018. We focus on understanding how perceived change makers – administrators, faculty, staff, and students – intentionally sought over time to enact sustainable development initiatives in the face of strong pressures for the status quo – a business-as-usual mentality. We relied on multiple data sources combining semi-structured interviews, observations, internal operating documents, email communications and news media to obtain a multi-faceted and contextualized understanding of the focal phenomena. We show how an actor's journey in attempting to embed sustainable development practices into the university was a dynamic process, where he/she experienced periods of persistence and periods of suspension in their work. Our theorizing reveals three key coping strategies that actors utilized in periods of persistence: connecting with others, being resourceful, and envisioning for the future. Our study contributes to the sustainability literature by addressing the underexplored concept of place-based sustainability, and relating this to resistance to change and individual coping mechanisms. In doing so, we explicate how actors persist in their efforts to pursue sustainable development initiatives despite strong pressures for the status quo.

Design Education for Sustainability

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Currently, more scientists recognize education for sustainable development as an integral element of improving the quality of education and a key factor for the sustainable development of society. Do not leave aside the activities of designers who contribute to improving education for sustainable development. At first glance, the activities of designers are aimed only at creating new products and supporting the economy; in fact, their activities are quite diverse and affect the environmental and social spheres of society. This article aims to expand the knowledge of designers' contributions to education for sustainable development. The article describes design skills, which include: research skills; skills to create a new product; presentation skills; communication skills; reflective skills (Kadyirov, 2019). All of these skills allow designers to engage in professional creative activities, as well as contribute to education for sustainable development, for example, to develop and create products using recycled materials to maintain the environment and the economy; find new solutions that will help improve the standard of living and culture of the population. Moreover, these skills can be mastered by other professions, such as engineers, architects, etc. In order to increase professional competence and the level of cognitive interest of students, the question arises of improving existing and creating new methods of creative work with students, as well as highlighting the most productive methods from a number of existing ones. It should be noted that lifelong learning is also an important component of training designers, as it is important to consider not only formal training, but also non-formal and an informal (Kálmán, 2016). The most productive pedagogical technology is art-project activity, as it helps to increase the level of students' professional training by completely immersing students in activities important for achieving learning goals, as well as motivating them to engage in self-learning and education throughout all life in order to lead them to sustainable development (Kadyirov, 2019).

Education for sustainable development literature and Whole school approach to sustainability

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This review of research aimed to clarify the evolution of concept “education for sustainable development” (ESD) and examine how ESD has been applied in schools in different societies across the world. A second goal of the review was to identify the range of ‘whole school approaches to ESD which implemented in specific seven countries. Finally, the review critiqued and synthesized successful features of these whole school ESD models.
This study of the ESD literature was comprised of two complementary methods of research review. In this first phase, the author identified 1,842 Scopus-indexed, ESD-related documents. These authors used Excel and VOSviewer software to conduct descriptive and bibliometric tests aimed at analyzing key features of the ESD knowledge base (e.g., growth trajectory, geographic distribution, and citation impact). In the second phase, the author drew upon results of the bibliometric analysis to identify the range of ‘whole school’ approaches to ESD. Having identified documents identifying these approaches, the author used the meta-synthesis review method to synthesize the key features of these approaches.
From science mapping method, ESD publications only bloomed over the past two decades ago. There have been diverse ESD research from various geographic in the past 15 years with the noticeable dominant of Anglo US-based scholars. From co-citation map, there are three distinctive, but interconnected Schools of Thought in the ESD knowledge base: “Education for Sustainable Development”, “Developing a Sustainability Mindset”, and “Teaching and Learning for Sustainability”. These Schools vary in terms of the number of scholars, author dispersion, author prominence, and density of links to other clusters.
ESD concept was implemented in two main ways in school.
In some countries, whole school approaches are displayed as award accreditation (China, Sweden, U.S.), and tirered system (Thailand). While those approaches are presented as ‘participating school’ (U.K, Australia, Japan).
Synthesis of the whole school approaches to ESD found some common features, which are capable to measure the effectiveness of the approach are identified as triple bottom-line in education, school leadership, stakeholder awareness and participation, awareness and participation, resource management and school grounds, teaching and learning strategies, and ESD curriculum.
The study leads to recommendations to increase ESD research in developing societies and to increase the proportion of cooperation research that would eliminate geographical imbalance, as well as more ESD action research in schools.
The bibliometric review part merely illustrated ESD-related knowledge production without analysis of the results of publications. The synthesized whole school ESD model developed in this review may require adaptation to the cultural contexts of different societies.
As a broad portrait, this study is a base stone for a similar study about ESD. The results from analyzing ESD school approaches yielded guidelines that can be applied to incorporating ESD concepts in schools. Synthesis of whole-school approaches yielded a new framework that can also guide the thinking and planning of school leaders interested in adopting ESD practices in their schools.

Framing Business Schools as Change Agents for Societal Transitions Based on Historical Reasoning

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Change agencies in society are understood via research and education. Business schools according to the recent literature tend to be rather traditional, not meeting the new requirements of the society concerning societal transitions. Business schools, which are the nests for business knowledge transmission and as part of academic institutions provide the practical and experiential knowledge base, may become change agencies in the societal transitions due to changes in the society such environmental, innovational or social expectations.

Analyzing the currently available literature, elements are collected in this article. These elements are based on a three-level analysis starting from change agency theories (change agents on an institutional level), through academic institutions as change agents till business schools as academic institutions being agencies of change to meet the new requirements of our society. The elements form a framework, which frames the role, responsibilities, barriers and challenges of the business schools in these change processes.

Pursuing the most key actors makes a change agent; therefore individuals willing to initiate change at business schools to meet the new requirements of the society must be persuasive towards the decision-makers at a supreme level. Action-gap is to be filled in via the personal motivation of change agents at business schools independently from their position. Business schools were first funded by the church, later mostly by the states, which inevitably creates dependence, therefore the interest of the business schools' owners have to be met. Business schools being part of academic institutions can become change agencies in countries that are on different levels of economic innovation but ought to choose a diverse pathway.

Business schools as academic institutions have been acting as reactive change agencies, responding to the outsider economic, social, political, religious expectations, though these institutions have never acted as pro-active initiators of changes for public service, which was originally one of the three missions of academies. They have been adaptive change agencies, instead of transformational ones.

It is generally going to be a significant win for the society at large when business schools step onto the road of becoming change agencies at a rather significant scope instead of local, smaller-scale and the knowledge transmission will be based on mode 3 type of knowledge production releasing the hands of future intra- and entrepreneurs acting as responsible business personnel to meet the new requirements of our society. This article provides the framework for it built up of elements gained with the comprehensive understanding of high-value research articles.

Higher Education in the Edge of Anthropocene: How does Business Schools embrace the 2030 Agenda?

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Greatly defined by the document Our Common Future sustainable development can be understood as a perspective that shifts the centrality of man, in the present moment, to nature and future, in an intergenerational perspective that looks with generosity and ethical responsibility towards the future generations of human and non-human beings.

The construct evolved as well as the pressure on the planetary life support systems of the planet. The changes caused by the human species are so concentrated and relevant that the term Anthropocene arises to denote the short timespan in which anthropic action is already considered indelible. On the verge of extinction, businesses, national states, civil society, academics and individuals of all sorts need to integrate this paradigm shift in all the dimensions of their life: only with this level of mobilization human race will be able to survive and move forward as a civilization.

The signals reflect on how enterprises organize themselves and demand actions from these agents who are greatly responsible to create a sustainable world. Since there can be no sustainable organizations without adequate leaderships these pressures reflect in Higher Education Institutions and in a more narrow scope in Business Schools. It is known that business schools are active agents in a dialectical relation within market demands and do not are passively exposed to institutional signals. Nevertheless, every time a scandal of corruption or a socio-environmental catastrophe emerges, they are put on check, especially through the lens of the decoupling effect: when schools don't "walk their talk", relying only upon the rhetoric of sustainability in a detached way from daily practices, curriculum, structure, etc. This puts schools in a two-fold situation: from one point of view, they don't play through their rules, at the same time they are keystone agents of the sustainable development paradigm.

The aim of this work is to identify the main dimensions of Education for Sustainable Development in business schools and propose a framework validated with agents of the educational context of Business Schools around the world.

From the Dyllick (2015) work we got our main model of dimensions who were complemented by a systematic review of 114 peer-reviewed papers related to the theme and iterated through in-depth interviews with specialists until saturation of the thematic. The model was transformed in a survey format, suited for Delphi specialist elicitation, and sent to scholars of many different business schools around the world. The most significant dimensions were them conformed into a final framework who also mirrors itself with the Sustainable Development Goals framework.

Preliminary results show that Dyllick's (2015) model is quite complete and reflects much of the dimensions extracted from the bibliography, even though it was released in 2015. However, other dimensions were added and made the model more heterogeneous. Especially with regard to experiential learning and communities of practice within the hidden curriculum. The work contributes theoretically to the intersection between Management Education and Education for Sustainable Development, especially by proposing an updated framework for integration of the thematic in business schools milieu.

Leading Change for Sustainability: Designing a Computer Simulation for Management Education

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Corporate sustainability is becoming increasingly significant for business. It is a great challenge that involves complex and systemic changes. Managers are required to address the change for sustainability through interaction with the organization's environment and under conditions of uncertainty. This requires new and more powerful tools to assist managers and their teams in understanding how to succeed under these challenging conditions. Simulations have emerged as a tool of choice when addressing sustainability issues due to their superior ability to capture the complexity of problems and related process.

This paper describes the development of a computer simulation that can be used with prospective and practicing managers to learn how to better lead change to sustainability in organizations. Learners will group into a small team to transform a company through the adoption of sustainable practices in three years. They must develop strategies and select activities to meet the needs of people at a given point in time through the iterative sequence of planning. Team's success will be evaluated by the number of staffs implementing sustainable practices and the company's performance that accrue from sustainable practices. Students can learn to develop, apply and see the results of different strategies for leading for sustainable success from their own decisions. This enhances their capabilities for higher order thinking about leading change in organizations. The utility of this simulation could be use in a management program or in a company to raise the awareness of staff as it seeks to embrace sustainable practices.

On-line Collaborative Learning Approach to SDGs in the Pedagogy Studies

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According to the new online learning environment and excellent teaching practices with Information and Communication Technologies (ICT), we need to implement the United Nations Sustainable Development Agenda for the Year 2030. In Sustainable Development Goals (SDGs), education has a unique role for developing inclusive equity, equity and property within environment limit. This development goal goes beyond traditional specific vocational education goals in VET, because of its importance in everyday life and its strategic nature beyond generations, it is capable of stimulating students' perceptions in sustainability. Our aim was addressing new sustainability changes in work relations, attitudes and values (Scones et al., 2018) using transformative collaborative learning tools. This paper presents on-going research to change the vision and needs for new content development in vocational education and training (VET) through online, collaborative learning. We were starting from our original construction of collaborative open content development (OCD) based on the results of learning content digitalizing projects (Benedek & Horváth, 2015, 2019), was built upon the recognition of the change in the teaching-learning paradigm. Nowadays, in VET content development, rapidly changing elements determined by digital transformation aspects (Beetham & Sharp, 2013), and dynamics of change are challenging to be forecasted. According to the applied methods, the central point was the improvement of students' activity in the frame of collective open content development tasks. We have assumed that this pedagogical approach through the new program-based learning as content constructs the students' cognitive domain, to enable the development of sustainability competencies. Serving the modernization of the subject named Digital Pedagogy, our project aims to develop an innovative method, relying on the principle of open access, allows students to do everyday development activities in a framework system (Moodle). The project has offered the opportunity of collaboration in developing learning content involving lecturers and students (46 persons) into the construction works on various micro-content manageable online with the help of the method. Our realistic target was to open up the possibilities of an online collaborative system of new media with the help of an open curriculum development model that supports the digital learning process of students. In our case, the dual functional linkage of teacher training (learning and transmission) allowed us to examine the first phase of the evolution of student activity, the nature of their attitudes. This study reviews the pedagogical micro-content produced by our MSc Vocational Teacher Training students in our Open Curriculum Development Project, which was created in the online collaborative learning process. The pedagogical course provides an opportunity to analyze global issues and challenges that have provided significant educational potential for VET students in terms of interdisciplinary interactions and the recognition and discussion of global challenges. The results of this research illustrate the potential of the everyday problem of sustainability in the methodological application of open curriculum development by analyzing the thematic and genre specificities of micro-content (system thinking, future-oriented thinking, collaboration, strategic thinking, modelling sustainable behavior) analysis in the school environment is a means of communicating students' motivational development. In conclusion, the process, which has already been introduced and tested in the teaching practice, shapes the teachers' content development culture at the micro-level. An essential pedagogical effect of this method, which focuses on a training field broader than the traditional discipline-subject-based view, is that teachers get targeted preparation to use it.

Educating For Sustainability

Climate innovation and entrepreneurship in primary and secondary education in Hungary

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Climate change is one of the biggest challenges of our age and education could play a key role in preparing young people to find innovative solutions to the many problems related to this phenomenon. An improved education system focusing on problem-solving, creativity, and soft skills can support students to provide complex answers to the heterogenous problems of climate change and sustainability related issues as well. This paper analyses how to effectively develop personal competences of Hungarian students putting emphasis on environmental education within the existing education frameworks and curricula. To answer this question, we introduce how the Hungarian public education system is structured with a strong focus on outcomes and challenges regarding primary and secondary level. The description of overall career development pathways of teachers, administrative responsibility for schools, educational funding and teachers' qualifications are also involved. The framework curricula are analysed describing how the curricula contents stimulate critical thinking, creativity, spreading innovations, entrepreneurial thinking and ability to teamwork. A brief summary of comprehensive literature is provided about potential solutions and existing research questions in the Hungarian thematic journals from the field of pedagogy, sociology and psychology. Briefly, the expenditures regarding the Hungarian educational system by analysing time series data is described. Regional differences in educational outcomes, basic data and public – non-public comparison are also introduced. The main conclusions reveal specific features and challenges of Hungarian educational system with regards to the decreased ability of our students to become more innovative, climate-conscious and creative.

There are several Hungarian and European initiatives that aim to improve the knowledge and commitment of students at different educational levels with or without the official involvement of schools. We have collected the most significant local examples of these initiatives from the past few years targeting students of primary or secondary schools. These programmes boost either students' critical thinking, creativity, innovative and entrepreneurial skills or raise their awareness to some climate change problem areas, eg: waste management, climate sciences, etc. Some are examples of joint initiatives involving primary or secondary schools and non-public organisations (incl. NGOs, companies, religious organisations) and some are independent of the Hungarian school system. The shown examples include among others the short introduction and analysis of the Hungarian Nature School System, the Energy hunting program by Energiaklub, Speak Smart! by the Foundation of Democratic Youth, Eco-Pack Playhouse and "Waste to Product" Exhibition, Innovation Camps and Student Enterprise programme by Junior Achievement Hungary/Europe, CsoPa Science Center in Budapest, the Young Climathon and the Young Innovators programmes by EIT Climate-KIC, etc. The analysis and the results of these programmes could be a source of guidance and inspiration for schools to improve their curricula which is needed to unleash the creativity, programme-solving and entrepreneurial potential of the students to tackle the climate change challenges.

Effectiveness of an RRI-based CSR course in shaping attitudes of students

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The paper uses the conceptual framework of RRI (Responsible Research and Innovation) and investigates its application in higher education. According to the definition of von Schomberg (2011 p.9.), RRI is "a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)". Based on this comprehensive definition, Tassone et al. (2018 p.344-345.) suggest three educational design principles for RRI in higher education: education for society, education with society and educating whole persons. Our paper mainly focuses on the first and the third principle. In line with The Lund Declaration (2015), the main goal of the analysed course "Corporate Sustainability and CSR" was to address societal challenges and provide students a set of solutions that can be effectively used for the benefit of society. Teaching methods were selected to relate to the cognitive, affective and conative behaviour patterns, for the sake of educating whole persons. This paper aims to measure the effectiveness and impacts of using RRI tools as teaching methods in courses with strong focus on sustainability, environmental and social responsibility. A course is considered to be effective when course objectives, targeted skills and competences, as well as expected learning outcomes get reached. This paper analyses the impact of a specific international blocked course on social and environmental sensitivity of students. Two qualitative methods were involved into the analysis. Q-methodology was used to measure responsibility-related preferences of students, before and after the course, regarding their individual behaviour and expectations towards companies. In addition, semi-structured interviews were conducted after the course, to measure individual perceptions about the impact of the course. Both methods focused on the applied RRI tools including the main focus of the course content and the reflective, communicative and argumentative teaching methods. Results suggest that teaching with RRI is highly appreciated by students, their effectiveness is perceived to be high in reaching the desired learning outcomes. Changes in responsibility-related preference order show stronger and weaker impacts alike which fosters reinforcement and further development of RRI based teaching. Students who were already responsibility oriented before the course, became even stronger responsibility driven after. Originally environmentally and socially inconsistent students became more sensitive in their individual behaviour, although their preference structure still shows inconsistencies. The factor of individualist students disappeared, while a new factor with conscious consumer expectations emerged. Interview findings indicate the recognition and appreciation of RRI based teaching methods, including the interactive manner of the course, the active involvement of students into discussions and team assignments, enlighten the problems and solutions via case studies and reflective teaching. In conclusion, research results have shown that RRI based teaching methods can be used effectively, especially when the course itself has a strong focus on responsibility and sustainability. Reaching the intended learning outcomes and develop desired skills and competencies in all aspects of human behaviour makes the application of a wide range of RRI tools necessary, including possibly all the three design principles for RRI in higher education.

Methods and effectiveness of environmental education in holiday camps in Portugal

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Environmental Education (EE) has gained importance over the years. Holiday camps provide informal learning while entertaining young people, often in a context of contact with nature, which is particularly favourable for EE activities. The research reported in this paper has two goals: 1) Assess the methods of EE applied in holiday camps in Portugal; 2) Evaluate the effectiveness of EE practiced in the case-study ATL do Zoo - Summer 2018, regarding the change of participants' attitudes and environmental behaviour. A methodology based on questionnaires was used. A questionnaire was developed for the summer camps, to which 42 operators answered. Another set of questionnaires was applied to the ATL do Zoo, involving 425 participants and 75 parents. The questionnaire for participants contains 25 items on environmental attitudes and behaviours and was applied at two times: before and after attending the holiday camp. The parents' questionnaire provided practical examples of changing environmental attitudes and behaviours. Results indicate that there is an effort by the organizers of holiday camps to approach environmental themes in their activities, even if the "environment" is not the focus of their programs. But the effectiveness evaluation of these activities is practically non-existent. The effectiveness evaluation realized for the ATL do Zoo allowed to conclude that EE in the context of holiday camps provides positive changes in topics such as the reduction on the use of disposable plastic, the separation of residues and the reduction on consumption of foods that have negative impact on living beings. The fact that the activities are developed in a "living classroom" brings the youngsters closer to Nature. It is hoped that the results obtained in this work will contribute the dynamism of EE activities in holiday camps and their effectiveness evaluation.

New approach in educating about innovative climate policy - a case study at the ISDRS

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Limiting global warming to 1.5°C would make it markedly easier to achieve many aspects of sustainability including poverty eradication and reducing inequalities, but with the current pledges under the Paris Agreement achieving this target seems unlikely. Meeting the 1.5C target would require transformative systemic change based on a significantly increased ambition, which can be enabled among others by a combination of innovative price and non-price policy instruments and a redirection of financial flows towards low-emission investments. However, mitigating trade-offs with other SDGs necessitates stronger coordination and disruptive innovation across scales of governance, which can also provide financial, technological and other forms of support for poor and vulnerable people. This would also imply complementing carbon pricing with sufficient transfers to compensate their unintended distributional effects. Even though current pledges and policy mixes seem inadequate in this regard, innovative policy instruments combining these requirements have been already proposed. The Energy Budget Scheme (EBS) endorsed by the Resource Cap Coalition, a European alliance of NGOs and scientists has the potential to meet many of these requirements in a holistic way. It is based on the Tradable Energy Quota (UK) and the Energy Entitlement Scheme (Hungary), which were debated (though eventually rejected) by national parliaments. The EBS is based on energy consumption entitlements allocated among all final energy consumers (citizens, public and private entities), covering high-carbon energy use, where underconsumers and overconsumers could trade through the assigned management organisation. Underconsumers would receive interest-free 'quota-money' for their unused and traded energy entitlement. The quota-money could be exchanged in a newly created secondary market for products and services with environmental and ethical certification (e.g. outstandingly energy efficient appliances, organic food produced with low-carbon energy input, solar panels, building insulation services). A Transition Fund would provide interest free loans for energy efficiency and renewable energy investments, as well as for research and innovation to pursue relevant new technologies. While the EBS is able to deliver systemic change in energy use and transform our production and consumption patterns in a socially just manner, the reluctance of decision-makers, researchers and the public even to debate quota schemes for delivering sustainability objectives is a huge impediment today. Our goal is to communicate the effectiveness and sustainability impacts of EBS and compare them with other tools aimed at CO2 emission reduction while considering broader sustainability impacts. We thus developed a software based strategy game, where the players aim to reduce the CO2 emission by 2050, while enhancing some key environmental, economic and social indicators. The game can be played in teams by 20-40 people (e.g. decision makers, researchers, policy campaigners, students or the general public), but a larger audience could be acheived through an online version. If the 2020 ISDRS in Budapest provides the opportunity, the conference participants would be invited to play and strategise for sustainability online during the three day conference. We would present the results at the end of the conference either online or in person, and would collect feedback from the players to advance effective policy scenarios and to improve the game for wider use in climate campaigns. We believe that this innovative approach would not only bring education benefits, but would also help to create a window of opportunity to debate and introduce policy innovation on systemic level.

Old teaching-learning strategies in a new scenery. Barriers and possibilities to develop student teacher's competences to implement sustainability issues into school practice

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Humanity is undergoing serious and unprecedented changes that evoke great threats and lead to raise basic questions about our common future. We live in "urgent" and "challenging" times so we need to undertake efforts to overcome unsustainable trends and disastrous effects of our pernicious practices. We face new demands which force us to deal with complex and contradictory situations. Mankind must make an effort to introduce and disseminate new concepts of functioning and recreating main dimensions of human life. The expected transition will only happen if we engage teachers to implement sustainable educational solutions to school practice of every level. Teachers seem to be the most effective force to influence thousands of students to change their life habits and accept new priorities and global goals. The transition towards sustainability needs to be total and common. Education for sustainability emerges as a core challenge of our generation. The conviction of multifaceted cooperation between schools and higher education institutions becomes more and more clear. In spite of that positive attitude towards ESD there is a strong reluctance and opposition against introducing sustainable development issues to higher education courses. Academics multiply barriers and prove that they have "more important" vocational obligations to complete, or they simply show the total ignorance towards sustainability issues. In Poland there are no formal and obligatory regulations about the amount and rate of sustainability topics to be referred to during academic courses. School education – just like higher education – do not recognize the importance of sustainable topics. In the current Polish National Curriculum one can find only some slight references and connotations to sustainability challenges. Despite such „unfriendly" and unfavourable state of educational environment I persistently try to establish problems of sustainable nature as one of my flag topics among academic courses that I am responsible for. When I give lectures and run workshops my students have to encounter sustainable challenges. I endeavour to show them that entering into the "dimensions of sustainable life" opens unrecognizable, unknown, and even unimaginable spheres of their concern and possible activities. The aim of the paper is to show actual possibilities to link the Polish National Curriculum content and contemporary promoted didactical approaches with university activities referring to student teacher academic training in terms of education for sustainability. I will present a sample of a project method application – considered as a desired in Polish compulsory school education strategy. Students who plan to become teachers should gain competences to use it in various educational situations. That's why academics should also feel obliged and introduce new issues and current problems to their work. The fusion of desired school strategy with sustainable issues seems to me a perfect match. Thanks to students' inter- and transdisciplinary individual and collective learning they managed to achieve complementary and holistic outcomes proving the integration of sustainable development, intercultural education, and artistic or scientific issues. Student teachers gained competences to implement sustainability issues into school practice. Thanks to making constant comparisons between local and global issues students experienced deep and significant development. Their understanding of sustainability in different contexts became multidimensional. Such profound student teacher education gives hope that future educators will be keen to interpret their school duties in perspective of sustainability and will spark the "greed for sustainability" among their students, parents, and colleagues.

Perceptions and attitudes about local Sustainability of young people: a case study in rural areas, Beira Baixa, Portugal

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In 2015, the adoption of the Sustainable Development Goals (SDG) defined a new agenda and supplied a holistic and multidimensional view for development. These Goals are challenges to traditional teaching methods, and important to educate for Sustainable Development (SD) and involve young people in the participative model. Young generation can contribute to promote environmental conscience, and to the change in values and attitudes towards sustainability. Bearing in mind that each player has its own "language" it is essential to promote dialogue between science and society, namely among the youth. The case study of this research takes place in the context of a special program, that aims to establish scientific publication partnerships between Secondary Education Schools (SESs) and the Higher Education Institutions (HEIs) and it refers to the Beira Baixa region. This region is predominately rural, that represents approximately 0.8% of the resident population of Portugal (around 83 thousand people), having one of the lowest rates of young people in the country (10.6%). The main goal of this work is to reflect on the perception that the youth has about SD, based on the results from a questionnaire applied to a group from the region's student population in Secondary Education. The questionnaire comprises of five parts: i) characterization of the sample; ii) SD perception, iii) SD evaluation in the municipality of residence, iv) what is important to evaluate in the region's SD, v) voluntary activities. The results allowed to verify that the large majority of the students has heard of the term SD, having school and the media been the major contributors. When asked about the evaluation of SD in the region, referring to the four dimensions, and according to a traffic light, the majority considered the environmental dimension "green", the economic and governance "yellow" and the social dimension is divided between "green" and "yellow". About 40% of the students considers that their quality of life "is the same" as in previous years. When asked about what is important to evaluate in their region's SD and, specifically which of the SDG are more important to their region, the main ones are: Good Health and Well-Being (SDG 3) and Quality Education (SDG 4). Most of them considers that the process for selecting indicators should have their opinion in mind. This project intends to improve the level of knowledge about SD (knowledge acquisition, skills and attitudes), mostly among young people, so that their future decisions are informed and efficient and promote a commitment towards a sustainable future. There is a continuous need, urgent and vital, to create and develop innovative tools to educate the young people on sustainability that allow for the improvement of their knowledge, their skills and their attitudes about SD and the SDG. This work demonstrates that the SESs, connected to the HEIs, can play a vital role in awareness about SD and, specifically about the SDG, so that SD can be reached from the local to the global levels, in order to contribute towards social change and a more sustainable future.

Research-based learning by means of SCRUM and sustainability evaluation – a good mixture?

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Two main requirements impact on current learning scenarios: the requirements for key competences for lifelong learning and learning for sustainability. The development of key competencies for lifelong learning, such as knowledge, skills and capabilities, include progressing national strategies and infrastructures enduringly (The Recommendation 2006/962/EC of the European Parliament and of the Council of 18 December 2006). The UNESCO recommends learning objectives in the area of Education for Sustainable Development Goals in the overall agenda 2030. "Education can, and must, contribute to a new vision of sustainable global development." (UNESCO, 2015) Beside cross-cutting key competencies for achieving all SDGs, e.g. systems thinking, anticipatory, normative, strategic, collaboration, critical thinking, self-awareness, and integrated problem-solving competency, all 17 SDGs are accompanied by particular sustainability learning goals.

Thus, clear competencies are given for the application of contemporary teaching methods and appropriate methodological settings. E.g. the integrated problem-solving competency need vital learning frameworks, such as learning through discovery, experience, research, play, practical doing and other forms of experiential learning – in line with the collaborative learning theories promoting social interaction. Thus, a cross-university, inter- and transdisciplinary module was designed and practiced integrating students from business management, business engineering and real estate and facility management. The respective teaching module include specialist knowledge, methodological skills for solving sustainability problems, among other things through digitised input. Then, practical projects are initiated, in which students develop their own ideas for a sustainability vision, design them interactively and finally evaluate them in an interdisciplinary manner. Focussing on the topic 'sustainable cities', the integrated stakeholders, like practitioners, urban planners, city councils or representative of the Agenda 21 process, can effectively contribute and network their technical and methodological skills and learn from each other. The agile method SCRUM supports this process and invites in a creative way to change perspectives and gain knowledge. SCRUM defines as agile design thinking method the type of cooperation for interdisciplinary teams. The space for creativity, created by openness, promotes innovation, a constructive culture and at the same time accelerates the creation of results. In detail, we followed the research-based learning according to Healey and Jenkins (2009).

In order to capture the usefulness of the above described learning design we applied a written survey and an oral interview study. In December 2019, we distributed the survey, containing 38 questions in total concerning the approach, the learning settings, the learning materials, learning processes and learning contexts, project work and competencies, to the students within an interim presentation and conducted interviews with selected group members of the 50 participating students. The preliminary results show that SCRUM is on the one side a very useful and structuring tool, but on the other hand not really appropriate for complex and networked contexts. The sprint phases supported the students to structure their work, but put them into trouble evaluating sustainability topics rapidly at the same time. Evaluating sustainability was not that easy as expected according to the students. Moreover, the ongoing feedback from the stakeholders was helpful and supported the overall process; however, sometimes the creativity was limited by the practical advice coming from the stakeholders. Having the sprint phases in mind, learning from errors was not easy possible. In total, SCRUM can help to focus on a thread when dealing with complex situations, but limits the development of sustainability competencies in total.

Sustainability teaching in Higher education institutions: gaps between practices, ideal competencies and pedagogical approaches

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Higher Education Institutions (HEIs) play a critical role in the transformative shift of values and actions across all society members and have ethical and moral responsibilities to increase awareness, knowledge, skills, and values in the target community. Given the importance of HEIs and considering the increasing number of students, teaching staff as well as administrative and management staff, it becomes more fundamental to ensure that sustainability is not only taught but also practiced within universities. Therefore, sustainability values need to be incorporated in all HEIs' missions and practices. However, a holistic understanding of how to incorporate sustainability-related initiatives into HEIs in an integrated way is still a critical challenge in HEIs teaching and learning plans. This was the fundamental reason for building a strategic partnership across four European universities and an international Non-Governmental Organization (NGO) to set up an ERASMUS+ EUSTEPs project - Enhancing Universities' Sustainability Teaching and Practices through Ecological Footprint – in order to undertake both theoretical and practical activities to develop a new generation of sustainable citizens. With the inclusion of the Ecological Footprint concept and tools in educational models it aims to educate students and the wider university community on the sustainability implications of personal behaviors. As a great number of scientific papers has been published since 2000 with a focus on education, including curricula, pedagogies, competences, and educating the educators for sustainability, this paper aims to analyze and summarize this literature focusing on: the emerging trend themes and patterns of research, teaching and curricula in the area of sustainability worldwide and the sustainability competencies needed and pedagogical approaches used within HEIs education and teaching for sustainability. Relevant examples of Footprint teaching methods applied in HEIs and other schools will be also reviewed to determine which type of tools are employed, their outcomes and key challenges. Based on this, a new students' sustainability teaching module produced by EUSTEPs team will be disclosed by analyzing its main teaching and learning activities, the applied educational materials and the expected outcomes based on each thematic areas. Then the results of testing the proposed module in multiple courses for one semester in the four HEIs involved in the project will be analysed and discussed. The gaps in current teaching given by the literature review, the analyzed Ecological Footprint practices and the testing of the EUSTEPs teaching module will then be discussed to inform EUSTEPs project and to understand how the new learning tool can contribute to the developing of ideal competencies and pedagogical approaches towards sustainability and the fostering of collaboration between HEIs. The results of the research will also contribute to shaping a new generation of sustainability-conscious citizens and professionals who will be trained to assess and analyze impact drivers with the use of dedicated tools and to enhance new professional expertise in the society and in the future labor market.

Teaching for sustainable development and sustainable learning. Experiences from a transdisciplinary development of the international master programme Leadership for Sustainable Development.

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Almost two years ago, we, a small team of researchers and teachers interested in the topic of sustainability stemming from different disciplines in the social sciences, invited neighbouring municipalities, a variety of enterprises and civil society organization to become partners in the development of a new international master programme named Leadership for Sustainable Development based in the School of Social Sciences. The invitation said that we "through our collaboration we want to create courses in sustainable development that not only align with demands of the labour market, but also contributes to a pro-active transformation of the same". Through workshops and numerous discussions, curriculum was formed, information spread, literature was chosen, applications administered, and then the first cohort of students were introduced. Partners, teachers and students in this venture all agree on the importance of sustainable development and the so called Brundtland definition from 1987, "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Raworth's doughnut model, illustrated a space where we could elaborate on 'our' social science perspectives of sustainability. But what do we mean with sustainable development? As work proceeded, it turned out that it was far from obvious-in spite of agreements on vocabulary. The aim of this paper is to contribute to the development of the understanding of sustainable development including first of all different social science perspectives. The paper is based on almost two years collaborative development of a master programme with a focus on social science's perspectives. It includes, among other things, different perspectives on social status of the world and social relations as well as specific aspects such as the role of culture and politics. The development of programme also highlights issues related to pedagogical aspects such *learning for sustainability* and even *sustainable learning*. Firstly, the transdisciplinary approach to the development process of the programme, resulted in adjusted learning outcomes in curricula, teaching and presentation techniques. The transdisciplinary approach also contributed to problematize learning, and more specifically the strive towards learning processes that in itself can be considered sustainable learning. This includes promotion of active student driven learning combined with interaction between students with different disciplinary backgrounds and experiences, as well as interaction with partners. The pedagogical approach also integrates traditional academic literature and writing exercises, field work, and action-oriented ideation and innovation tasks. This forward-looking action-oriented approach is saturated by critical reflections and a strive to promote ongoing life-long learning for a long-term transformation towards a more sustainable development. The paper is based on the ideas behind, preparations and experiences from the first year with an international and disciplinary diverse student group.

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The urban transition curriculum: Preliminary outcomes from a collaborative learning workshop with international inter- and transdisciplinary sustainability practitioners and educators

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Inter- and transdisciplinarity have gained increasing importance in sustainability discourses. They request to rethink educational and research approaches, as well as pedagogies and the forms and ways of collaboration, in order to move from "silo" thinking and separately addressing diverse sustainability challenges to a more holistic understanding that would also help to fulfill the agenda of the Sustainable Development Goals (SDGs). Educational challenges are closely intertwined with (urban) sustainability challenges like energy, transport, water, waste, local economy, social inclusion, to name a few, but there are still several gaps on how to address these challenges more systemically and on how to integrate inter- and transdisciplinary methods, tools and practices into education and research. To address these gaps, an action research approach was followed. A two-days collaborative learning workshop with 30 international educational experts and practitioners was organized in order to explore the participants' experience in different sustainability learning approaches and to develop jointly ideas for an urban transition curriculum. Building on the concept of the four-dimensional education (knowledge, skills, character and meta-learning) for the 21st century learner of Fadel et al. (2015, 2019) and the transformative understanding of education for sustainable development (ESD), the workshop was designed as a learning journey, with individual and group exercises around reflective writing, using among others elements from Theory U (Scharmer, 2008), coaching and embodiment practices. The workshop was co-designed by members of an European Horizon 2020, named SHAPE ID project, and a research platform called Transdisciplinarity for Urban Sustainability Transition (TRUST) from Politecnico Turin, Italy, in February 2020. For the analysis of the workshop, the authors follow a mixed-methods approach combining concrete results from the exercises with participatory observation, post-workshop assessment and meta-evaluation. The findings are two-fold: first, they include reflections on current discussions about sustainability competencies and related pedagogical approaches, practical examples for overcoming institutional barriers against inter-and transdisciplinarity and a prototype of a toolbox for the urban transition curriculum. Second, the research format itself is scrutinized in its applicability and effectiveness. Using the collaborative format of an extended learning workshop with the necessary setting for focus, reflection and balance between intellectual and embodied knowledge can be regarded not only as a powerful research method, but also as a transformative learning experience for all parties involved.

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„I am committed to making my home better so I am planning a sustainable future.” Students, education, designcommunication and the sustainable result of an action research.

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Sustainability is at the heart of communication. In addition to the school's communication and activation activities, elementary school students are also exposed to the concept and significance of sustainability from parents and the media. Thus, it is not negligible that background information and facts related to the topic determine their thinking. An important research question is how and in what amount of time this type of thought is transformed into action, whether in a participatory or an initiating role. In our study, we analyze why sustainability as a central topic is most prominent in an unusual innovative situation we generate. Nevertheless, we are looking for an answer to how this positive outcome can be deepened and influenced at the level of attitudes, transforming thoughts into action within the educational framework, using the methodology of design communication.

In the course of our action research, we present the results of a self-developed series of workshops in all Hungarian counties involving sixth grade primary school pupils and their classmates. As part of the action learning process, students set out to make their homes better by using design communication, a method based on creative interaction. As part of the workshop, we built on the tools of wikinomic cooperation, so the whole class needed to think together to develop the workshop and produce the result. Together, with the full agreement of all participants, the design process was carried out with the task of undertaking the task of improving their home. Without defining milestones, guidelines, expected results. The reflections written by the children at the end of the workshop are an important part of the qualitative research concept, and the results of the content analysis of the reflections are also one of the important outputs of the study.

As a result of the research, it was noticeable that almost all classes identified the concept of home with the environment Almost without exception, home improvement was seen as showing a conscious attitude towards their environment and encouraging others to do so with their project. During the presentation the most important results will be presented. The main objective of the study is to present the projects created during the 21 workshops that focused on sustainability, and to explore the links between the products produced and the reflections. Building on these results, this article proposes a theme and structure for a built-in, education-integrated designcommunication workshop. A further goal is the conscious integration of sustainability into education through the focus on design communication methodology.

Biodiversity And Ecosystem Services

Assessment of organic matter as indicator of soil formation in a Mediterranean subwatershed with intensive agricultural land uses

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Agroecosystems occupy 40% of the global terrestrial surface. Transformation of natural ecosystems into agroecosystems is leading to major environmental degradation and loss of ecosystem services (ES). Assessment of ES supply is a useful tool in order to make effective decisions in the management of agroecosystems. Soil formation is an essential support ES for agricultural and natural systems, however it is not usually evaluated. In this study, we estimated the provision of soil formation service in a Mediterranean agricultural subwatershed located in the River Flumen watershed (Aragon, NE Spain), using its organic matter content (OM) analysed by the loss on ignition method as an indicator. We measured the OM at 0-5 cm and 5-10 cm of depth. We compared the ES supply in 10 different land-use types (riparian forest, conifer forest, restored riparian forest, olive grove, corn grove, steppe scrubland, alfalfa crop, barley crop, rice crop, abandoned crop) at patch and subwatershed scale, and in four scenarios of land use change and restoration (restoration scenario, agricultural scenario, light agro-ecological restoration, intensive agro-ecological restoration.). We checked significant different between OM content in land uses by an ANOVA (α=0.05) followed by multiple pairwise comparisons using Tukey's Honestly Significant Difference (HSD), using the statistical software R. We used ArcGIS to estimate the area of each land-use, and re-estimated the new soil formation supply at subwatershed scale in the four scenarios. The results show that the average value of OM of the two soil layers is better indicator of the ES than each one alone. At patch scale, natural and semi-natural land uses, with the exception of scrubland, supplied more soil formation than agricultural land uses. At subwatershed scale, this supply depends mainly on the surface occupied by each land use in the territory. Between different alternatives (from agricultural intensification until naturalization through restoration of degraded ecosystems), the restoration scenario (restoration of riparian forests and abandoned crops as their potential natural ecosystems, conifer forest and steppe scrubland) would provide more soil formation at watershed scale. The agricultural scenario (transformation of abandoned crops into alfalfa crops) provides less than any other scenario. The other two scenarios offer intermediate values, being a little greater the intensive agro-ecological restoration (3.59) than the light agro-ecological restoration. In any case, low differences were observed between the four scenarios but indicative enough of the potential management of land uses to orientate changes in the provision of ecosystem services at watershed scale. It is strongly recommended to incorporate the restoration of degraded ecosystems as a tool for soil enrichment and the sustainability of intensively used agricultural territories.

Business for Ocean Sustainability

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Growing scientific evidence shows that the health of seas and oceans is strongly at risk and that marine ecosystems are already subject to extreme stress due to over-exploitation of natural resources, biodiversity loss, acidification and pollution. This is a serious and complex problem, since the conservation of the ocean is fundamental for our health and well-being. We present a research work that opens up a new perspective on the relation between ocean's sustainability and the economy with a novel focus on business organizations. In this work, we extended the traditional boundaries of analysis to include not only the direct, but also the indirect pressures coming from business on marine and coastal ecosystems with the main objective of evaluating what companies are doing to address these challenges. The analysis was carried out using the Driver-Pressure-State-Welfare-Response (DPSWR) environmental accountable framework with the aim also to introduce a common social-ecological language that allow mutual interconnectedness to work on aspirational objectives and targets for ocean's health. The focus of this research has been concentrated in the Mediterranean region; with estimated annual revenues of €386 billion, €205 billion of Gross Value Added, and 4.8 million jobs, preserving the health of its marine and coastal ecosystems is paramount for the region. This study was based on primary and secondary data and information, collected, analyzed and elaborated through qualitative and quantitative research methods. An extensive compilation of existing information was carried out. 47 companies and organizations went through qualitative interviews and 133 valid questionnaires were obtained and assessed through on-line surveys to analyze business organizations' awareness, strategies and innovative practices.

Direct and indirect ocean pressures of twenty industrial sector activities were analyzed in connection to the 11 Good Environmental Status (GES) descriptors defined by the EU Marine Strategy Framework Directive through a scientific review involving a panel of 34 scientific experts. The Environmental Governance of the Mediterranean Sea under an Ecosystem Approach strategy and the Mediterranean Action Plan architecture responds to the central objective to achieve GES for its waters and ecosystems. State descriptors were linked to human benefits in a welfare evaluation by applying a hierarchical classification on coastal and marine ecosystem services. Finally, these ecosystem services were related to business responses dealing with present social-ecological challenges.

The possibility of changing the course, preventing or at least mitigating the pressures on marine and coastal ecosystems is real, and business is expected to play a fundamental role in the transition to an economy where ocean and non-ocean-based activities operate in balance with the long-term capacity of the marine environment to regenerate, safeguarding the potential for uses and activities by current and future generations.

Socio-cultural valuation of whale ecosystem services in Skjálfandi Bay, Iceland

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Economic valuation of ecosystem services (ES) carries a potential for informing policy by making economic ES values are visible. However, monetary ES valuation does not capture the full extent of ES contribution to human wellbeing or the multiple values assigned to nature by people. To account for these values, an increasing number of ES researchers have suggested applying a pluralistic approach to ES valuation, in which monetary approaches have dominated while socio-cultural perspectives and values have often been overlooked. A range of quantitative and qualitative methods are available for assessing socio-cultural ES values, and they are constantly being developed and refined. Humans source multiple benefits from marine mammals, including food, tourism, ecosystem regulation, aesthetic enjoyment, and artistic inspiration. Despite this fact, ES of marine mammals have been lightly explored in academic literature and in the context of the Arctic, including Iceland. The uses of the ocean and whale resources in Iceland are rapidly changing with the decline of commercial whaling and rapid increase in whale watching tourism in tandem with the growing Icelandic tourism sector, requiring communities to adapt quickly and change their economic activities and, at times, cultural identities accordingly. This study presents the first attempt to apply socio-cultural valuation in the context of marine ES in Iceland, presenting an opportunity to explore multiple values assigned by a coastal community of Húsavík to whale resources and complement the biophysical and economic data on the role of cetaceans in Iceland's marine environment and economy. The main purpose of this study is to assess the values of ES provided by whales in Skjálfandi Bay, Iceland from a socio-cultural perspective. To do this, a multi-method approach is applied that allows to account for multiple value domains, avoids the pitfalls of monetary valuation, and integrates both qualitative and quantitative information. The main aims of the study are: (i) to identify ES provided by whales in Skjálfandi Bay, different place-based values that people assign to them and how they have changed over time; (ii) to identify the most important whale ES from a socio-cultural perspective and assess their relative importance using a preference scale survey; (iii) to map out the current management practices and needs related to whale ES in the area. A multi-method approach is applied in this socio-cultural analysis of whale ES in Skjálfandi Bay consisting of stakeholder mapping, non-participant observations, semi-structured interviews, socio-cultural preference surveys, and qualitative (grounded theory) and quantitative (statistical) analysis of interview and survey data. The paper begins to address the research gap in non-monetary values associated with marine ES. This socio-cultural valuation study elicits the values and perceptions related to whale ES in a community-based context. The multi-method non-monetary approach to ES valuation allows the study subjects to express their perceptions and opinions in their own words, without necessarily labeling them as 'ecosystem services' or putting a monetary value on them. The results of the study have the potential to inform marine resource management in Iceland, including less tangible but nonetheless important socio-cultural values associated with whale resources.

Structural and functional aspects of green infrastructure components in urban zones and their contributions to city sustainability

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Urban green infrastructure is made of a number of different components with a variety of structural and functional characteristics. Based on structural features a number of systems are ussualy quoted as green infrastructure: parks, public gardens, recreational areas, sport facilities, domestic gardens, city farms, playgrounds, recreational pathways, green roads, vegetated roofs, street trees. From a functional perspective, green infrastructue systems may contribute to mitigate climate change, buffer meteorological extrems, regulate water flows and soil erosion, nutrient cycling, and waste impacts, contribute to biodiversity conservation and also to cultural aspects. However, in order to contribute to city's sustainability, green infrastructure components should contribute to social, environmental and economic benefits for the human population, it is for the whole city as a socio-ecological system. Considering these three fundamental aspects of sustainable development is a way for evaluating the relative contribution of green infrastructure components to city sustainability. An indirect relationship is observed between natural degree of the components and its contribution to social benefits, while a direct relationship is observed with environmental benefits. The economic relevance of different green infrastructure components could be evaluate in relative terms. A sound economic analysis requires using a combination of techniques. In general, more complex and natural components contribute different types of economic benefits. The number of benefits decreases as the complexity and the naturalness of the green infrastructure component is reduced. This approach is illustrated with the example of the green infrastructure of Zaragoza city (Aragon, Spain). Different degrees of naturalness are observed in a number of urban reaches of the three rivers crossing the city, as well as in seminatural forested areas and urban parks. Major trade-offs between social and environmental benefits provided by these types of green infrastructure are observed based on their recreational use by the people and the restrictions to provide environmental functions after creating facilities for recreation. Improving the green infrastructure of cities as Zaragoza should include recovering naturalness of sites as riparian zones, establishing a network of seminatural parks and incorporating constructing techniques as vegetated roofs and street trees. This approach would contribute to the sustainable development of cities.

Two Challenges in Valuing Biodiversity & Ecosystem Services: Type of service and the mismatch of physical, social, environmental and economic space

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1. A Type-of-Service Challenge

The dominant purpose of pursuing monetary valuation of ecosystem services (ESS) is using it as an interpersonal, i.e. non-subjective aggregate value metric for ESS of different kinds and in different places. However, this is an ambitious endeavour as different services are not independent (so their values could be added up) can be co-produced by different objects, causing value attribution problems, generated by the same objects, and can be more or less overlapping. Taking the human dimension into account, ESS are co-produced by humans and nature, and valued differently by different people, in particular dependent on local cultures and social status (income, prestige, profession, etc.). In any case it is not trivial to distinguish nature's contribution to humankind from the human contributions in the processes of use value attribution, ecosystem service potential (ESP) mobilisation, ESS appropriation and often ESS commercialisation.

Furthermore, usually ESS are not useful as such (hence the suggestion of IPBES to replace ESS by the term of Nature's Contributions to People NCP), but even the improved semantics does not make explicit that human interventions create both services and disservices. Trees grow fruit and bushes berries not for the benefit of humans, but for their reproduction. The water purification ESS of a wetland only exists as long as there is polluted water to be purified – before pollution, there was no service, and after building a waste water treatment plant, the value of the ESS drastically declines. Bugs, spiders, insects and their parasitoids are part of natural regulation mechanisms, but only once humans start agriculture, plant hoppers and aphids become pests (ecosystem disservices) and some beetles, bugs and the parasitoids become natural pest control agents, and thus ecosystem services. Similarly, the pollination services of wild bees, bumble bees, bats and birds only exist when humans make use of the plants pollinated.

An ESS is the result of human intervention into natural processes, with effects throughout the food web. These effects are judged by humans according to the effect they have on them, which is different by different groups affected directly or indirectly. Thus the hope for *objective* value attribution is bound to fail, and interpersonal values will only be achieved by people in similar situations. Usually this homogeneity of valuers for comparable values will imply proximity.

2. Spaces (physical, environmental, social and political)

Obviously space has a role to play, but which space? The physical space measures either distances or describes landscapes, while the environmental space either describes consumption volumes or biomes. The latter can coincide with landscapes, but not necessarily so. The social space is defined by social connectivity which can both reach across the borders of physical and/or environmental space (tourism, internet, including their social and environmental impacts). It may be globalising, but follows different patterns than the economic space shaped by supply chains and (container) transport routes. The management of all these spaces is regulated politically, but the political space is rather fragmented as compared to the economic one, and is (at best) effective within borders which are not aligned with the environmental, economic and increasingly the social space.

As all these spatial patterns influence the importance of a certain ESS, also the hope for a unifying metric to compare different services in different places appears ignorant of real world circumstances.

Valuing the recreational services provided by Hungary's forest ecosystems

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Estimating the monetary value of ecosystem services can provide valuable input for policymaking and decisions regarding the management of natural areas. For some ecosystems, such as forests, the potential for recreation represents an important part of the ecosystem services they provide. The aim of this paper is to assess the economic value of recreation as an ecosystem service enjoyed by hikers in Hungary's forests. As such, this is the first study on the monetary value of recreation as an ecosystem service in Hungary. Within the recreational use of forests, hiking is the most significant activity in terms of the number of participants and was therefore selected as the focus of the valuation exercise. The assessment is carried out in the framework of a national undertaking to map and assess the state of ecosystems and their services in Hungary, as called for by the EU's biodiversity strategy (Mapping and Assessment of Ecosystems and their Services - MAES). We combine several approaches to estimate the recreational value of hiking in Hungary's forests. First, we conduct a local case study for the Pilis area, which is a low forested mountain range not far from Budapest and one of the country's most popular destination for hikers. Here a survey was carried out in 2017 that elicited information about visitors' activities, approximate time spent, and distance travelled, which provides a suitable basis for calculating a monetary estimate via the travel cost method. As nationwide data on such recreational visits is not available, the other approach is to derive estimates from foreign studies. After reviewing the literature, we identify several studies (based on the travel cost method as well as contingent valuation) that can be suitable for benefit transfer and apply them to estimate an annual value of the recreation service for all of Hungary's forests. The results from the above approaches are then combined to provide a best estimate of the recreational value that can assist policymakers regarding future decisions on the protection and management of Hungary's forests. Comparing the results obtained via the different methods also allows us to draw conclusions regarding the applicability of benefit transfer across different countries in case of recreational ecosystem services.

Predictions And Responses (To Climate Change)

A New Approach to Measuring Climate Change Impacts and Adaptation

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This study develops a new approach to measuring climate impacts and adaptation. Earlier work that estimates the impact of climate change on economic outcomes (e.g. Mendelsohn, Nordhaus, and Shaw, 1994; Schlenker, Hanemann, and Fisher, 2005) has relied on the permanent, anticipated components behind meteorological conditions, but faces serious omitted variable bias. The more recent panel fixed-effects approach (e.g. Deschenes and Greenstone, 2007; Schlenker and Roberts, 2009) exploits the transitory, unanticipated weather shocks, and deals with the bias, but identification of climate effects using weather variation is not trivial (Hsiang, 2016). Our unifying approach addresses those key challenges of the literature, provides a measure of adaptation by comparing short- and long-run effects (Dell, Jones, and Olken, 2009, 2012, 2014; Burke and Emerick, 2016), and, because these effects are creatively estimated in the same regression model, tests whether the magnitude of adaptation is statistically significant at conventional levels. A key element of our approach is the decomposition of meteorological variables into two components: long-run trends and weather shocks, the latter defined as deviations from those trends. Taking advantage of high-frequency data, we decompose temperature (and precipitation) into a monthly moving average incorporating information from the past three decades, often referred to as climate normal, and a deviation from that lagged 30-year average.

We apply our novel approach to study the impact of climate change on ambient "bad" ozone in U.S. counties over the period 1980-2013. We have four main findings. First, a changing climate appears to be affecting ground-level ozone concentrations in two ways. A 1°C shock in temperature increases ozone levels by 1.7 parts per billion (ppb) on average, which is expectedly what would have been found in the standard fixed-effect approach. A change of similar magnitude in the 30-year moving average increases ozone concentration by 1.2ppb, which is 14 percent higher than what would have been found in the standard cross-section approach. Second, we find evidence of adaptive behavior. For a 1°C change in temperature, our measure of adaptation in terms of ozone concentration is 0.45ppb. When we compare our estimate of adaptation to the direct effect of the CAAA "non-attainment" designations, it is equivalent to over one third of that effect. Also, if adaptive responses were not considered in the measurement of the impact of climate change, then the climate penalty on ozone would be overestimated by approximately 17 percent. Third, adaptation in counties with levels of ozone above the EPA's standards is estimated to be over 66 percent larger than baseline adaptation in "attainment" counties, and is equivalent to about 45 percent of the direct effect of the CAAA "non-attainment" designations. Indeed, counties out of attainment must reduce ozone concentration by making costly adjustments in their production processes (Greenstone, List, and Syverson, 2012). For those counties, regulation-induced adaptation represents 40 percent of the total adaptation. Lastly, we have found a higher degree of adaptation in the 1980s relative to the following decades, but a similar magnitude for the estimates of adaptation in the 1990s and 2000s. This suggests that adaptation opportunities in the context of ground-level ozone might be shrinking or becoming more costly.

Exploring the energy-carbon-water nexus of construction activities: a comparative analysis of developed and developing countries

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Given current and projected trends of urbanisation and population growth, impacts linked to global construction activities will likely continue to increase, and possibly at a faster rate, in the coming decades. However, the Global Environment Outlook already warns that the world is not on track to achieve the Sustainable Development Goals (SDGs) or deliver long-term sustainability; this further exacerbates the environmental pressure that additional construction will cause globally.

Previous studies on the environmental impacts of construction have chiefly focussed on material flows, energy demand as well as greenhouse gas (GHG) emissions. Little is known, however, about the water consumption of construction activities at national levels and how these relate to energy demand and GHG emissions. This paper therefore aims to investigate the nexus between these three environmental impacts and establish how these are interlinked to the diverse contexts of developed and developing countries.

We adopt environmentally-extended multi-regional input-output (EEMRIO) to compile a global ad-hoc database for the footprint analysis. Our EEMRIO database includes each of the EU27 countries, Russia, China, India, USA, Canada, Australia, South Africa, and an additional entity which acts as a proxy for the Rest of the World (RoW). Due to inconsistencies and inaccuracies in some national data of the global database that we used as a starting point (Eora) we have replaced these with context-specific data from national statistics, Eurostat, or reports from international bodies (e.g. World Bank, World Trade Organization, Organisation for Economic Co-operation and Development).

The focus of our analysis is on five counties which allows pair-wise comparisons by normalising results either per capita (i.e. similar national population) or per monetary unit (i.e. similar GDP), specifically: the UK, Italy, India, China and South Africa. Our results show that neither energy nor GHG emissions can univocally act as a good enough proxy for water footprint, thus requiring this latter to be routinely added to the basic environmental indicators used in impact assessment of construction activities. Results also show that despite developing countries are often associated to less-efficient supply chains, they show lower normalised impacts than developing countries as far as construction activities are concerned. We further investigated the supply chains behind each national construction sector, which revealed where the largest hotspots are as well as the similarities and differences between national contexts.

The findings from this paper shed light on an additional important impact category for construction—the water footprint—and how it relates to energy demand and GHG emissions. Given the projected growth of global construction our research can inform action and policy to avoid exacerbating the already pressing issue of water scarcity. Our findings can be of practical use to national professional bodies, governments and policy-makers to mitigate environmental impacts of construction in developed and developing countries. Further research can extend the analysis to different contexts and also refine the results by improving the quality of underpinning data.

Measuring energy poverty in Hungary: a Logit model

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Energy poverty is a complex phenomenon affecting numerous households in Europe. The problem roots in reduced welfare of households in several different but interrelated ways: besides financial difficulties, health and environmental problems, mental strains or social exclusion may also arise. The number of research and policy programs aimed at understanding, defining, monitoring, and mitigating energy poverty has increased significantly in recent years. As a result of these efforts, the European Union has made this problem a priority in its new energy policy regulatory package. Despite the aspirations, nowadays, only a few member states have an official, nationally accepted definition and a comprehensive monitoring framework of energy poverty. The purpose of our research is to understand the driving factors of energy poverty in Hungary. Previous work has typically examined the country's households with a qualitative methodology and focused on the impacts of building's performance on energy poverty. The primary aim of our research is to provide quantifiable results on the effects of a broader set of variables. We conduct an econometric analysis on a large-scale representative survey (*Household budget and living conditions survey*by the Hungarian Central Statistical Office) to identify the most critical causes of energy poverty in Hungary. Based on the literature assessing energy poverty in Eastern Europe and our preliminary data analysis, we assume significant regional differences in the characteristics of exposed households. First of all, we conduct a qualitative analysis to identify the potential key variables and to draw up a map of interactions between them concerning different types of energy poverty. In the second step, we apply rigorous empirical analysis to test the hypothetical assumptions coming from the qualitative analysis. By applying a multidimensional logistic regression approach, the significance of each factor's effect and also regional differences in these effects tested. The preliminary examinations showed that energy-poor households are most likely single-family houses, while the geographical location of the buildings is also significant. People who exposed to energy poverty also tend to behave lower income and be less educated. Also, they are most likely to use wood, coal, oil products, or even waste to heat their homes. Based on our first analytical findings, we made a few policy recommendations. First of all, a unified definition is essential, at least on a national level, to identify the involved households to measure and reduce the rate of energy poverty. After the identification of the energy-poor households, regionally specified targeted actions required, which reach the right target group and aim one of the aspects of energy poverty. The leading causes of energy poverty are poor energy efficiency and financial difficulties due to low income. These attributes should include the strategic framework of national and sub-national level energy and climate policies.

Strategy for a sustainable decarbonization of the energy sector in Portugal: economic and environmental implications

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In line with the international efforts to mitigate climate change, Portugal has committed to achieve carbon neutrality in 2050. The energy sector has to overcome serious constraints: despite notable progress in areas like wind and solar power, there is a high dependence on fossil fuels; energy intensity is above European average, improving very slowly mainly due to technological renewal. Energy policy in Portugal has focused on supply, lacking ambition and effectiveness in promoting energy efficiency. Energy market distortions amount to 3900 M€/year, half of which correspond to environmentally harmful incentives (e.g. tax rebates for fossil fuels, subsidies to large dams and to private cars). Energy savings potential amounts to 20% to 30% of current consumption in all sectors. Such measures are not being put to practice because families and small business do not have the expertise or the financial capacity to perform the necessary investments. The recently approved National Energy and Climate Plan for the horizon 2030 (PNEC 2030) has interesting targets for decarbonization but mediocre targets for energy efficiency, and no effective means to reach either. The goal of this research is to develop policy measures to ensure the energy transition to a more sustainable model. Previous work identified energy efficiency, decentralized renewable energy and tax reform as critical focal points for action. Shifting to carbon-neutral energy system will entail high economic costs and risk adverse social effects. It will also put a rising pressure on natural resources, particularly minerals and metals, linked to the shift to electricity. The proposals developed have three major pillars: (i) the replacement of carbon-blind fuel taxes by a universal carbon tax (beginning at 120 €/t CO_2 and increasing to 190 €/t CO_2 by 2030), while eliminating harmful subsidies; (ii) the substantial upgrade of incentives to energy efficiency and decentralized renewable energy, especially residential and service buildings, industry, and public transportation, decreasing energy intensity by 2% per year; and (iii) a strict tax neutrality, where all proceedings of the carbon tax are used to either finance energy efficiency and renewables, or to decrease the burden on income tax and other taxes, for families and companies (to offset potential adverse social effects). The amount rearranged in relation to the previous tax system (maintaining tax neutrality) is about 1200 M€/year. The overall macro-economic and environmental effects were examined with a previously developed dynamic general equilibrium model of the Portuguese economy. Results indicate that the proposed approach (carbon tax + ambitious energy efficiency policy + tax revenue recycling) will result in the following effects in 2030, relative to the baseline: an increase of 2.4% in GDP; an increase of 1.4% in employment; an increase of 1.8% in welfare (improvement of revenue for lower income groups); and a decrease of 35% in CO_2emissions. The proposed energy measures alone, representing a public investment of only 600 M€/year, would create savings of 14% of total final energy demand and an improvement of energy intensity by 11% by 2030 (not including changes in transportation, land use and indirect economic effects). Work in progress includes examining more effects by economic sector and on other environmental indicators (land use, resource consumption, other pollutant emissions). In conclusion, our research indicates that, with this approach, it is possible to achieve a more just energy transition, with decreasing environmental impact and a positive macro-economic performance.

The sustainable use of bioenergy to achieve energy transition and decarbonization of the energy system

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The challenges of climate change involve rethinking the world's energy system and a more responsible exploitation of resources. One option increasingly invoked in integrated assessment models to reach ambitious decarbonization targets is carbon capture and storage (CCS), particularly when associated with bioenergy (BECCS) due to the negative emission the latter allow. Greater use of bioenergy is considered a possible track but little is known about the global potential of emerging and future negative emissions technologies, nor about the sustainability and cost of large-scale deployment needed to meet "safe" climate stabilization targets. However, avoiding the required gigatonnes of CO_2 emissions by investing in BECCS technologies requires a significant use of biomass resources whose potential level is critical for the sector's plausible and sustainable development strategies. In this context, this analysis aims to highligh the influence of biomass resource potentials, combined with carbon storage potentials, on the long-term development of BECCS technologies. It is conducted with the optimization model TIAM-FR, a bottom-up, long-term, multiregional model, minimizing the total discounted cost of the world energy system with the objective of satisfying energy service demands under resources, technological and/or environmental constraints. TIAM-FR integrates several (BE)CCS technologies and the biomass potential assessment is based on a methodology considering climate change impact on crop yield, food competition, etc. We investigated various scenarios featuring different levels of potential and different climate targets. Regarding the first results in the electricity sector, these alternative potentials significantly impact the development of BECCS to different extents. The lower the carbon storage potential, the higher the share of BECCS in CCS development. This can be explained by the fact that BECCS is privileged as a solution due to its negative emissions, in order to meet drastic climate constraint. In the lowest case of biomass potential, the CCS development decreases but the share of BECCS increases. Biomass potential has a more significant impact on the development of both CCS and BECCS than carbone storage potential. In case of lower biomass potential, (BE)CCS technologies represent between 27% and 15% of power generation against between 45% and 33% for the highest level of biomass resources. It is interesting to note that a lower biomass potential leads to less investment in BECCS but this is not offset by an increase in CCS (fossil-based). These technologies appear less competitive compared to other solutions. The effect of carbon storage and biomass resource potentials on the development of BECCS appear similar in other sectors of the energy system. The following results will put regional differences and bioenergy exchanges into perspective. The feasibility of significant mitigation actions by investing in BECCS technologies is still debatable and will strongly depend on how biomass resources are developed. Regarding carbon storage potential, it seems to be sufficient to satisfy the climate constraint by developing (BE)CCS technologies, which is not the case for biomass potential for which the challenge is therefore to maintain a beneficial balance in fine. The benefits of BECCS negative emissions are only effective in the case of sustainable use of biomass. The more sustainable and conservative the constraints, the more limited the biomass resource potential; and so the potential of BECCS.

Affordable And Clean Energy

Assessment of Carbon-neutrality Efforts of Zalaegerszeg Automotive Proving Ground

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The aim of this paper is to provide a systematic analysis of greenhouse gas (GHG) emissions and offsetting opportunities of a special state investment, the automotive proving ground ZalaZone in Zalaegerszeg, Hungary. The analysis is relevant and useful for multiple reasons. The automotive sector is a significant contributor to GHG-emissions, therefore the scientifically based assessment of decarbonization options is highly needed. The facility's main profile is related to research, development and innovation, which are essential in targeting sustainability challenges. Since it is a state-funded project, example-setting is also crucial. The research targeted two parallel issues: GHG-emission estimation and the evaluation of offsetting options in order to provide a feasible decarbonization mix. Since the proving ground is a special facility, existing emission estimation methods had to be tailored and a special tool – the GHG simulation model – has been developed. For emissions calculations, we have relied on the procedure outlined by the GHG Protocol (Scope 3) and the methodology relied heavily on the standard MSZ EN 16258:2012. For the calculations, the definition and collection of input data types was the first step. Afterwards, the calculation for direct test-related emissions has been conducted by taking into consideration the geometric shape of test platforms, the anticipated vehicle loading of track elements, the typical distance-speed diagrams, as well as the vehicle types tested (passenger cars, trucks and buses). We calculated CO_2-equivalent emissions from gasoline and diesel fuel consumptions – based on fuel demand and conversion factors – using "Tank-to-Wheels" and "Well-to-Wheels" approaches. The other important source of GHG-emissions is related to the energy consumption of the buildings. Since the estimation was prepared during the construction phase of the project, we relied on parameters from the design documentation. The third important category of emissions is related to the operation of the site, including emissions from commuting, transportation within the site and business trips. Input data for calculations have been provided by ZalaZone. Emissions related to material flows (water and waste) have also been estimated but found to be negligible. The other major task was to evaluate offsetting options. Considering earlier practices in Hungary, the geographical features of Zala County, and the opportunities of the proving ground, the following three CO_2 offsetting options have been chosen for detailed assessment: forestation and green surface development; energy crop plantation for heat generation and the establishment of a photovoltaic (PV) farm for electricity production. We have shown the main characteristics of the three main options and their advantages as well as limitations. Based on the decarbonization pathways, the most significant deductions can be reached by the PV farm, while forestation and energy crop plantation exhibit no significant difference in decarbonization potentials. Four scenarios have been proposed to achieve the vision of "net zero – or negative – emissions" of the project. The management board has selected a scenario of "mixed measures". The implementation of the measures has the additional benefit of contributing to renewable energy production. It was concluded that carbon-neutrality is feasible and our analysis provided valuable information for the management to be able to choose the most preferable option. The theoretical contribution of the paper is the development of carbon emission estimation for a special facility, as well as the assessment methodology of offsetting measures.

Payback periods of nuclear and wind energy: exploring the issue from an embodied carbon perspective for the UK

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The urgency of mitigating climate change through – among other things – clean energy sources is at times met with renewed interest in nuclear energy. With 450 nuclear reactors operating in 31 countries, 50 currently being constructed, 100 which are on order or planned and over 300 more proposed, it is imperative to understand the role that nuclear energy can play in the transition to clean and affordable energy.

The 2019 World Energy Outlook from the International Energy Agency shows that in two out of three global scenarios analysed, global energy demand will increase steadily yearly until 2040, and nuclear energy retains a significant share in the global installed capacity. In the UK, nuclear power is considered essential for meeting national greenhouse gas (GHG) emissions reductions targets as demonstrated by the UK Government's decision to procure a 3.2 GW nuclear power station (Hinkley Point C).

However, in 2019 wind power generation has on average been on a par with nuclear energy generation, and during the first weeks of December 2019 wind has contributed 19.9 – 28.4% of the total power, with nuclear significantly behind 17.5 – 19.1%. Additionally, nuclear energy incur significantly higher capital costs and is considered as a risky investment. Nuclear power stations take time to build and are commonly affected by significant delays which make the upfront investment even higher. For instance, Hinkley Point C should have begun powering the UK grid in 2018 but it is now estimated that it will not be operational before 2025, with an overall cost exceeding £20bn which is almost double the 2008 figure.

In this paper we investigate the argument for nuclear energy as an essential element in the clean energy transition through a comparative investment analysis underpinned by a dynamic life cycle approach. We firstly establish the upfront investment, in embodied carbon rather than economic terms, required for a nuclear power station. We then model the possibility of using this available embodied carbon capital either to pursue the nuclear option or to build alternative forms of energy delivery, namely wind farms. The two alternatives are enriched with scenarios to factor in sources of uncertainty such as the length to construct a nuclear reactor, the likely decarbonisation of the UK energy grid in the coming years and decades or the variability and unpredictability of wind energy. For each scenario we calculate payback periods (PBP) from a carbon perspective.

Results show that given the long construction time of nuclear reactors, wind energy is an alternative, viable option to transition more quickly and with more certainty to clean energy. Results hold also when considering the variability and unpredictability of wind energy and the potential temporal lag between energy supply and demand. Our model, whilst built for the UK, is sufficiently flexible to be used—with different inputs—in different regional and global contexts.

Renewable Energy and International Law: Should a Global Regulatory Framework be Established?

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The debate concerning the global shift from fossil fuels to renewable energy has continued for decades. In the coming years, the discussion is expected to become more intense due to the increasing environmental problems associated with the use of conventional energy. Climate change is seen as one of the most important challenges that renewable energy can tackle in the long run. In this context, this article is seeking to examine the role international law can play in pushing toward such a shift. The article seeks to answer the following question: is the establishment of a global regulatory framework addressing renewables possible and needed? The authors will examine the various stages of energy utilization, which are relevant to foster a smooth energy shift from fossil fuels to renewables.

The Costs of Populism in Developing Countries: Evidence from 'gas price holidays' in Brazil

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Policymakers, especially in developing countries, often rely on 'gas price holidays' as a populist strategy for transferring wealth to the population while also gaining political support. During a gas price holiday, the government de-facto subsidizes fuel consumption by artificially setting the gasoline price below its international value. Taking advantage of an unexpected announcement to end such a program in Brazil in 2013, we present some of the first credible empirical estimates of the *full* costs – gross and external – of gas price holidays in an event-study setting. To conduct our event study and measure the effects of these announcements on firm values, we collected a comprehensive dataset that includes, in addition to detailed information on the institutional details of the events, daily stock prices for Petrobras voting and non-voting shares, daily international crude oil prices, as well as standard financial data, such as the general market index. When estimating the daily return on the Monday following the announcement, our event study design controls for possible confounding factors, including potential anticipation effects on Friday, rebound effects on Tuesday, general international oil sector movement, and general domestic market trends and volatility.

Estimates from the event study constitute a 'sufficient statistic' of the costs of a gas price holiday program. The gross cost of the program reflects the opportunity cost of selling gasoline at an artificially lower price domestically plus the potential additional risk burden Petrobras may face when securing a lower domestic price, given fluctuations in international crude oil prices. Others have relied on event studies with financial market data to evaluate the costs and benefits of environmental regulations (Bushnell et al. 2013, Lemoine, 2017, Meng, 2017). In the context of fuel markets, however, most of the studies that have examined fuel taxes or subsidies typically do so with simple equilibrium models that require structural assumptions and parameter values for key elasticities, such as the oil supply elasticity. And, as Davis (2014) points out, estimating the long run elasticity of oil supply empirically is extremely difficult, since there is a great deal of scope for global oil producers to respond to crude oil prices. This is particularly true in the last decade, with improved shale oil techniques and other emerging technologies that have opened up vast new production areas. By calculating the costs of the program as a 'sufficient statistic' estimated through our event study, our estimates are free of structural and elasticity value assumptions and thus likely to be more credible.

Our central result implies that the continuation of the gas price holiday would have resulted in an overall cost of approximately $6.47 billion. Given baseline fuel consumption and prices, such a continuation would have transferred approximately $3.2 billion to consumers, implying that for every dollar transferred to consumers via lower gasoline prices the distortionary cost of the program was roughly $1. By comparison, it costs about $0.40 to raise $1 with a labor tax in the U.S. This is suggestive that financial markets were quite sensitive to the potential additional financial risks Petrobas faced when securing a lower domestic price (risks due to the volatility of oil prices and exchange rates), increasing the distortionary costs of the program. It also implies that, as a mechanism for transferring wealth to individuals, this is a rather inefficient and costly program.

Corporate Social Responsibility And Sustainable Entrepreneurship

Companies' role in the energy transition. Analysis of the prospects of change in incumbent firms' behaviour

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The 2015 United Nations Climate Change Conference (known as *COP 21)* defined a temperature commitment to keep global average temperature rise well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C (UN, 2015). In order to do so, national governments have been encouraged to implement climate policy packages, including carbon pricing. Carbon pricing refers to a policy that sets an explicit price to CO_2emissions, capturing the external costs of greenhouse gas (GHG) emissions. It offers an economic signal to emitters, in order to induce behaviour changes, stimulating them to decide to either transform their activities and lower their emissions, or continue emitting and paying for their emissions (World Bank, 2017). Carbon pricing may be implemented through emission trading systems (ETS) or through carbon taxes. This paper explores the latter. Specifically, it studies the effects that the implementation of a carbon tax in Colombia has had on the behaviour of regulated companies. This tax is one of the first to be implemented in the Latin American region. Our qualitative study is based on ten interviews, five to policy makers involved with either the formulation or the implementation of this policy instrument, and five to private sector actors who are targeted by such policy. The interviews aimed at uncovering the extent at which this policy has ignited behaviour changes among the regulated companies. The guiding research question of this study is *To what extent does the Colombian carbon tax induce changes within high-carbon emitting firms?*Using the sustainability transitions framework (Grin et al., 2010), this paper approaches these firms as incumbent actors in a stable carbon-intensive regime. Our findings show that the Colombian carbon tax might not be sufficiently expensive (the current price is 5 USD / ton CO_2) for companies to make significant behaviour changes. On the contrary, regulated firms are willing to pay the tax. We have also found that these companies charge this extra cost to consumers, so that their profit margin is not affected. This strategy (indirectly) affects the price of primary goods, which in turn has an adverse effect on the poor. Additionally, the carbon taxation policy is not complemented by any other climate policy, which creates much room for companies to continue on the business-as-usual pathway. These findings correspond to the typical mode of behaviour of incumbents to *delay the transition*, which can be found when organizational privileges and social positions would be threatened if the transition took place (van Mossel et al., 2018). Our findings suggest that a weak carbon pricing policy makes incumbent actors more powerful and reduces the possibility of the regime to be destabilised. In contexts such as Latin America where there are significant inequalities, such policies disengage companies from their responsibility of reducing their contribution to the social vulnerability of climate change.

Entrepreneurship, Plastics, and the Circular Economy: What does an incubator's cohort tell?

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As the policy actions from the first European circular economy package are being implemented, the concept is subject to a massive boost in the scientific and the business community. Hence, a new generation of organizational models and approaches to circularity has become visible in recent years. The implementation of circularity affects several levels, from material flows to corporate strategies and finally society as such. Furthermore, it includes established companies, start-ups and bottom up initiatives, as well as a variety of sectors and stakeholders, as also outlined in the focal areas in the CEP. Understanding circularity approaches and inherent sustainability implications on a systemic level is crucial to determine organizational (in this study: businesses and initiatives) strategies for an effective CE. While there is a research stream on business model innovation for CE, ex-post evaluation of circular strategies on a high level is yet largely missing. The aim of this study is to contribute to an improved understanding of sustainability implications of circular strategies, deepen the knowledge on circular transitions, and ultimately the functioning of a CE. Therefore, this study draws on a set of 25 projects executed by start-ups, initiatives, and NGOs tackling the plastic problem from a circularity perspective. The projects were selected from a social accelerator platform in Berlin/Germany. A concurrent mixed method approach including action research was chosen for the analysis: First, self-descriptions, written by the initiatives are content analysed and systematically evaluated, including operational levels and foci of the projects. Based on this, sustainability implications are derived and categorized, using the principles of the Framework for Strategic Sustainable Development. Second, the research team was involved as experts to consult the initiatives under investigation and assess the projects from a systemic and sustainability perspective. Finally, project descriptions were analysed using a topic modelling approach to cluster and analyse the main approaches of the project sample. Results suggest diverse approaches to tackling the plastic problem, ranging from materials-based solutions to platforms and reductionist approaches. Also, a wide range of social inclusion into circularity approaches (during production, but also addressing consumers) was observed amongst the projects, thereby addressing a clearly underrepresented area of European CE. At the same time, the level of systemic understanding of sustainability implications varied. This can lead to negative consequences especially when major trade-offs are overlooked. The study shows that approaches to circularity can be diverse, even within a specific focal area, and that every focal area (also a very materials-based one) can include social aspects to a high degree. Also, as opposed to established companies, the analysed start-ups and young initiatives show a higher degree of freedom when choosing strategies, explaining the diversity within the projects. Regarding sustainability implications, a systems perspective seems useful to qualitatively estimate sustainability implications. However, specific attention needs to be given to potential negative feedbacks and time lags, that in the worst case could offset the positive intended sustainability contribution. Here, a strategic and holistic inclusion of sustainability principles, such as the framework for strategic sustainable development or the UN SDGs, are encouraged.

Social sustainability and responsibility in business model innovations for sustainability in the fashion industry: A systematic literature review and derivation of typology

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The fashion sector is considered to bear enormous responsibility in terms of environmental pollution. Besides, leading companies in this industry have repeatedly been publicly accused of social misconduct and non-compliance behavior at profit maximization quest. Common examples cited in the respective literature on social (un)sustainability in global apparel operations and value chains include poor ethical labour and working conditions, child labour, human rights abuses or the questionable proliferation of mass production and a culture of consumerism as a matter of fact. As an important dimension in the triple bottom line of corporate sustainability practices the social dimension of sustainability addresses the management of human and social capital issues in order to more or less explicitly reduce a broad range of risks and costs arising from serious business disruptions due to sustainability challenges and societal effects associated therewith. At its very core, proper management of social sustainability can also be conceived as preventing and protecting against crises in a non-commercial way. However, with regard to the fashion industry, the implementation of principles, commitments, strategies and mechanisms in order to (voluntarily) foster social sustainability remains largely fragmented and all too often low credible.

Previous literature has emphasized that integrating all dimensions of sustainability requires innovation from companies and transformation of traditional value creation processes and business models. In this context, business model innovations for sustainability are seen to be decisive for corporate profitability and long-term success. Further, they are considered to promote transition thinking as well as catalyze systemic and radical change since the notion of value and its distribution across multiple stakeholders is broadened. Extant studies on business model innovations for sustainability in the fashion industry have examined solutions such as circular business models, product-service systems or redesign practices, amongst others. In general, however, these models are often criticized as treating the social dimension of sustainability only as peripheral matters which, conversely, somewhat counteracts their very conceptualization. Despite growing attention by fashion companies for adopting sustainable business models, a further gap remains in terms of what theoretical themes and concepts relating to social sustainability are actually considered in these alternative business models.

This study builds on these shortcomings by extracting issues relating to the social dimension of sustainability. In doing so, a set of academic publications, standards and management tools on social sustainability and responsibility (e.g., GRI 400 series, ISO26000, UN Global Compact) as well as prominent textile-related standards and guidelines (e.g., STeP, GOTS, FWF) are analyzed in order to identify main themes embraced by the term ‘social sustainability’. Subsequently, peer-reviewed scholarly publications on business model innovations for sustainability in the fashion industry are systematically investigated in order to detect social issues, thereby employing a systematic literature review as well as content and thematic analysis. By mapping and condensing the findings from these two major steps, we construct a framework and typology of social sustainability-related themes and categories in business model innovations for sustainability in fashion. In doing so, our results show a great number of social issues which have been neglected in previous research on business model innovations for sustainability in this particular industry while advocated in general research on social sustainability and/or management standards and tools for social management, corporate responsibility, accountability and textile sustainability (and vice versa).

Taking lead for sustainability: Environmental managers as institutional entrepreneurs

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This paper aims to identify critical events that have affected the professionalization process of environmental sustainability professionals in the Swedish Architecture, Engineering, and Construction (AEC) industry. Based on a phenomenological study of eight experienced environmental managers' life stories, the findings describe how they have actively engaged in the development of the institutionalization of a profession; and in bringing environmental practice into construction project management practice. The findings also indicate how environmental sustainability professionals' agency has been closely interrelated to the sustainability discourse in society. The implication of this is twofold, on the one hand it serves as a way of initiating institutional change towards enhanced sustainability, on the other hand it causes frustration when agency to act is challenged or temporarily 'lost' because of a discerning discourse in society. This implies that their ability to act for sustainable change has typically revolved around 'one issue at a time' as a result of a unilateral sustainability focus. Their agency has, however, revived over time as the environmental managers continuously work to create and establish environmental sustainability practice. This paper contributes with a better understanding of environmental sustainability professionals' roles and agency in shaping the pace and direction of an environmental sustainability agenda; something that is needed sooner rather than later in times of climate change and of realizing the UN SDGs. However, more empirical studies are needed to fully understand how environmental sustainability professionals are received and established within the AEC industry.

Tensions in Corporate Sustainability: a case of an East European country

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Based on the system-level concept of sustainable development, corporate sustainability (CS) is achieved at the intersection of economic development, environmental protection and social responsibility. Recently, the number of organisations committed to sustainability has grown. Drivers for transition from *business-as-usual* to a sustainable organisation are not limited to government regulations and economic benefits, but also include external pressures such as customers and even internal pressure from employees (Lozano, 2015). Additionally, in case of organisations operating in an East European country, the business culture of neighbouring countries, particularly investments coming from Scandinavian countries, act as a relevant force for engaging in sustainability. The majority of scholars in the field seem to follow a holistic perspective and agree that CS requires organisations simultaneously to address interconnected and interdependent economic, environmental and social concerns at different levels (Bansal, 2002; Baumgartner, 2014; Lozano, 2015; Engert et al., 2016). However, tackling multiple objectives simultaneously results in tensions since progress on one sustainability issue might have detrimental effects for others (Passetti et al., 2018; Wright and Nyberg, 2017). Tensions could be described as objectives that seem to be in conflict – they are values that seem to be in opposition and we often treat them as either/or choices when they should be treated as both/and dynamics (Quinn, 2015). Tensions in CS may exist between temporal and spatial contexts or between competing social, economic and environmental goals (Hahn et al., 2015). Although there are studies dealing with tensions in CS (van der Byl & Slawinski, 2015; Hahn et al., 2015; Hahn et al., 2018; Daddi et al., 2019), there is nonetheless a lack of understanding how organisations address these tensions particularly bringing empirical insights. Moreover, according to the best knowledge of authors of the current paper, there is no empirical study examining tensions in CS in East European countries, although due to historical situation (from planned economy to wild capitalism) business in these countries is noted for certain distinctive characteristics. Thus, the **aim of the paper** is to close the existing gap in the literature by revealing the tensions inherent to CS of organisations in an East European country and introducing the strategies for managing these tensions. During the qualitative research, the data was collected from the representatives of CSR committed organisations through 20 semi-structured interviews. Qualitative data were analysed by coding and categorising the responses into the major conceptual areas. The empirical results demonstrated that business uses four approaches addressing the tensions in CS, namely win-win, trade-off, integrative and paradox. Actually, few organisations opt for the win-win approach, which looks for alignment between social, environmental and economic goals while bypassing tensions. Some companies reported the trade-off approach, which represents a choice between options. Incidentally, in some cases companies have chosen financial goals (making it difficult to speak of sustainability), but in several cases the priority was given to social goals (for example, additional paid holidays). However, the bulk of organisations reported contradictory yet interrelated goals arguing that they try to attend to competing demands simultaneously (paradox lens). One of the ways to deal with paradoxes is through collective action and negotiations with stakeholders. Concluding, the empirical results suggest that organisations acknowledge the tensions in CS: it is recognised that tensions exist; some actions to manage them are implemented.

THE INNOVATIVE CONTRIBUTION OF MULTINATIONAL ENTERPRISES TO THE SUSTAINABLE DEVELOPMENT GOALS.

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The 2030 Agenda recognizes the role of the private sector as drivers of productivity, inclusive economic growth and job creation. It calls on their innovative and creative capabilities to help solve sustainable development challenges. Judging by the positive reactions of companies, for example in sustainability annual reports, this call to help achieve the Sustainable Development Goals seems to resonate. However, the nature, extent and motives of this engagement remain unclear. Has it substance or is it "cheap talk"? Are they mere defensive reactions to stringent environmental regulations, legitimacy issues or stakeholder pressures, or pro-active, strategic investments in unfulfilled sustainable development opportunities? This paper is concerned with the role that large stock listed multinational enterprises (MNEs) play in SDG-related technological innovation. Sustainable innovations are measured by assessing SDG-relevant keywords in full text European patent descriptions. The number of SDG-relevant sustainable patents are assessed for over 1000 MNEs as a proxy for SDG-related innovation and associated with sustainability disclosure, membership in sustainability initiatives, regional and industry membership, company size and sustainability ranking. It can be concluded that MNEs play an average role in green innovation, and under-average in unmet needs related innovation. Using a negative binomial regression model, it is concluded that there are strong regional and industry-specific differences, and that there is a clear link with the Global Compact initiative and SDG mentions in sustainability disclosure. It can be concluded that SDG-related contributions from MNEs are less symbolic than could be assumed, though this is more obvious with green innovation than with innovation directed at meeting unmet needs.

Towards a Sustainable Entrepreneurial Mindset: Using the Sandbox Innovation Process to Tackle the SDGs

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With the ever-clearer notion of compromising life-support systems on earth, environmental issues assume greater prominence within a global agenda. The SDGs are the current proposal for this trajectory adjustment. With a broader scope, the SDGs are a functional, long-term, highly flexible and interconnected framework. Complex problems for sustainable development, such as energy, food, urbanization, and climate resilience, are some of the interdisciplinary agendas that require unprecedented mobilization among different actors of governments, businesses, academia, and civil society. How can we mobilize these actors and develop solutions for these complex problems?

In this paper, we explore the possibilities of the so-called Sandbox Innovation Process to address challenges in the area of sustainable entrepreneurship by incorporating the SDG framework. The Sandbox Innovation Process, further developed by the Leuphana University of Lüneburg in an EFRE-funded project (European fund for regional development), aims to build an innovation community through a structured open innovation process in order to tackle regional challenges. It is a practice community that can foster the integration of different actors and harnesses the dispersed collective capacity of social groups. In a joint research project, we aim to combine this innovation process with a framework that incorporates the SDGs. By this, we enable the participants to develop an entrepreneurial mindset of "Think global (SDGs), act local (Sandbox approach)!". The research object, in this case, in this case, is a particular workshop format, executed with the general public, that aims to foster this mindset with these elements:

1. Creating an atmosphere of trust
2. Matching groups with a high level of diversity (e.g. age, gender, social background)
3. Collection of local challenges (fostered through a preparation exercise using the ZMET-approach to collect visual data of each participant about the challenges).
4. Introduction and reflection of the SDGs in the plenary
5. Further understanding the local challenges and their relations to the SDGs through focus group discussions based on the ZMET-approach
6. Ideation phase using various creative tools
7. Rapid prototyping of the developed concepts
8. Presentation and discussion of the prototypes in the final plenary
9. Afterward: supporting the development of sustainable business models

With this approach, we collect a) visual data about local challenges and how the participants connect these to the SDGs, and b) prototypes and presentations to examine whether the SDGs were tackled in this format. We conduct further evaluation of the workshop results via content analysis over the record of activities, especially the SDGs layering process and final plenary. In a multiple case study design, we examine this approach in various countries, starting with Germany and Brazil, in order to consider contextual constraints.

The results are currently conformed into a framework able to posit a suitable easy-going tool for SDGs and innovation iterations. The preliminary results show that the SDGs framework is able to work as a meta-layer able to adapt to many different contextual constraints. The workshop approach is connected to active methodologies for learning and promoting innovation, and benefits from the global agenda represented by the SDGs. There

are still some workshops running and results will be updated. Our research reveals how people can become key drivers for innovation solutions aligning the “Think global (SDGs) act local (Sandbox)” perspective with an effort that is enjoyable, insightful, low cost and highly effective in many contexts.

What are Motivational Factors for the Integration of Health, Safety and Environmental Management Standards in Local Public Administration?

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Growing concern towards sustainability management has emerged in local public administrations that persuades them to integrate their sustainability actions and principles into their management activities. In this context, standard-based management systems have gained enormous success as a popular sustainability management tools, particularly in the sphere of meta-standards. However, sustainability management practices have most often been applied to private sectors and yet, local public administrations usually neglect or consider this issue at a slower trend compare with private organizations. Although a large number of municipality's sustainability actions are directly related to Health, Safety, and Environmental (HSE) issues, there are relatively few studies that explored the causal connections between the motivators of adopting the HSE-based standards in the scope of sustainability management. Most of the existing studies have been limited in the domain of environmental standards, and yet, little attention has been paid to driving factors of adopting the health and safety management standards. This research aims to identify the leading motivations for adopting, implementing, and maintaining the HSE-based management standards in municipalities. These standards are perceived by municipalities as tools and support the implementation of HSE related policies and practices and contribute to assessing their general state of performance towards sustainable development. Tehran municipalities were selected as the case study. In the first step, a set of management standards adopted by municipalities to manage their HSE performance towards sustainability goals were explored and categorized based on their relevancy to HSE domains. Then a questionnaire survey was developed and forwarded to the target municipalities to identify the most effective motivations. Two methods were applied to analyse the data, including a descriptive data analysis for close-ended questions and content analysis for open-ended questions. The findings revealed 20 effective motivators by clustering them into three main categories of i) dimension of motivations (socio-cultural, legal, Economic, Political, and technical), ii) Type of motivations (internal or external), and iii) nature of motivations (positive or negative). The main survey outcomes provided an integrated picture of the municipalities' motivations for pursuing HSE-based management standards. Also, the results of the survey trace the main motives that influence on selecting the contractors who are also working with the municipalities of the case study, which jointly influence municipalities HSE sustainability performance. In terms of theoretical implications, the study affords practical guidance to local public administrations interested in contributing to sustainability issues through considering management standards. In terms of societal impact, the outcome will have a significant impact on the social groups such as citizens and stakeholders, which may be related to improving the level of services offered by municipalities through considering not only internal but also external motivations such as citizen satisfaction or stakeholders pressure by adopting the management standards. It also can make improvements on the level of satisfaction and welfare among the society, and increasing the quality of municipal services offered by stakeholders.

Design For Sustainability

Designing for Social Value of Energy at The Grassroots: A Multi-Criteria Design Framework for Clean Energy Interventions.

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Access to meaningfully sufficient and cost-effective energy services is key for enabling a variety of sustainable development outcomes. However, handouts and incremental solutions have consistently failed the poor; because of their supply focus and little attention to utilization for well-being or anticipation of burdens and consequences. Therefore, the design challenge for energy access projects at the grassroots is to enable individual prosperity and communal thriving, by disrupting the systematic underdevelopment that breeds and propagates deprivations. This requires a framework to include actors positioned to address challenges and institute processes for engaging them dialogically.

In order to test new design strategies in this space, the applied research project *'Implementing Off-Grid Renewable Energy to Create Social Value and Community Development'*was carried out between June 2018 – May 2019. Two academic entities partnered with grassroots energy practitioners in Nepal, Philippines, Uganda and Bolivia and tested a participatory design framework through collaborative projects with communities, leveraging off-grid energy technology to advance several sustainable development goals. The co-designed capacity building process involved systematically deconstructing past successes and challenges faced by the practitioners (retrospective phase), discovering opportunities to enhance processes and capacities within the enterprise from user value and socio-technological ecosystem perspectives (reflective phase) and applying the insights to new projects (prospective phase). While designing and implementing new projects, insights from the reflexive process were integrated with the multi-criteria design framework to design new participatory energy-sustainable communities projects. Following the three categories in the framework *(Social Value of Energy, Organizational actors and Knowledge processes for Social Learning)* and six parameters of design *(Capabilities, Capacity-Complexity matching, Leaders & Influencers, Governance & Institutions, Continuing Evaluation and Communication)*, the partners implemented multiple community off-grid projects and redesigned enterprise process for greater coverage of SDG's through their work in the clean energy sector.

The key results from one year of collaborative efforts are at several levels. At the community level, a strong driver of sustained outcomes in socio-economic-ecological change was the continued discovery and fulfillment of value proposition of energy services. Additionally, the deliberative forum for co-producing the energy system became an effective platform for furthering the local development agenda. For enterprises, transparent expectation setting at the pre-project stage and participatory monitoring and evaluation mechanisms that inform and educate users about technology, transactions and household utilization planning, are key actions that build trust. Operationally, it was evident that generative energy projects in marginalized communities should encompass identification and planning for a set of development goals. This required strategic partnerships with entities having appropriate skills (agriculture, micro-finance, education etc.) and engaging local government, religious institutions, regulatory processes and political tendencies at the grassroots. The evidence contributed to improvements and adaptations to the ecosystems approach to systems/enterprise planning and the multi-criteria project design framework for sustainable energy interventions at the grassroots. The framework offers the ability to create concrete and realistic pathways for energy utilization for sustainable outcomes and a heuristic for designers to locate and negotiate risks and uncertainties emerging from a variety of sources.

On the establishing of a PhD education in innovation for sustainability

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1. *Oslo*

The UN Sustainable development goals (UNSDG) have been received with great attention and are at the political agenda globally. The green shift has caused demand for new types of knowledge in how to tackle the climate change and to create sustainable solutions for production and consumption. This goes for both the business community, the public sector and on individual level. OsloMet – Oslo Metropolitan University, is presently working with how to contribute to the SDGs, with such an education. The main question is how this broad issue should be approached, and what its contents should be. Recent international investigation from The European Association of Universities (EAU)); nationally at The Confederation of Norwegian Enterprise (NHO), Innovation Norway and the Ministry of Climate and Environment, as well as in academia, showed that several PhD educations more are emerging. They are mostly technology-oriented and based on one subject field, although claiming to have an interdisciplinary approach. Further, in Norwegian business enterprises as well as public sector, there is a great demand for competence to adjust to the green shift and still be competitive. Sustainability has generally been understood as consisting of an environmental, an economical and a social pillar. According to recent research, the cultural significance of sustainability is paramount, and an increasing number of researchers and practitioners claim that culture (human thinking, acting, attitudes and behaviour) constitutes a fourth and main pillar. Environment is here understood as both physical and mental. A new PhD in sustainability would therefore be more comprehensive and timely if it is based on this understanding. At OsloMet the academic staff at the Department of Product Design has a particularly strong tradition in teaching sustainability from a cultural perspective. Added by the Department of Art, Design and Drama, The Department of Computer Science and the Norwegian Institute for Urban and Regional Research, it constitutes a cluster of various competences that should be fit for creating a PhD with this approach. The program will be applicable to people with a master education in most disciplines. Interdisciplinarity as well as transdisciplinarity (co-design) will constitute a part of the education. It will also be adapted to the new European Research program, Horizon Europe, where shaping of healthy surroundings is a main issue. The program will particularly address SDG Goals 3, 4, 5, 9, 11, 12 and 13 (healthy environments, inclusive quality education, gender, lifelong learning opportunities, equality, innovation and climate action). It will consist of an obligatory course in Philosophy of science, comprising critical realism, hermeneutics, post-phenomenology, symbolic interactionism. A second obligatory unit will deal with the concept of sustainable development, its theories, history and impact, as well as the significance of interdisciplinarity. The remaining unbound credits will comprise Sustainable production and consumption, Innovative management, Sustainability awareness, Universal design and User interface, Smart cities and environments, and Circular Economy. The main challenge is how to fulfill the strict official requirement for scientific unity. This will hopefully solved by a description of the coherence of the theme of the program, the overlap of the competences and scholarly theories and methods, and the skill in interdisciplinary cooperation.

The life cycle approach to compare health and safety performance of products. A new risk assessment methodology applied to an Italian leather company.

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The tanning industry recovers and transforms animal skins into non-putrescible, hygienic, breathable and resistant products. The use of chemicals in tanning companies represents a relevant risk for health and safety (HS) of workers both for inhalation and adsorption. The risk management model is an opportunity for companies to assure preventive and protective measures to reduce these risks. At the same time, with market perspective, companies are more and more interested to demonstrate the sustainability of management measures to reduce the impacts of products with life cycle (LC) approach. The research aims to define an innovative methodology to assess the HS risks related the processing of leather products made by an Italian company; the methodology is tested to compare HS performances of two leather products realized for the automotive sector. Originality of the research concerns the adoption of LC perspective in assessing HS issues related the products. The research starts with in-depth analysis of processes, in order to define the goal and scope of LC risk assessment, and to identify all substances and mixtures involved in LC phases of products and their dangerousness, working conditions and potential exposures. The research continues through the quantification of HS risks, through the adoption of systematic risk assessment methodology applied to the processing phases, concerning retanning, dyeing, fattening and finishing operations. Finally, the HS performances' evaluation of leather products guides to identify during LC the activities characterized by highest HS risks. The results highlight the LC phases of tanning processing that are most critical for HS of workers, with direct and repeated handling of dangerous chemicals. The results also demonstrate what is the leather product characterized by higher HS risk index. The methodology implemented in the case study supports a systematic inventory of substances' dangerousness, an ad-hoc analysis of LC phases and LC processes, a consistent evaluation of risks associated to each product and each activity. The implications both for practitioners and scientists derived by research are underlined in conclusions. For companies, the HS performance assessment of products supports a critical review of adequacy of measures adopted to prevent and protect workers' risk exposure. For scientific community, the LC approach, born to quantify the environmental hotspots associated to products, can be adopted also to assess the HS performance of products and to compare different products in a risk management perspective. New research perspectives can be identified, concerning the integration of environmental and HS assessments at product level, to support sustainable considerations by managers and markets.

Circular Economy - Part 1

An interdisciplinary conceptual framework exploring the barriers facing the circular economy at the regional scale

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The resource security, environmental and economic benefits postulated to come from a circular economy are major areas of policy relevance and are attracting significant interest from policy and other stakeholders at the regional scale. However, whilst there has been significant research on sub-national scale initiatives for other environmental issues and their economic implications, as yet there is little relating to the circular economy from this perspective. The circular economy is a rising area of interest from both a policy and business perspective, seeking to produce economic growth whilst reducing environmental impact. Circular economy literature discusses the need for cooperation between different stakeholders. However, the potential for differences in interests between them has not been addressed, especially in the context of the relationship between companies and particular places in a globalised world. Local authorities have a responsibility to promote prosperity for stakeholders in their administrative region, while companies can have financial imperatives associated with shareholders and other stakeholders who may be globally distributed. Business and Geography as disciplines discuss similar concepts such as economic and regional development, and supply chain relationships but limited steps have been taken towards a shared conceptualisation. There is a need to synthesize these interdisciplinary literature themes, which may help to elucidate potential challenges facing regional circular economy development. For example, economic geography literature often discusses the significance of building prosperous places for stakeholders, however neglects the role of business in developing the region. While on the other hand, business literature argues that companies are responsible for creating competitive and prosperous regions, with little consideration given to other local stakeholders. The main aim of this paper is to critically explore interdisciplinary perspectives on developing the circular economy at the regional scale drawing on the Business and Geography literature. From this, we devise a place-based conceptualisation of the circular economy which develops an approach to researching the circular economy at a regional level. This paper will use critical discourse analysis to compare policy and business documents in order to examine how they discuss the circular economy from a discourse analysis perspective. The policy documents which will be studied range from European Union to regional level policies, particularly focussing on the Humber region in the UK. The business documents will predominantly consist of sustainability reports of companies located in the Humber region. The findings from these documents will help validate the conceptual framework, by offering practical insights from both policy and business perspectives to developing a regional circular economy. Future research should explore this interdisciplinary framework in a practical setting, to examine how the priorities and values of companies compare to aspirations of local public agencies when developing the circular economy.

Analysis of industrial waste management regulation to drive resource management in a circular economy: a case study in Spain

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Waste generation is outpacing the rate of materials recovered and recycled. So, a problem is generated when materials that should be cycled back to industrial production follows a linear approach wherein energy and resources are being exhausted. To ease the environmental burdens created by poorly management of waste, countries have conceived policies to deal with waste. Nevertheless, it is not enough to handle waste, but most importantly is to create other applications for this waste to be used as a resource for other industrial activities. Thus, an approach such as industrial symbiosis (IS) has been around for more than 20 years to solve this issue, still, implementing this approach at a country level is hard to achieve. The European Commission (EC) under its 'green deal' foresees IS as a vehicle to achieve a better resource efficiency in which a high quality secondary raw materials market is guaranteed to reduce waste. Hence, an enhanced waste policy is endorsed to support waste prevention though the implementation of IS. In that sense, the efficacy of policies for the waste management sector plays a crucial role to integrate a linear waste management to a more comprehensive approach for resource management. Thereby, studies are needed to highlight how waste management policies might assist authorities in analyzing the materials with better chances of being recovered and potentially be used in other ways, therefore, paving the way for enabling the emergence of IS by increasing resource efficiency. Thereby, this paper explores the efficacy of a specific policy enforced as a measure to enhance waste reduction in ten industrial areas located in the Basque Country (Spain) for a period of five years. The findings of this study show that an increasingly strict waste management policy improves collection of waste, especially in three waste streams. These findings highlight the opportunities to shift from a mere waste management regulation approach to a resource management strategy.

Carbon storage for climate change mitigation: An investigation of the potential in the United States' building stock

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One way in which the principles of a circular economy can be explored in the built environment is through a material flow analysis and lifecycle assessment of low-carbon, and carbon-storing materials in buildings. If on the one hand many materials have high embodied emissions (e.g. steel and concrete), on the other hand there are materials that have the ability to store carbon through photosynthesis (e.g., wood and grasses) and carbonation (e.g., concretes and mortars). While the understanding of carbon storage is well-developed at the material and assembly scale, few studies have quantified the building stock scale potential for carbon-storage. The focus of the present research is to quantify the opportunities for using carbon-storing materials within the context of the United States' (US) building stock. This research is timely due to the fact that the supply of biogenic carbon is limited by available resources, such as land, water, and time, required to grow crops and forests. Quantifying the potential future demand and flow of carbon-storing materials is essential for policy and planning purposes as the globe continues to urbanize and demand sustainable cities. To evaluate this research aim, two models are developed. The first model computes the carbon storage potential of construction materials, while the second model develops, for the first time, a dynamic analysis of the future US residential and commercial building stock to prognosticate material flows. The carbon storage potential of biogenic and cementitious materials is evaluated using a dynamic lifecycle assessment methodology to account for biogenic carbon and various end-of-life scenarios. Multiple scenarios are generated to explore the carbon storage potential of structural systems. A reference case is identified for future growth, where no additional adoption of carbon-storing materials occurs (i.e., building with wood and straw). Two scenarios, one medium- and one high-growth, are compared to the reference case, considering an S-curve rate of adoption of carbon-storing structural systems between today and 50% and 75%, respectively, in 2050. The results of this modelling effort are two-fold. First, the future demand for carbon storing materials is quantified under multiple scenarios. Second, the use of carbon storing materials show significant potential for the US building stock to act as a carbon sink. The end-of-life scenario chosen for materials with biogenic carbon has a significant impact on the carbon storage potential, highlighting how a circular economy increases the carbon storage potential of the built environment. Our computational models provide a conceptualization of a future US building stock that stores carbon for as long as possible through maximization of circular economy principles. While the present study focuses only upon the US, the modelling framework can be extended to evaluate both regional and global carbon storage potential. Furthermore, other building systems, such as insulation and façade systems that can use carbon-storing materials can be investigated in a similar manner.

Circular Business models and the challenges for recovering value from used lithium-ion batteries

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Business models for the Circular Economy, or Circular Business Models (CBMs), is a growing field of research applied in various industries with the incentive to close the loops of materials and energy through maintaining the value of goods throughout the lifetime. Global trends, such as electrification of the transport sector and increased consumption of energy from renewable sources, have led to rapid growth in the number of high capacity lithium-ion batteries (LIBs) in use. As the use of LIBs increase, sustainable lifetime management (including end-of-life) is needed to avoid potential harm to our health and the environment and to ensure effective resource efficiency. Some literature exists regarding this topic; however, it is primarily focusing on technical and economic issues with recycling and reuse of batteries rather than circular business models. The purpose of this study is to explore CBMs for spent LIBs, critically assess their potential, barriers, drivers, and necessary stakeholders to enable the second life of LIBs. The Delphi panel method is applied, communicating with LIB experts from various disciplines to identify and rank appropriate CBMs. The Delphi panel structure covers the following categories: ecological impressions of LIBs; CBMs; drivers for recovering LIBs; barriers; and stakeholders. According to the experts, the highest-ranked CBM is resource recovery of discarded materials followed by product life extension. Findings furthermore reveal that the most important driver is national and international regulation and policies, and the most critical barrier is financial closely followed by lack of technical standards. There are several opportunities for further research on the topic, including empirical, and examine value creation in CBMs for LIBs.

Keywords: Circular Business Models , Lithium-ion Batteries, Electric Cars, Delphi Panel, Circular Economy

Circularity as alterity: the interplay of mainstream and alternative economic spaces for the circular economy development

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The new transformative circular economy paradigm, which emerged to address the pressing global challenges such as growing resource scarcity and climate change, has gained momentum among scholars and practitioners in recent years. Currently, the circular economy discourse and practice is overly focused on industrial, resource-related and profit-oriented mainstream economic processes and organisations whilst significantly overlooking alternative circular economic practices that generate non-monetary value in terms of social well-being and social inclusion. Very few studies have attempted to conceptualize and map the circulation of value in the CE using a diverse economy perspective developed by Gibson-Graham (2006), who challenged mainstream representations of global capitalism that conceal rather than reveal the diversity of local economic activities and practices. We propose that a more holistic approach to the circular economy offers the potential to couple the ecological premises of circular economy thinking with mission-driven social enterprises, which are often committed to tackling poverty and inequality, promote communitarian mode of functioning, and are increasingly addressing environmental issues.

This contribution reports conceptual and empirical findings of a research project aiming to elucidate the social dimension of circular economy by positioning social enterprise as an alternative economic form of organising with the potential to stimulate the development of a socially sustainable and locally-based circular economy. In doing so, the research draws upon the literatures on alternative economic spaces and diverse economies, and uses a case study of a social enterprise project, *heidenspass*, which is engaged in diverse circular economy activities across the furniture/wood, textiles and food sectors in the city of Graz, Austria. Apart from meeting environmental objectives, *heidenspass* empowers young vulnerable individuals by providing them with employment opportunities. The key research methods included interviews and interactive workshops with core team members and employees; customer surveys; as well as videography, which enabled to feature key stories from the field, document activities and present research findings in an engaging way to audiences beyond the academy.

The research presents the social circular enterprise as an entity entangled in the complex web of social, spatial and material relations that form circuits of value spanning mainstream and alternative economic spaces of exchange, production and consumption. By examining how social enterprises, their partnerships and networks, co-create and circulate value by stimulating transposition of materials, labour and relations in a given institutional context, and across the mainstream/formal and alternative/informal economic realms, the study redefines the concept of value and its meaning for accelerating a transition towards more inclusive circular economy. It concludes that understanding complex relationships underpinned by monetary and non-monetary, material and non-material transactions, as well as ever-evolving political, socio-ecological and economic contexts in which social enterprises are embedded, is important when studying transition pathways to more local and socially sustainable CE.

Closing the Loop in the Fashion Industry: Circular Fashion Transition Dynamics in New York City

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Industrial restructuring and innovation have continuously shaped the production landscape of cities in advanced capitalist countries such as the United States. From the processes of deindustrialization to the recent resurgence of tech start-ups, artisanal makers, and advanced manufacturers, new forms of production and industrial concentration reconfigure the urban space, patterns of production, industrial relations, and employment opportunities in cities. The fashion industry is one of the exemplary sectors that have been impacted by these dramatic shifts, while simultaneously, the importance of design and innovation still favor agglomeration patterns and experimentation in the urban and city context.

This paper specifically focuses on sustainability experimentation and innovation in the fashion industry towards achieving *circular fashion*, in which the key is to extend the fashion product life cycle and incentivize value creation opportunities from closing the loop of the fashion value chain, with the purpose to minimize nonrenewable resource consumption and the landfilling or incineration of textile waste. These strategies and experimentations do not happen in a vacuum; rather, their dynamics shape and are shaped by place-specific institutions and inter-organizational relations, for which cities are increasingly being identified as important enablers. Hence, I ask **how the fashion industry's *transition*towards the circular economy, or circular fashion, happens in fashion hubs such as New York City.**

I build on the works of economic geographers and urban planners that have examined the industrial and innovative dynamics of New York City's fashion industry from the perspective of *cultural industry innovation*theories. To this I bring in the *sustainability transitions*theories that have so far focused on technological innovation in clean-tech industries at the expense of examining sectors such as fashion that hold as many opportunities and challenges for implementing sustainability transitions. I show that these two theoretical fields share many commonalities and emphases in thinking about territorialized processes of innovation that when intentionally brought together, the synergy would make a useful contribution to the ongoing policy discussion on the circular economy and its implementation as a local industrial policy.

I then ask the following sub-questions: (1) How does the spatial pattern of the fashion industry, including its local value retention actions such as reuse, repair, recycling, and remanufacture, look like in New York City? Specifically, does spatial proximity matter in the circular fashion dynamics? (2) What roles do fashion industry intermediaries play in the urban experimentation of circular fashion and moreover, in translating local experiments into a systemic sustainable transition?

I address these questions by conducting a mixed-methods approach that examines, first, the occupational and industrial cluster analysis of New York City's fashion industry, including its reuse, repair, and recycling sectors, in order to understand its dynamics and spatial agglomeration patterns that extend to the end-of-life phase of the fashion products. Second, semi-structured interviews with actors such as independent and high-end retail fashion designers, manufacturers, and cultural intermediaries are carried out to address how the circular fashion experimentations at the design phase are navigated in the current industrial ecosystem of the city in order to balance commercial, aesthetic, as well as ecological considerations. Moreover, how local experimentations could translate to a wider system-level transition of the industry's practices will be examined.

Exploring the Engagement of Public Sector Organizations in Circular Economy Practices and Strategies: The Case of the Portuguese Central Public Administration

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The Circular Economy (CE) is generally examined as an opportunity to transform the current unsustainable linear economic system and to tackle its environmental and social challenges by redesigning the way organizations provide goods and services, rethinking how society consumes and uses those resources in a way that maintains their value at the highest level for as long as possible in the economy. In this context, the public sector is mostly recognized as a significant actor of the CE transition having the potential to enable the implementation of a sustainable CE through governmental interventions and policy-making initiatives impacting both companies and citizens. However, there is a lack of studies considering the public sector at organizational level and how CE principles are and can be applied in the operational and strategic activities of public sector organizations. Research on CE implementation at micro level has focused on companies of the private and manufacturing sector. Given the importance of the public sector not only as a policy-maker but also as an example of good practice, it is important for public sector organizations to be aware of and to consider their organizational contribution to the CE and to a more sustainable production and consumption system. In order to explore this as yet overlooked area of the economy, the aim of this study is to identify CE practices, organizational barriers and organizational change strategies supporting the implementation of CE in central public sector organizations. In order to fulfill this aim, this research is taking a case study approach by conducting 14 interviews with public sector employees working on CE and sustainability issues in the Portuguese Central Public Administration and has analyzed governmental reports and legislative documents using qualitative content analysis. Applied to a public sector context, this research has the potential to bring awareness to stakeholders and practitioners working on sustainability and CE issues in public administration as well as to increase the understanding of how the public sector is taking up the concept internally. The results of this research are ongoing and forthcoming.

The relevance of social themes and concepts while moving towards a circular fashion industry: A comparative analysis of publications

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As second largest sector across the world, the fashion industry has been faced repeatedly with scandals and accusations in terms of environmental and social burdens due to long-prevailing linear production and consumption patterns of 'make-take-dispose'. Economic pressures and rising general public awareness, however, have been accompanying strategies to reshape business models and to foster transitions towards sustainability. One of the most advocated approaches in recent years is the concept of a circular economy which is considered to aim at creating a restorative and ecological economy. It includes aspects such as closing loops, decoupling of economic wealth creation from natural resource consumption, designing out waste as well as shifting towards environmental and long-term resilience. Furthermore, the concept of a circular economy is considered to providing benefits for society. However, research on what aspects of a circular economy are actually essential for society and which could be potentially significant is scarce. This particularly proves true for research on the integration of the concept in the global fashion industry.

Rising pressure for (social) compliance has been forcing fast fashion retailers to newly develop or align their CSR policies. Increasing demands for socially responsible business operations and inducing systemic changes also extend to altering prevailing production and consumption patterns in the fashion industry. Yet, such profound changes are likely to require more radical, non-technological innovations. The little consideration of social aspects in a circular economy has been repeatedly criticized. In fact, potentials for including social sustainability in the concept involve aspects such as deeper changes of social values underlying the economic system and activity, thereby promoting non-ownership, low consumerism, social awareness, sense of community, cooperation and participation as well as increasing labor-intensive activities based on diverse and dignified work activities. Moreover, as circular economy concepts mainly focus on environmental, technical and economic issues and social issues are underrepresented, the main questions are how social sustainability is embraced in circular concepts, and how both are embedded in the fashion industry.

Drawing upon this shortcoming, the present study examines the integration of social sustainability-related aspects in corporate sustainability reports of the fashion companies C&A and H&M. It contrasts them with publications of scholars and stakeholders about sustainable and circular fashion between 2014 and 2018 by applying the software-based content analysis tool Leximancer^{TM}. We analyzed similarities and differences by comparing concepts of social sustainability and circular economy in corporate, academic and stakeholder publications.

The results delineate specific themes and concepts related to social sustainability in the fashion industry by comparatively assessing publications from the business, academic and wider public spheres. In doing so, the analysis reveals similarities and differences between various temporal and thematic courses of development among single players related to the fashion industry. The manifestation and integration of social aspects are identified and analyzed for each party to assess their trajectories of development towards more sustainability and circularity in the fashion industry. Our findings show that fashion companies have gradually been communicating more about social sustainability-related aspects opposed to academic and stakeholder publications. Furthermore, while single social sustainability-related aspects exclusively appear in each of the publication groups analyzed, others seem to reflect a mutual influence among the three parties involved. Yet, a considerable amount of aspects and themes relating to social sustainability remains that do not occur in any of the concept maps.

Circular Economy - Part 2

Closing phosphorus cycles with life cycle perspective

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Circular economy (CE) is a strategy to guide the transition of society from a linear-material-flow society to a closed-material-cycle model. This transition is a holistic and complete change because it includes human ideology, behavior, and performance. CE tried to close the material loops by reducing materials use, reusing second-hand products, and recycling wastes. In order to promote the transition of society, China has adopt the CE strategy for two decades and implemented it in practice with three ways, which are green firms, eco-industrial parks, and eco-cities. This study will introduce the CE pilots at these three levels and then, how to apply the CE strategy in closing phosphorus cycles in China. These approaches includes the quantifications of anthropogenic phosphorus pathways, improvement of phosphorus use efficiency throughout the supply chain, and recycling phosphorus containing wastes such as kitchen wastes, agricultural residues, and animal breeding wastes. More importantly, it was found that reducing the food consumption was the elementary way to sustaining phosphorus resource supply because it can reduce the inputs of phosphate rocks with consideration that more than 90% of phosphate rock is used to produce chemical fertilizers, feedstuff/food additions, and pesticides. This study improves our understanding of phosphorus cycles and more importantly help us to expore more effective ways of implementing CE in practice.

Collaboration for a circular economy in rural Luxembourg – the Circular Hotspot Wiltz

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Studies from all over the world claim that the circular economy is well established as a solution to meet the goals of sustainable development. At the same time, as the concept constantly evolves, academics, as well as professionals, still see a need to consolidate its definition, boundaries, and principles. As a consequence, some authors request more research on the social and institutional aspects of the circular economy. Since 2014, the Grand Duchy of Luxembourg's national policy aims at transitioning the economy from a linear to a circular model. Moreover, since 2015, Wiltz, a municipality in the Luxembourgish Ardennes, 50 km northern of Luxembourg-city and close to the Belgium border, performs as the national circular hotspot to showcase implemented circularity. Thus, the overall aim of the CIRCULUX research project is to analyse the effectiveness of the circular economy policy in Luxembourg by studying institutions and practices in businesses. The study follows a qualitative research design, including documentary analysis, 20 exploratory and 55 semi-structured expert interviews with representatives from the public and the private side conducted between 2017 and 2019. The research grounds on social practice theories adapted by relational and institutional economic geography in the aim to capture different dimensions of the motivations and barriers for shifting towards circularity. The results of the empirical study put forward that the understanding of the circular economy concept is generally good; most of the interviewees are familiar with the relevant publications and stakeholders working in the field. Although well informed about the theoretical foundation of circularity, the interviewees are partially sceptical about the time horizon of the implementation of a circular economy in Luxembourg. Some think that the companies are not ready yet, and transitioning change will not happen within the upcoming five years. Others argue that circularity does not always make sense and nobody knows if a circular economy performs better from a holistic point of view than the 'business as usual'. Besides, the circular economy in Luxembourg is, first of all, a political vision, initiated by the government and since then continuously promoted by public authorities through pilot projects. So far, initiatives that foster a circular economy mainly concern construction and urban development projects, e.g. in the circular hotspot municipality of Wiltz. The masterplan for the new urban development 'Wunne mat der Wooltz', for instance, integrates circular planning criteria for materials, water management, energy, and social cohesion. This masterplan development brought together decision-makers from public authorities, and the planning team constituted of architects, urban planners, and engineers. This integrative planning approach in such an early stage of a development project is considered key in sustainable construction and circular economy. Over fifty people worked on this masterplan and contributed to its finalisation within one year. However, implementations in Wiltz witness the importance of the state in all the projects. Without the commitment of local and national authorities (i.e. municipality of Wiltz, Housing Fund, Ministry of the Economy), the concept of a circular economy in Luxembourg would not anchor in any standardisation. In the talk at the ISDRS conference 2020, the focus lies on strategies to transition towards a circular economy in Luxemburg. Different scenarios, drawn from the interview data, will be presented and discussed, taking into consideration the theoretical framing of the study.

Corporate reporting of Circular Economy: An overview of current reporting trends

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The concept of Circular Economy (CE) is promptly moving towards an integration with organisational sustainability initiatives and approaches. Companies are leading the transition, with the principles of CE providing new opportunities for innovative products, services, business models and social responsibility practices. This increased CE commitment from companies demands the development of best practices and guidelines to ensure successful and consistent external communication. Sustainability reports allow companies to display not only their sustainability objectives but to increase transparency of their business activities. As the CE model gains momentum in the private sector, reporting remains a viable pathway for companies to attract future investments and the likelihood of increased CE implementation. Governmental bodies and international institutions, such as the European Commission, are increasingly adopting and promoting CE as a key strategy to transform society and accelerate progress towards sustainability. This is evident most recently in the Commission's 2019 publication "The European Green Deal" which will not only introduce a new CE action plan but will also revise the Non-Financial Reporting Directive. However, the validity and assurance of CE to deliver progress on all dimensions of sustainability remains uncertain. Content provided within sustainability reports is likely to be increasingly examined, to ensure that companies are implementing and assessing CE in a reliable and verifiable way. With the current absence of standardised guidelines for reporting of CE implementation and assessment, it is not clear if the concept of CE is an opportunity or a challenge to improving the legitimacy of the field of corporate reporting. This paper aims to create the foundation of knowledge on how the concept of CE is currently being assessed and externally communicated within corporate reports. This central aim of this paper is to determine how companies are reporting CE and how this reporting has changed over time. Using a content analysis approach, an extensive review of company sustainability reports, integrated reports, CSR reports and annual reports was conducted. Purposive sampling was used to include reports only from companies associated with national and international level CE networks. The sample of collated reports includes publicly available reports (accessed via the websites of each company), published over a time period of 2012-2019 (since the first publication from the Ellen MacArthur Foundation in 2012), without any limitation by sectors. By including reports over this time scale, the change in CE reporting of a company was also assessed in line with the change of a company's sustainability strategies. Preliminary findings suggest that there is no consistency between approaches to integrating CE within company reporting. Moreover, the majority of reports reviewed present sound sustainability performance assessment, however, companies remain primarily narrative and vague in their communication of CE. In some instances, the terminology used within reports has changed from labelling an operation as sustainable to being circular, without any actual reported change in processes. The preliminary insights obtained from this content analysis have established an overview of the current landscape of corporate reporting of CE. These insights have created a basis for future research, to develop a reporting framework which includes guidelines to inform corporate communication of progress toward circularity.

Decision-making support to develop products for a circular economy: actors, tools and information flows

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The population growth and economic boost experienced in the second half of the 20th century has not only posed severe environmental pressures on the planet, but also fallen short in consolidating more equitable societies. The conciliation of healthy ecosystems, thriving communities and prosper economies has been addressed through the Sustainable Development Goals (SDGs). In this regard, the concept of circular economy is of great interest because it is viewed as an operationalization for businesses to align their activities with global targets. For businesses, circular economy (CE) means adopting several value-retention options (Rs) along their operations. These aim at preserving and recovering the integrity of their assets and products for as long as possible. These strategies encompass long-established end-of-pipe interventions such as recycling or recovering the energy of products. Nevertheless, preferred options occur before that point - e.g., products' redistribution, refurbishing or reusing. The process by which products are made fit for these strategies is product design, in which around the 80% of the total environmental impact of a product is determined. The choice of a certain R determines product characteristics that might present a trade-off with other Rs. These dependencies and mutual exclusivities open room for circular loops with a higher impact than others, originating lock-ins in insufficiently sustainable loops or environmental rebounds. These risks highlight the importance of developing decision-making support to influence the design phase. This descriptive study aims at contributing to decision-making support development by mapping the current tools, users, lifecycle-wide information flows and company processes supporting designers' decision-making. The research has followed an empirical approach and has combined a literature review with in-depth semi-structured interviews conducted to product developers and sustainability experts working in companies operating in the technical cycles of the CE. The findings reveal that along the design process phases, key decision-makers evolve from strategic to operational. The reason for that stems from the close interlinkage of product design with other core aspects of companies, such as the business model. The decision-making support tools transition from being participatory to data driven. Consequently, the nature of the information used evolves from qualitative to quantitative. Sources of lifecycle information and collection mechanisms have also been mapped, showing a higher frequency and standardization of exchanges with upstream actors – suppliers of materials and product parts. Collection of information from use phase occurs driven by compliance, liability or market analysis activities. The findings also point at occasional or absent exchanges of information with actors managing the end of life of products, preventing the understanding of the R strategy products actually follow. All in all, this research highlights the importance of aligning the scope of the intended impact of a design – whether it only entails product-level implications or aims at higher systemic changes – with the involvement of decision-makers who have a proportionate area of influence and their subsequent requirements on providing an effective decision-making support.

Exploring the need for integrating mechanisms in circular business models

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The project 'Smart Sustainable Composite Products' (CompDetect) is a partnership between three Norwegian composite producers and a research institution active in the period of 2018-2022. Emphasis is put on containers for liquefied petroleum gas, which are exported worldwide. Research is needed to develop suitable, low-cost damage detection techniques in order to ensure long product life time. Moreover, there are currently no available techniques for material recycling of these products, leading to high end-of-life costs. In short, CompDetect aims to develop more circular business models based on materials with attractive properties, such as high strength, resistance towards corrosion and low weight. The project is based on a cross-disciplinary setting where 'smart' technologies is used to ensure damage detection, e.g., through sensors integrated in the products, and chemical recycling is tested in a lab setting. Moreover, life cycle thinking and business model frameworks are used to explore the strategic relevance of the new technologies. A preliminary finding is that conceptual framing is key to unleash the potential for more circular business models. Originally, the research was organized in specialized work packages with little awareness of the cross-disciplinary potential of combining the somewhat conflicting technological needs of longest possible lifetime and material recycling. However, by conceptually framing this is a both/and problem, the research approach has become more open-ended. This has led to exploring of new technologies, e.g., mechanical recycling, as well as including product design as a possible integrating mechanism that can ensure both extension of product lifetime as well as value creation from discarded products.

Packaging re-use in the circular economy: an LCA evaluation for Italy

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Re-use is among the most important tools to increase the lifetime of materials and products, preventing the generation of waste and reducing the need for final sinks, and this is especially true for packaging. For this reason, it is important to have an overview of the re-use of packaging items in Europe and to quantify the environmental benefits of such practice.

The pluriannual research described in this paper has started with a qualitative and quantitative assessment about the practice of packaging re-use in Italy. Thirty-eight types of packaging items that are currently re-used were identified. For each of them, the constituent material, the market of use, the sector of use, the main basic characteristics (e.g., size and/or weight), the possible reconditioning process applied, and the type of service based on which is managed were defined.

Then, a Life Cycle Assessment (LCA) was performed for some of those packaging items that require a reconditioning process, i.e. intermediate bulk containers, steel drums for the transport of chemicals and petrochemical products, reusable plastic collapsible crates for fruit and vegetables distribution, and refillable glass bottles for the delivery of mineral water in the domestic and Horeca sector. For each typology, the life cycle perspective was used to assess the impacts of the packaging as a function of its number of uses (the so-called “rotations”) and to quantify the contribution of the main stages (production, reconditioning, distribution, and end of life) to the total impacts of the life cycle. Moreover, each assessment investigated if the analysed system based on re-use performs better than an equivalent system based on single use. These LCAs were performed mainly with primary data about the packaging system, collected through tailor-made questionnaires and field surveys at some facilities located in Northern Italy. The adopted methodology and the main results are reported in the paper.

Transitioning towards a circular forest-based bioeconomy in Finland: A three-phase expert assessment

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The European Union (EU) promotes bioeconomy as one solution towards a carbon-free future. The bioeconomy encompasses the production of renewable biological resources and the conversion of these resources and waste streams into value-added products, such as food, bio-based products, and bioenergy, replacing fossil-based fuels and materials. Together with circular economy as another prominent policy concept, they are jointly shaping the future development of forest-based sector. Finland makes a prominent case for this with the forest-based sector having a long tradition and contributing strongly e.g. to regional development and export income, and with recent pledge to national level carbon neutrality toward 2035. This study assesses the sustainability of the transition towards a circular forest bioeconomy in Finland by focusing on three segments: wooden multistorey construction, fibre-based packaging, and
biorefining). We approach this topic of circular forest bioeconomy from two complementary aspects by asking the following questions: i) what are most relevant policy instruments to steer sustainability driven transition, and ii) how is sustainable consumption and business developing toward future in 2060. Our study investigates the emergence of a circular bioeconomy in the Finnish forest-based sector by using the two-stage futures research approach, followed up by a long-term backcasting exercise toward 2060. In total, we contacted over one hundred bioeconomy experts, 42 of which agreed to participate in the workshops. Each workshop was initiated by brief presentations from the industry, policy, and consumer views that guided the topics and questions discussed in the small groups. In the second stage, the analysis was complemented with a survey for workshop participants excluding the project researchers. Based on expert opinions-based research approach during 2017-2019, the results indicate that the perception of sustainability in the circular bioeconomy transition relies on resource-centric views concerning the improved environmental performance of forest-based products compared to fossil fuel-based products. We identified various policy instruments supporting the creation of new and the destruction of old practices in the circular bioeconomy transition, enabling us to discuss the motivation of increasing the interaction in the business and consumer interphase. Backcasting phase in 2019 enabled us to identify possible pathways to circular forest bioeconomy all the way until 2060. Our results call for more transformational regulation and stronger incentives for meeting the circular bioeconomy aspirations. For this end, the support for small firms at the local level, promotion of co-operation between companies, and smoother environmental permission processes, would also enable more efficient exploitation of industry side streams. We also conclude that better alignment with climate-mitigation policies and R&D policies may improve the integration of the upstream part of the forestry-wood value chain in the sustainability considerations of the wider circular economy development.

Zero-waste Campus: From concept to practice

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Following rapid urbanization and improvement of living conditions in developing countries, people's consumption behaviours have altered, leading to an increase in municipal waste quantity and changes in components. This problem is especially significant in China, and has imposed heavy burdens on the end-of-life disposal of wastes, mostly incineration and landfill. The Government of China started the "Zero-waste City" initiative in 2019 to encourage each "unit" in the city, including community, company, and school, to reduce and separate its own waste. However, most efforts have been focused on communities and universities, while secondary schools and the younger age group have been neglected. Construction of a zero-waste campus in secondary school context not only relieves pressure for municipal administration, but more importantly, educates teenagers to adopt a more environmentally-friendly consumption pattern. Therefore, we launched a zero-waste program in Nanjing Foreign Language School, which consisted of three steps. First, based on field surveys we characterized the quantity, composition, and monthly variation patterns of campus waste throughout a year; second, we explored factors that caused waste generation with the methods of literature review and face-to-face interview; third, we provided recommendations to reduce, reuse, and recycle wastes on campus. Results show that the total waste generation was about 98.0 metric tons in 2019 and the majority was food wastes, followed by plastics, papers, and garden wastes. Based on our analysis, we provided suggestions on waste reduction and recycling including: 1). providing food in the cafeteria based on surveys so as to reduce food wastes, 2). on-campus recycling of food and garden wastes with composting technologies, 3). working with student organizations to separate recyclable wastes. This study managed to combine planning with actual implementation, and provided a feasible model for zero-waste in secondary schools. Finally, this study also explored the possibilities of introducing composting to recycle organic waste.

Circular Economy - Part 3

Circular Economy: An alternative growth model?

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In recent years in order to strike a balance between ecology and economic growth there has been a shift in measuring growth from neo-classical frameworks to alternative growth models such as de-growth, steady-state economics and circular economy (CE). Amongst these, CE has gained immense traction in the recent past as a means to tackle the issue of the current consumption and production model based on continuous growth and increasing resource throughput .CE is often regarded as an economically suitable solution aspiring for sustainable growth amidst mounting environmental pressures.Through examination of the literature we quite unsurprisingly find that the current literature on CE business models is typically centred around the growth driven motive of the firms. In another body of CE literature, we find that it is used as a national development policy by countries such as China promoting the development of eco-industrial parks or larger eco-cities thereby mobilising CE as a strategy to fuel economic growth. These revelations from the literature motivate us to formulate a hypothesis suggesting that existing work on CE pre-supposes a capitalist context economic growth-oriented focus.

There have been studies that have aimed at establishing a quantitative linkage between CE and growth indicators however there is no study which performs a systematic empirical analysis to uncover the relationships between CE and economic growth in literature. Hobson et al., 2016 in their study critically address the concept of CE as an economically suitable solution aspiring for sustainable growth amidst mounting environmental pressures overlooking the social and political implications of such transformative agendas. They argue that, whilst many CE interventions and experiments have led to technological, material and business advances, radical transformation requires diversification of the current CE frameworks to accommodate de-growth and down-scaling of the current production and consumption patterns. The prevailing dichotomy of the growth or no-growth linked to CE remains a point of contention and we aim to clarify that. The research question that we aim to answer is: In what way is CE related to economic growth according to narratives in CE literature?

Our literature database has over 3000 articles on CE and from these we automatically extract sentences that verbatim quote “economic growth” or “GDP”. We then use axial coding , a qualitative grounded theory technique for theory development. The axial coding framework allows to synthesize and organise data into more coherent, hierarchically structured categories. Based on this we uncovered four narratives from the literature i.e.,vulnerable growth, eco-economic decoupling, fostering continued growth and growth critique . Narrative categories were assigned to each of the sentences manually. From the first three narrative types it can be established that CE has been mobilised as a strategy for continued (sustainable) growth, rather than degrowth and reduced consumption. Meanwhile, growth critique narratives establish that in order for CE frameworks to be successful, it needs to incorporate the ideas of degrowth and reduced consumption.Further, in order to scale up the assignment of categories keeping in mind the growing CE articles we train a text classification model that can automatically predict the narrative category using the manually annotated narratives as a training dataset. The predictions from the text classification model demonstrate that the assignment of narrative categories can be reproduced not only by other human coders but also through an automatic method.

Keywords: circular economy, economic growth, narrative analysis

Designing the foundations of a dynamic company-level CE assessment framework

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Transitioning from a linear to a circular economy (CE) has become a fundamental approach in national and EU-level policy to address systemic sustainability issues. Companies are expected to play a large role in this transition, since they are the entities that extract natural resources and transform them into products. They can use CE strategies to reduce their environmental impact while creating social value and profitability. A new field that focuses on how companies could measure their degree of 'circularity' and subsequent impacts on the three sustainability dimensions has emerged: it is part of assessing micro level circularity (i.e. products, organizations, supply chains). However, questions regarding *key desired properties* of a CE assessment framework, particularly with attention to ensuring final implementation, have currently not been addressed in much detail. In this paper, a critical review of evaluation approaches is used to extract key desired properties of micro level CE assessment, in order to design a preliminary dynamic assessment framework. More precisely, 74 approaches, methods, and tools to evaluate micro level circularity have been collected through a systematic literature review. These 'CE evaluation approaches' have subsequently been reviewed from a descriptive (methodological), normative (contribution to Sustainable Development) and prescriptive (implementation-focused) perspective. The two main results from the review are that (1) the collected evaluation approaches are highly heterogeneous in terms of their methodological foundation, and (2) only roughly a quarter (27%) of the collected publications includes the needs and wishes of the end-users in the design of the approaches. Building on this, the first result signals the importance of harmonization of the methodological structure of CE assessment approaches, while the second points towards the necessity of applying a transdisciplinary collaborative approach to better understand company needs for CE assessment. The key desired properties that resulted from the review are also divided into the three review perspectives mentioned earlier: i) *methodological perspective* - CE assessment should be based on existing (environmental) assessment methods such as Life Cycle Assessment, it should allow for sector-specific inputs if necessary, and an assessment framework should offer the flexibility to be applied on either product or organizational scale, depending on the goal of the assessment; ii) *normative perspective* - we argue that CE as a concept is valuable only when positively impacting the three dimensions of sustainability (environmental, social, economic) while also carrying information about the 'resource efficiency' – circular – domain; iii) *prescriptive perspective* - the assessment framework should be accompanied by operational and implementation guidance and the end user should be involved in the design of the approach. These identified *key desired properties* allowed to design a new company-level dynamic CE assessment framework. It is called dynamic to indicate it allows for sector-specific changes based on company needs. Future research will include participatory collaboration with SMEs to provide insights into the practical feasibility of the framework. Its alignment with the organizations' specific needs in CE assessment will then be investigated, after which the framework is further adjusted and, finally, implemented.

Environmental and economic impacts of Portugal's transition towards a circular economy

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The transition towards the circular economy is recognized as a fundamental part of a carbon neutral, resource efficient and competitive economy. Countries and regions must prepare for the impeding societal transformation, building on existing capacities but avoiding one size fits all solutions. As many other countries, Portugal established their roadmaps towards the circular economy, identifying several key areas and measures to support the transformation. However, Portugal still lacks a comprehensive and detailed analysis of the current state of affairs and the possible impact of circularity and resource efficiency measures. Available information shows that Portugal's resource productivity is significantly below EU average values, but this can partially explained by the country's economic profile. In this work, we present a detailed analysis of Portugal's standing in terms of resource efficiency and circularity at the sector level and compare it to other European countries. The analysis is based on an allocation method which combines input-output tables from the World Input-Output Database and the European Environmental Accounts and results in sector-specific material consumption. This approach allowed to us to conclude that Portugal is lagging in the construction and related sectors, with significant impacts in the upstream supply chain, as well as in the machinery and equipment industry. However, Portugal leads in sectors such as the textile and apparel sectors, which is expected due to Portugal's specialization in these sectors. These results helped us to define a set of objectives associated to the transformation towards the circular economy, which include, for example, industry-wide higher resource efficiency, dematerialization of the construction sector and increasing recycling and energy recovery rates. We then determined the economy and environmental impact of these measures using an environmental extended input-output model. The proposed measures would enable a 28% reduction of domestic raw material extraction and 5% of material imports by 2030, in comparison to 2015. The economic analysis required further assumptions, namely the allocation of the surplus created by increased resource efficiency. We considered that this surplus will ultimately contribute to increase final demand in a one to one relation. We concluded that there is a negative economic impact in resource extraction sectors, but that is greatly compensated by the increased economic activity in sectors such as recycling and the increased final demand. We estimate that the net economic impact of the proposed measures would be approximately 2.2 billion euros by 2030, around 1% of Portugal's GDP. These analyses suggest that it is possible to conciliate economic and environmental benefits and that Portugal must address the low resource efficiency of the construction sector and the dependence of fossil fuels imports.

Evaluating the impacts of Waste of Electrical and Electronic Equipment policies: Historical insights and experiences with extended producer responsibility in the European Union

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Waste Electrical and Electronic Equipment (WEEE) poses a considerable socio-environmental challenge. The volumes of WEEE are projected to increase in subsequent years. Whilst its complexity, in terms of weight, diverse and potentially hazardous components and quantity of scarce materials (e.g. rare metals in smartphones include Yttrium, Terbium and Dysprosium), makes the adequate collection and processing a challenge. On this basis, the policies for organizing such practices are of great importance. Circular Economy (CE) is a major research and policy subject in the European Union (EU), concerned with resource depletion, altering consumption patterns and waste reduction. As CE moves from theory to implementation more research is needed on existing governance (actors, processes and policy) contexts to support future developments, in particular for complex WEEE streams. This research examines the effectiveness of extended producer responsibility (EPR) policies (as an example of an established CE practice) in the EU member states of Italy, France and the Netherlands. Since 2002, WEEE within the EU has been governed under the 2002/96/EC Directive, with modifications from 2012(19/EU), which set specifications on collection, processing and reporting. However, policy implementation is left to the member states. This research explores the organization and evaluates the impact of WEEE policies within these member states from 1997-2017, with particular attention to the continuing effect(iveness) of the EU Directives and their national equivalents. This proposal follows a mixed-methods approach, including a quantitative examination of WEEE generation and treatment figures and qualitative interviews with constituent actors, e.g. policymakers and EPR representatives. We develop a baseline to estimate WEEE consumption and generation from 1997, which is used as a reference point to examine actual trends in case study countries. Policy effectiveness is explored by presenting actual figures compared to the baseline and targets reached. This is contextualized by qualitative reflections and insights from associated actors on how policy regime and system has functioned. Research and results ongoing/forthcoming.

Framing and assessing the emergent field of Business Model Innovation for the Circular Economy: A combined literature review and multiple case study approach

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Unsustainable patterns of production and consumption are pushing the economy beyond natural planetary boundaries, thus requiring an urgent shift towards a sustainable trajectory. In recent years, the Circular Economy (CE) has been promoted as an effective contributor to Sustainable Development and, even though there has been a broad interest on the concept, the business community has been slow in adopting its principles. Widespread adoption of sustainable and circular business models is required to accelerate the transition, however, the literature supporting the process of business model innovation (BMI) for the CE - or Circular Business Model Innovation (CBMI) - is currently emerging. Though several publications on the topic have been published since 2014, there is still a lack of understanding on the process of CBMI, particularly for incumbent firms; and, as the majority of the literature is theoretical, further empirical insights are required. Furthermore, there is no comprehensive review that provides an updated overview of the research field and there has not been an attempt to integrate the already established BMI field to the emergent field of CBMI, which can be considered as a subset of the former. The present research aims to first, map and frame the field of CBMI, building upon the structure of the BMI field; second, to assess the current state of research of the field, proposing a future research agenda; and third, to explore the most relevant elements of the CBMI process in the practice. The article uses a combined literature and multiple case study approach, starting by synthesizing a BMI framework, based on four highly cited systematic reviews on BMI, which is then combined with the findings of a systematic literature review (n=64) on the emergent field of CBMI, to propose an original CBMI framework that frames and structures the field. The research field has three streams, namely (i) the conceptualization of CBMI, (ii) CBMI as an outcome, and (iii) CBMI as an organizational change process. This article focusses on the elements, distinctiveness and research gaps of the third stream, the change process. The review includes an assessment on the state-of-research, based on the number and level of analysis of the studied articles. The framework is then validated through a multiple case study on incumbent firms that have implemented a substantial CBMI (n=13), revealing which topics are more relevant from a practice perspective. Future research should prioritize those topics that are very important or important from the practice and still un-researched in the CBMI field (i.e. organizational culture, organizational inertia and ambidexterity as moderators of the CBMI change process) or under-researched (i.e. sustainability strategy and dynamic capabilities as antecedents of the CBMI change process; top management role and change management as key elements of the CBMI process; and organizational performance implications of the CBMI change process). The Sustainable BMI literature is integrated to propose contributions to the aforementioned gaps. The results of this research contribute to the emergent CBMI literature, by framing and assessing the field of CBMI, proposing a future research agenda, and will aid practitioners interested in innovation for the CE, by identifying the most relevant topics of the CBMI process and guiding future literature research.

Industrial Symbiosis Incentives: Mitigating risks for facilitated implementation

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Industrial symbiosis (IS) is considered as a business model of the circular economy. This business model proposes symbiotic exchanges, also known as synergies, between companies, allowing the flow of resources, wastes and utilities. In recent years, the IS initiatives (Eco-industrial parks, Urban Industrial Symbiosis and symbiotic exchanges) have been exponentially growing around the world. This increase is related to raising environmental awareness and the opportunities to obtain economic, environmental and social benefits through the implementation of this model. Despite the exponential growth of IS initiatives, the companies are still facing problems in the achievement of reliable and permanent synergies, especially those without antecedents and IS background. Over the years the literature has identified several factors in the IS emerging process. Incentives are among these factors, being defined as unlocking tools or mechanisms related to diverse areas such as: economic, political, social, intermediaries, process, technology, etc. Authors believe that the large-scale implementation of IS incentives has not been properly addressed. In order to promote facilitated IS implementation and achieve a replicator effect, incentives should be fully addressed. In many case studies, it has been observed that the incentives for IS can be threatened by risks, compromising the implementation and hindering the emerging process. The aim of this paper is to contribute to unlock the emerging IS process, based on incentives identification, implementation risk identification and proposal of mitigation actions. With this purpose, this study developed an incentive identification framework based on the best practices of IS; a risk assessment model, based on internal and external risk factors and finally, a set of mitigation actions directed to the stakeholders. The main result of this study is a risk assessment model for IS implementation. The proposed methodology in this study, can be a useful tool for companies aiming to start symbiotic exchanges. This model might allow companies to have a facilitated implementation, allowing companies to prevent waste of resources in the emerging IS implementation process.

Plastic policies: the contested visions of a circular future in the Netherlands

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This paper analyses the discourse and policies of the circular economy (CE) in the plastics sector in the Netherlands. In the last 10 years, the CE has become a major discourse, with proponents in the public and private sectors expecting many economic and environmental benefits from the application of circular solutions. The Netherlands seeks to become fully circular by 2050 and the EU has set ambitious circularity targets in its CE Action Plan of 2015 and its European Green Deal of 2019. The plastics sector, in particular, has gained a lot of attention as it is a priority area of both the EU and Dutch CE policies. However, there has been little research on the different and often contested discourses, governance processes and policy mechanisms for the transition to a circular economy and society. This paper aims to fill these gaps by asking what circular discourses and policies are being promoted by different government, corporate and civil society actors and what are their sustainability implications. It does so through a mix of media (newspaper) analysis, policy analysis, semi-structured interviews, and participatory workshops focusing on the plastic sector in the Netherlands. This research is based on the circularity discourse typology developed by Calisto Friant, Vermeulen, and Salomone (2019). Preliminary results indicate a dominance of technology and growth-based imaginaries, and a general lack of discussion on holistic, and transformative post-capitalist visions, which integrate the full social, political and ecological implication of a circular future. For a more diverse discussion on the CE and a more comprehensive mix of circular policies and practices, this research promotes a better governance of the circularity transition, which integrates a plurality of transformative circularity discourses.

Seeking clarity through the plastic transition: "Turning points", "windows of opportunity" and legislative options in the UK plastics packaging food industry.

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The ubiquitous nature of used discarded plastics, particularly for single-use food packaging, and their associated environmental impacts has recently attracted public and political concern in the UK. Addressing this significant global environmental problem however will require urgent and sustained long-term at a range of political and spatial scales. Recent initiatives from the EU include the European Green Deal (2019) and Circular Economy Action Plan (2018) whilst in the UK, a potential UK packaging tax (HM Treasury, 2018) to encourage recycled content, a voluntary industry "Plastics Pledge" and a number of other policy initiatives have been suggested. These actions mean that legislative change is imminent with the potential to make an important contribution towards a more sustainable and resource-aware future. Yet poorly considered policy choices carry the threat of unintended barriers to more sustainable material choices and path dependency. Transitions theory and the Multi-level perspective (Geels, 2018; Markard et al., 2012) propose that there are "windows of opportunity" in which significant changes can be made to alter unsustainable use of resources and enhance environmental innovations. Yet the role of legislative and policy change as opposed to more long-term changes in public and business attitudes and behaviour is not clearly understood. We report on an innovative inter-disciplinary project in the Humber region, "Evolving a Circular Plastics Economy" which examines how local stakeholders perceive the changing plastics landscape, particularly for single-use food packaging and their expectations and understandings of current plastics usage. We draw on data from interviews and focus group discussion with industrial stakeholders including food manufacturing firms, packaging manufacturers, local authorities and waste firms. We find that local stakeholders were keen to respond to consumer demand and reduce their use of plastic but seek long-term clarity on policy goals since the current perfectly adapted and incrementally improved nature of much plastic packaging means that there is limited incentive to change their behavior and considerable fear of the costs involved in doing so. Our analysis shows that the combination of factors in the wider landscape including increased plastics awareness and legislative change means that change is at a tentative tipping point on the interstices between the concepts of the landscape and regime. Contrary to theory, innovations appeared to be driven by large retailers decision-making and their interactions with suppliers, taking account of current waste infrastructure. The rationale for these decisions however was not always clear and suggests that industry decisions are being taken in a knee-jerk anti-plastic fashion without consideration of the long-term consequences, or consideration of the whole life-cycle effects of alternative packaging options. In contrast to theoretical suggestions, many firms actively sought policy clarity to guide decision-making. At this important tipping point therefore, it is unsurprising that no clear outcome is yet clear.

Sustainable Value Chains and Trade

A classification of new data sources for sustainable product management in a circular economy

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The information and communication technology architecture of a company and its dynamic adaptation to technological developments such as the Internet of Things, Big Data, artificial intelligence, blockchain (collectively known as digital technologies) are of relevance to implement a sustainable circular economy. The sustainable circulation of resources could be seen as a means to an end for sustainable development. For organizations, the goal is to investigate under which conditions their products are designed and used to maximise sustainability performance and circularity. Making informed decisions in this context means that the sustainability and circularity performance of products needs to be assessed on a case-specific level. These assessments, however, are time, effort, and data-intense endeavours. At the same time, it is not yet clear how and which data could and should be collected and shared along the product life-cycle to assess the product's sustainability and circularity performance as a prerequisite for a sustainable circular economy. This research gap is addressed by adopting a sequential mixed-methods approach combining (1) a systematic literature review of 375 documents, (2) a quantitative analysis of 233 and qualitative content analysis of 154 selected articles, and (3) a cross-disciplinary focus group with ten (industry) experts. The main results of this work are: (1) a synthesis of findings and descriptive review of articles concerning digital technologies for sustainable product management (2) an understanding of potential and existing application cases of digital technologies for sustainable product management (3) insights from industry experts regarding their sustainable product management experiences and practices as well as existing and potential new data sources for sustainable product management along a product's life cycle. Finally, the key findings are contrasted to other studies, and an outlook for further research is given.

Managing knowledge-based value chains in a changing business environment, whilst maximizing translational impacts

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The paper is based on management research program related to ZalaZONE Proving Ground and its ecosystem. The research results and themes shown are run in order to study and understand features of knowledge-based value chains in rapidly changing business environment, whilst striving for maximizing translational impacts. The summary report consists of three fields which are understanding impacts of new technologies, classification of business and research entities in view of their characteristics in order to develop a comprehensive business model approach and developing method to evaluate translational economy impacts of complex value generating structures. The current paper summarizes the actual status and current outcomes of the related researches.

The complex nature of buyer-supplier relationships and their role for the sustainability of global cocoa value chains.

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Swiss chocolate manufacturers are facing several sustainability issues ranging from deforestation to low farm gate prices and child labour. Several chocolate manufacturers are trying to improve their value chains by introducing environmental and social standards, monitor suppliers, and engage in supplier development. However, there is little evidence on the impacts of these measures on overall sustainability of the cocoa supply chain and literature suggests that high-quality relationships between buyers and suppliers are an essential element for achieving sustainable value chains.

Past research on relationship quality in buyer-supplier relationships has highlighted the importance of trust, power, information flow, and commitment. These studies have largely focussed on relationships between companies within a value chain, and existing assessment frameworks mostly focus on these relationships. Assessment frameworks developed for companies, however, are not suitable to assess relationship quality as perceived by smallholder farmers in agricultural value chains. So far, little attention has been paid to the buyer-supplier relationship within agricultural supply chains, and an in-depth understanding of the perceptions and behaviour of farmers and buyers along the cocoa value chain is missing.

The main aim of this study is to gain in-depth knowledge of how the actors along cocoa value chains interact with each other, how they exchange information, and what social and cultural rules apply. Real supply chain settings with large numbers of farmers were examined to understand how such a social network influences sustainable cocoa production and processing, as well as the emergence and solution of conflicts.

Based on literature research, we developed a data collection framework covering the main characteristics of relationships: commitment, satisfaction, dependency, power, trust, information flow, and transparency. Semi-qualitative interviews were conducted with 200 cocoa farmers and their intermediaries within two case study value chains: i) Fine flavour cocoa from Ecuador being sold through local intermediaries and an international export company to a large Swiss chocolate company; ii) Organic-certified cocoa from Uganda being sold through a national export company to a small Swiss chocolate brand. Data collection was embedded in a large-scale sustainability assessment project, which allows analysing the link between buyer-supplier relationship and farm-level sustainability performance.

Preliminary results from the first case study showed high satisfaction and commitment levels for both farmers and intermediaries. Over 60% of farmers indicated that intermediaries did not pay adequate prices to them and more than half the farmers received a loan from their intermediary. This suggests that farmers' trust towards intermediates was limited while their dependency on them was quite high. Nevertheless, both parties appreciated their, generally longstanding, collaboration. An in-depth analysis of the buyer-supplier relationship in the two case studies will provide an insight into the social mechanisms on the farmer and intermediary level of the value chain. Furthermore, it will show how these relationships are linked to sustainability performance on the farm level.

The findings will contribute to the understanding of relationships along value chains and their connection to sustainability performance. Main factors influencing relationship quality will be identified and effective means to improve the buyer-supplier relationship will be proposed. By considering and addressing the buyer-supplier relationship quality, chocolate brands could increase the effectiveness of their sustainability activities. This study will provide valuable insights and lessons on how buyer-supplier relationships within agricultural value chains can be assessed.

The role of external agents in collaborative sustainable supply networks

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External agents such as consultants and brokers are identified as key elements to moderate collaboration in eco-industrial networks as they facilitate knowledge sharing and trust among member organizations. Their role is considered determined for improvement of network performance. This research explores the role of external agents in a sustainable supply initiative in Colombia based on evaluations of participating firms. Literature on external agents and sustainable supply collaboration underpin interviews carried out to ten different service providers who participated in a sustainable supply initiative.

Outcomes confirm the importance of external agents influencing collaborations with suppliers and between supplier and anchor firms through facilitation of alignment of visions and providing new information. Moreover, external agents with different professional profiles presented homogeneous performance in terms of environmental and economic benefits produced by the various supply networks. The contributions of this research add to literature by identifying the specific role of external agents in collaborative eco-industrial networks. Likewise, the study confirmed the wide application of the sustainable supply model used in the Colombian initiative, were external agents with different professional profiles contributed to homogeneous economic and environmental benefits.

Towards a working definition of a Smart Mix

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Since the concept of 'Smart Mix' was first proposed in the late 1990s, many authors have embraced the term as a potential approach for promoting sustainable development in the global South. The author of the OECD due diligence guidelines: John Ruggie, suggested that achieving significant progress would require moving beyond the mandatory vs. voluntary dichotomy to devise a Smart Mix of reinforcing policy measures. However, research into whether the Smart Mix approach can truly create change has been hampered by the lack of a working definition of what such a mix actually is, which has led to claims that the concept is based on a false assumption that the private sector will voluntarily undertake public tasks. The aim of this contribution is to examine different sectors to identify a) whether reinforcing policy measures exist in the real world, and b) whether they do promote sustainability in supply chains by motivating voluntary change in the private sector. Identification and examination of such mixes was taken as an approach to finding a working definition. Following the principle of maximum variety, five sectors were chosen as case studies: conflict minerals, palm oil, timber, single-use plastics, and finances, and each of these sectors was examined using desk research complemented by 10-12 expert interviews per sector. A three-step procedure first identified an inventory of policy measures relevant to the case, then evaluated the interactions between the measures, and finally evaluated whether there was an identifiable improvement in the performance based on the interaction. The results showed that such interactions do exist and that they can provide a means for governments in consuming countries to influence behaviour by the private sector, and industry in particular, located outside their jurisdiction. In other words, the concept appears to be sound. Policy mixes were found to be particularly effective in promoting due diligence by industry stakeholders and in encouraging the voluntary participation by industry in cooperative organisations, such as alliances and accords, which can collectively adopt standards and require a commitment by members. These findings enabled us to create a working definition of Smart Mixes that appears useful in both identifying Smart Mixes and in diagnosing cases in which goals might be better achieved with the addition of complementary measures. We define a Smart Mix as a *"mix of measures that includes at least one binding public measure; accompanied by at least one voluntary cooperative measure that gives guidanceto the actions that should be undertaken to achieve stated objectives;and at least one voluntary private measure that must have consequences outside the jurisdiction of the intervening government. The mix of measures must interact and thus improve the achievement of the objectives of at least one of the measures.* The results of this study allow the conclusion that the Smart Mix concept is indeed a promising approach to promoting sustainability in global supply chains in which parts of the chain lie outside the jurisdiction of the governments with the sustainability goals.

Sustainable Consumption And Consumers

Catch Me If You Can – reduction of food loss and waste during the spread of COVID-19

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Food security and food waste are one of the most cardinal challenges of the modern world. Since the early eighties, international organisations like the UN and the FAO have worked on assessing and solving this challenge and it is because of their work, that we now know the extent of food wastage. In 2011, and estimated amount of 1.3 billion tons of food has been lost or wasted in the food supply chain all over the world, which is about one third of all the food produced. The ecological, social and economic implications of this amount of wastage are severe and developing and developed countries each have a role to play in solving this matter. This role was further confirmed by the creation and ratification of the Sustainable Development Goals (SDGs) by the UN in 2015, where sustainable consumption and food waste play a significant role in a number of goals, directly or indirectly. Several studies have assessed the generation of food waste through the Food Supply chains (FSCs) demonstrating the most common challenges in both upstream and downstream phases. Challenging that, the estimation of food waste levels is growing despite the fact that the measurements have several difficulties concerning the reliability. The estimation of food waste may lead to mitigation when businesses, households, communities take the responsibility to intervene.

Concerning food waste levels Gustavsson et al. (2011) found that food losses occur rather homogenously across regions, representing one-third of each region's food wastage, while the level of food waste varies much more significantly, from 4-16 percent in low-income regions to 31-39 percent in middle and high-income regions. But in both cases, it results in environmental impacts, such as waste of resources (e.g., land, water, energy, materials) and associated emissions and their intensity and extent vary according to local context and type of commodities (FAO, 2013). This pattern was also confirmed by other regional and national investigations. For example, according to the European Commission's investigations (EC, 2011), food waste generated in the 27 countries of the European Union was estimated to be approximately 89 million tons each year (or 179 kg per capita), where 42% was originated from households, 39% from processing, 5% from distribution, and 14% from catering services. It further noted that 60% of the household food waste is avoidable, while most of the food loss during process is unavoidable. A recent study in 2016 again acknowledged that household contributed the most to the food waste generation (47 million tons ± 4 million tons) in EU-28, followed by processing (17 million tons ± 13 million tons), both of which represented 72 percent of total EU food waste (Stenmarck et al., 2016). These estimations are valid for peacetime, not for COVID-19 times: from panic buying at grocery stores to restaurant closures, is bound to inflate those percentages, as several experts say.

Current study has to dedicated purpose: at first we demonstrate how the current coronavirus pandemic might influence the food waste patterns through the Food Supply chains (FSCs), at second what kind of solutions are available for potential reductions. By applying desktop research, we will map priority stakeholder actions according to the food waste hierarchy.

From Brown to Green: Developing and Validating a Scale Quantifying Switching Costs From Conventional to Eco-friendly products

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In a consumerist society confronting an environmental crisis, green consumption arises as a liberal alternative to contribute to the wellbeing of the environment without compromising the quality of life nor the quantity of consumption: a consumption that has a lesser environmental impact (Liobikienė & Bernatonienė, 2017). This green alternative has been on the market for over four decades now, however, switching from conventional to green consumption has been a difficult step for consumers in their sustainability journey. In fact, while consumers state their willingness to contribute to a cleaner environment, they often fall short when it's time to take real action. This phenomenon is known as the green intention-action gap.

Research on the subject has identified a number of barriers that prevents consumers from switching to the greener alternative, however, there has not yet been a formal study that develops a scale to quantitatively assess the weight of each of these factors in green decision making. For this reason, and based on an extensive literature review on both the green gap from the environmental psychology literature and the switching costs from the service literature, we develop a scale that quantifies switching costs involved in the choice of Eco-Friendly Products. This paper draws on the analogy between purchasing services and purchasing green products, as both of these purchases are perceived as high involvement decisions (Bell, Auh, & Smalley, 2005; Tarkiainen & Sundqvist, 2009)

Through a multiphase scale development process, we first generate items based on both existing scales and primary qualitative data. We then purify the items through a confirmatory factor analysis of data collected from over 200 participants by the means of an online survey. Finally, we assess for predictive validity and discriminant validity between the different categories of the switching costs tested through two empirical studies.

Our results (Study 1) show that nine different types of switching costs are related to the eco-friendly purchase: 1)Pre-switching search and evaluation costs, 2) Costs of lost performance, 3) Uncertainty costs, 4) Learning costs, 5) Sunk costs, 6) Monetary costs, 7) Brand relationship loss costs, 8) Sensory appeal costs, and 9) Variety loss costs. Detailed results concerning the variability of each category of switching costs will be presented at the conference. This research provides managers and decision makers in the green industry with an instrument to assess the weight that each category of switching costs holds in preventing consumers from accomplishing the green purchase. Additionally, by comparatively measuring each category of these switching costs, this scale allows decision makers to adapt the marketing mix strategy based on the most nuanced type of switching costs in a particular product category. It also provides insights to strategically shift the consumption to a cleaner level, thus contributing to the transformation of the society through sustainable consumption and sustainable living.

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Motivation for using ridesharing systems - case study of Hungary

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Ridesharing in Hungary is operational since the end of 2007; in the last 12 years, 775 000 users rode 6.5 million rides (blog.oszkar.com). Almost 8% of Hungary's population registered on the platform. These numbers are showing that ridesharing is a popular way among people. There are numerous researches about sharing economy from different perspectives and about a various point of views. Although the literature lacks research about the motivation of sharing economy in transportation, especially ride sharing. There is some research about motivation among the sharing economy (Airbnb, Uber, carsharing) users asked. Our research focuses on motivations among ridesharing users in Hungary. An online questionnaire was created with the help of the Hungarian company (named Oszkár) to the users. There were different types of questions asked according to the users' habit and were grouped into four groups: drivers (regular and professional), passengers, and inactive users. Next to socio-demographic questions, we asked about the motivation for using ridesharing, but there were questions about their environmental and social effects as well. During the research, we tried to find answers to the following questions. 1. What is the primary motivation for registering on a ridesharing system? 2. What are the reasons for using the ridesharing system? 3. After registration, what is the reason for not using the ridesharing system (only for inactive users)? 4. What are the benefits and disadvantages of using the ridesharing system? Our hypothesis is that people are using it because of economic benefits and instead of public transportation.

Repairing the circular economy: public perception of the repair economy in Hull, UK

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Circular economy literature is increasingly recognising the necessity of shifting from a cyclical consumptive model to one that reduces production and consumption and slows the cycle of products and materials. Repair services are vital to the realisation of this ambition, while providing unique opportunities for employment and social sustainability. Many structural barriers to a thriving repair economy have been identified. For example, producers may view reparability as a risk to their market share, and therefore promote design for obsolescence and restrict access to replacement components or repair manuals. The cost of labour for repairing products also remains very high in relation to the cost of replacement. There are several opportunities surfacing which address these structural barriers, including the Right to Repair movement, and national-level legislative action for the promotion and affordability of repair. In addition to existing structural barriers, it is also crucial to recognise the role of the user in supporting a repair economy, as user perception will affect the demand for such services. From a user perspective, access to and awareness of services, consumer culture, and lack of trust in the quality of repair have been identified as barriers in the literature. This paper aims to contribute to this literature by presenting the results of a public survey from Hull, UK. The city of Hull has been historically disadvantaged compared to UK national indicators, and recent statistics indicate that the city still ranks relatively low in employment, income, and skills and training dimensions. There may, therefore, exist a particular opportunity for the city to realize the social benefits associated with an expanded repair economy, such as increased employment, affordability, quality of life, and social inclusion. The overall aim of the survey presented in this paper was to understand how a thriving repair economy might best be supported in the city of Hull. The survey was developed and disseminated through a partnership between the University of Hull and Hull City Council. 740 Hull resident responses were analysed. Findings indicate that the main barriers to the repair economy in Hull are cost (both replacement cost and cost of repair services), access to and awareness of professional repair services, and lack of skills and confidence to repair products at home, all of which are supported to some extent through previous studies. The assertion that lack of trust in the quality of repair services is a major barrier is not supported by this study. The study also reveals a high willingness to participate in the repair economy as a user of professional services, and as a DIY fixer. Furthermore, demographic and value orientation associations are identified to develop a profile of individuals likely to participate in the repair economy. The authors conclude that promotion of existing repair services, a focus on repair skills education, the development of specific strategies to target pro-repair individuals, and adoption of strategies for structurally lowering the cost of repair services are essential to a thriving repair economy.

Socialpsychology of World Problems in the Mirror of Changing Value Systems

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This paper presents our recent analysis of representative surveys conducted through personal interviews to assess the relationship between the perceptions of world problems and the changing value systems and lifestyle in Hungary. The original study forms a part of an international endeavour to establish the extent to which the agency described by Paul Ray as *cultural creatives* is present in various parts of the world, including the US, Japan, France, and Italy. The second basis of the research are our unique investigation in three different waves of the Hungarian adults opinion about the most important world problems.

There is no question to study the comprehensive public opinion of matters of the world. Which is in the frontline of the international organisations (as UN), which is the leading subjects of the scientific research as the problems of humankind. And also essential to know our constant and changing values with their implications to our lifestyle.

The purpose of this investigation is to understand the interpretations of different subcultures (value systems) on serious issues. The yearly reports of many specialized institutions of UN indicate disappointing trends, implicate effective and efficient interventions. The results can help us to understand the peoples' view and ranking of our great problems.

We use three waves of representative surveys with interviews about world problems, and one big survey of values systems with many focus groups and personal deep interviews to understand the reasons of changes. The subcultures of the society is based on K-means clustering of values.

Our analysis focused on identifying groups with distinct value and lifestyle patterns and evaluating the behavioural and demographic characteristics of these groups. We identified three clusters: about forty percent of our sample demonstrated materialistic orientations; another forty percent was more inclined towards humanistic values, while the remaining twenty percent scored low in both value sets. We intend to show that demographic variables are not decisive in defining group membership. We then examine relationships between cluster membership and ordering patterns of world problems. The rankings are so robust, with no significant social or demographical differences. The clusters are the same stable distribution in this subject.

Our conclusion is that the main dimensions of value clusters, as the acceptance of ecological and feminine values, responsibility for the local environment, social networks, self-development, social sensitivity and responsibility, and non-materialistic values are related to worldviews of our great problems. We can base some new initiatives about the worldwide refugee crisis, unperishing armed conflicts, slightly decreasing starvation, increasing inequalities, and, in the first place, the unsustainable consumption.

Sufficiency and Affordability: the Demand Side of Degrowth

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It is increasingly obvious that for reaching the Paris Accord climate targets, let alone more comprehensive environmental sustainability objectives like dematerialisation and sustainable land use, the supply side policies of "sustainable production" will not be sufficient, even if they go significantly beyond the current hesitating small steps. Fortunately, strong sustainable consumption as demand side transformation offers potentials for safeguarding environmental sustainability of the same order of magnitude as production-focussed supply side policies, once eco-efficiency measures are complemented by sufficiency. However, the demand side management potentials of a sustainability transition have so far been underinvestigated by sustainable development research, and have hardly been addressed and mobilised by public policies. One key reason is the past dissatisfying experience with the most popular forms of consumer policies, i.e. information campaigns and product labelling. We hold that this failure is not due to a lack of potential, but to an ineffective approach not least caused by an inappropriate theoretical basis. So far, most demand-side efforts are conceptualised based on the hope that more information will change behaviour, a hypothesis derived from the Theory of Planned Behaviour TPB. In its most simple version often underlying consumer policies, it holds that knowledge will change the decision calculus, and more knowledge about environmental impacts would lead to a more sustainable consumption pattern. Hence the focus on gains (win-win, quality of life, happiness, …) and less on responsibility, community or the common good. While some authors consider TPB to address conscious as well as routine behaviours, the mechanisms they assume to link knowledge and behaviour is de facto only applicable to conscious decisions. Addressing these weaknesses, Social Practice Theory SPT analyses practices as social phenomena, institutions which are populated by humans as carriers. It focusses on habits and routines, i.e. non-reflected decisions, often repetitive, which are the vast majority of all decisions humans take. Practices evolve and adapt to a changing social and physical environment, and if in the course of such changes different practices or different elements of the same practice get into conflict, the people populating a practice may choose to abandon it and switch to another one. Thus the Theory of Planned Behaviour TPB and Social Practice Theory SPT offer different views on consumer behaviour, and on ways to change it through social innovation. However, both bodies of theory underestimate the insights of political economy and political science into the motivations for and obstacles to practicing specific behavioural adaptations. We thus suggest to combine the relevant insights (not a synthesis as the different ontologies do not permit defining a shared epistemology), letting them populate different dimensions of the human decision space. To make this complex structure politically operational, we introduce the "Prism of Sufficiency Policy" which distinguishes four dimensions of affordability of change, and offers hints how to support such change by effective policy interventions in a multi-pronged, four dimensional policy approach. We compare these suggestions with empirical findings and conclude that (i) effective interventions are possible, (ii) they have to address several dimensions of affordability simultaneously, and (iii) the sufficiency policy space prism can be a useful tool in structuring planned interventions.

Sustainable Consumption and Production in Cities:

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Cities have emerged as focal points for transitions towards sustainability, which is becoming increasingly urgent because of accelerating urbanisation trends. Whereas many cities around the world are already developing climate adaptation visions, pathways and action plans, limited attention and efforts are dedicated to Responsible Consumption and Production (SDG12). Nevertheless, SCP in cities contributes hugely to the environmental footprint of cities, to a large extent due to importing products that are produced elsewhere. In theory on Sustainability Transitions, one of the starting points is that novelty emerge in niches, which can evolve around new sustainable and social innovations, including new sustainable and alternative consumption practices. This paper presents two cases using a niche-transitions framework combining a transition multi-level perspective analysis with a Stratetic Niche Management evaluation of the emerging sustainable consumption niches . Two cases in two different continents are presented. The first case consists of Circular Urban Agriculture in the Dutch city of The Hague consisting of three initiatives: (i) the Edible Park, a local permaculture initiative, (ii) Urban Farmers, a vertical farming business, and (iii) Haagse Zwam, a micro-firm that collects coffee waste locally, which is used to grow mushrooms. The second case consists of internet biking in the Chinese city of Hangzhou. The case describes the rise of internet biking initially leading to a quick increase of both internet biking firms competing among each other and issues on the streets and other public places, which were successfully addressed. These two cases illustrate opportunities and relevance for SCP in cities and also show that SCP in cities is a matter of addressing different domains of consumption, while local production and prosumers are important, as well as that it requires social innovation. A final point is that more attention and research is needed on how SCP and CE in cities relate one another and what possible synergies and pitfalls can be.

The social representation of sustainable food consumption and the role of SFSCs in the way towards sustainability

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The global food system faces several challenges concerning ecological sustainability, and robustness in the face of shocks and global change (EC,2019). We already know how to be sustainable; we are familiar with the planetary boundaries and future scenarios, and we have developed strategies (such as Sustainable Development Goals of the United Nations) based on vast scientific evidence. The necessary technology is present, sustainable diets are calculated. Still, the key and often missing element remains the consumer when we aim for real success in holistic change. What encourages some of them to make additional effort intending to act in a sustainable and responsible way? Why do they believe in one hazard, like GMO and not in the other, like health issues due to overconsumption of meat? The attention of this study is directed, on one hand, towards a special approach: social representation theory (Moscovici, 1961) examining what sustainable consumption means for end-users? On the other hand, we turn towards the farmers, and with field research, we examine how local farmers contribute to sustainable food production and what is the role of short food supply chains (SFSCs) in sustainable food systems.

As we better understand the values and meanings of the food chain participants we get closer to the ideal tools and means to innovate resilient and sustainable food systems, what is the faraway objective. Social-psychological studies have unexploited potential to enrich and contribute to the studies of sustainability. Social representations are systems of social influence and communication that constitute the social realities of society. Turning back our reasoning to sustainable food consumption it might be interesting to see what given concepts mean to the consumers we try to incentive to act according to our understanding of the given concepts. In this study we assume that these understandings differ indeed, and for the sufficient incentivisation of consumers towards sustainable food consumption and general behaviour; a better understanding of their reality brings us closer.

An altered version of the associative network technique (de Rosa, 2002); a free association game has been used, and 3 different groups participated: local food consumers, local farmers, and a control group of consumers. The local farmer's markets (mostly also falling into the category of SFSCs) where the producers and consumers were included in the research were situated in the Balaton Upland, Hungary; while the control group of consumers was collected randomly. The free association research is still in progress, but some concepts representing a strong relation with the concept of sustainable consumption are already emerging, like local, rural, health, green, plastic, bio, vegetarian, chemical, food waste. The suggestions of the initial data and this exploratory research will be supported by word categorisation and analysis as well as with SPSS data analysis, where we hope for exploring connections between the personal characteristics and sustainable consumption concept of the consumers and the comparison with the local producers.

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Travelling from bad times to good times: footprinting carbon and pleasure of tourism

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With its annual growth rate of 4%, tourism is one of the fastest growing consumption areas, a major source of pleasure and 8% of the global carbon footprint. Reducing carbon footprint is not possible without significantly changing travelling habits. Our paper studies the extent to which people's perceived subjective well-being would be affected by an assumed change in travelling habits and the likelihood that they would voluntarily do so.

After a literature review on the travelling behaviour of young citizens in different countries, results of two empirical studies are compared. First one was carried out in 2013. It examined young adults' adaptation strategies when their income declined significantly due to the economic crisis. Focus group studies showed that in such situation people change their travelling habits as first reaction, foreign tourism is replaced by domestic tourism, or travelling is given up completely. We expected to experience significant reduction in subjective wellbeing but surprisingly, when travelling to foreign destinations was replaced by domestic holiday, this change had only short term negative impact on the subjective well-being of participants. They reported to have immediately adjusted to the new situation and enjoyed their holiday in the domestic destinations the same way, provided they were with their friends or family. After the economic crisis, most respondents returned to previous habits, adjustment to externally restricting circumstances seemed to be short term. However, some sustained the more frugal lifestyle from intrinsic motivation and appreciated its benefits, acknowledging spending leisure time with beloved people as main source of pleasure, not the destination primarily.

The second study of 2019 focused on the young generation, grown up after the economic crisis. In a research with mixed methodology students had to calculate their carbon footprint by three different calculators and reflect on the results, individually and collectively. We found that travelling is a typical form of entertainment for young people and is seen as a great source of joy. Regarding consumer behaviour (related to food, mobility, housing and secondary consumer goods), travelling habits were reported to be the most difficult to voluntarily give up, and most people were convinced to experience habitual change as painful. Higher consciousness of negative impacts of tourism on climate change and the environment did not seem to result in higher willingness to change travelling behaviour.

The lesson of the two studies is that in the field of tourism, one cannot expect a large proportion of young people to voluntarily switch to more environmentally friendly travelling habits. This shift may be triggered by external constraints – economic shocks, drastic price increase or regulation. Forced change in habits make young people to adapt surprisingly easily to the new situation. Perceived level of their subjective well-being can be quickly restored, provided that change is carried out together with those who are important for them. However, maintaining behavioural change for a longer term remains a challenge which has to be addressed in order to not return to environmentally damaging travelling habits.

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Where to stay while travelling?

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The United Nation created the World Tourism Organization, which implemented all the Sustainable Development Goals into the tourism industry and have not only goals to achieve but actively supports organizations and enterprises in practice. By focusing on Europe, there are many different ecolabels for example, which can give a certificate to hotels and tourism accommodation. I compared the European, the Scandinavian and the Austrian Ecolabel and as my result I can say that the main goals are the same: less water, electricity consumption and produced waste, but there are differences in details regarding some fields like training employees for example. In my work besides international guidelines, I present specific hotel(chain) examples of the EU, Austrian and Scandinavian eco-labelled hotels, supplemented by some hotels' own perceptions and experiences, which data is available on their websites and I also have some information as a result of questionnaire responses. My most important researched chain is Scandic Hotels, which exemplarily monitors and develops its hotel members for sustainability and economic growth at the same time.

While analysing the Hungarian situation, I visited dr. Vilma Éri, Lead Certification Director of the Eco-labelled Product and European Eco-label, who shared with me the draft certification for Hungarian restaurants. In addition to this analysis, I also studied the Green Hotel Certification established by the Association of Hungarian Hotels and Restaurants, examining the composition of successful applicants. In addition to the eco-labels and official international initiatives, I also found it interesting to introduce Ecobnbs activities, which is an alternative, eco-friendly accommodation-advertising start-up company. The Italian-based accommodation search website is a platform, where you can choose from eco-labelled accommodation only, the conscious tourist can select the environmental requirements of the accommodation.

The motivation from the customers side is not as high as it could be in the future, my questionnaire results showed that young people would mostly choose eco-labelled accommodation if the renting price is not higher than in case of non-eco-labelled accommodation.

Agriculture And Sustainability

A paradox : mercantile organic against sustainability in Europe ?

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The food market for organic products is soaring in Europe. The standard governing organic farming in the European Union is public in nature, but there is a derogation for certain non-EU origins. These provisions allow the supply to continue to grow in order to support the exponential development of the market, but we assume that they have other effects. The market aggressiveness of “organic” in Europe influences the market shares available for alternatives, which could be considered more sustainable than “organic” practices for two reasons: the quantities produced are greater and at modest prices; technically, it happens that a commodity cannot be grown everywhere in organic[1], while alternative practices are available everywhere. We are studying the case of dessert bananas for export, a leader in organic and conventional fruit and vegetable products in Europe. We conducted surveys among stakeholders (producers, exporters, ripeners, wholesalers, supermarket retailers, researchers) in the conventional, “organic” and agro-ecological sectors (not certified organic). We analyzed the exchanges according to two axes: the evolution of prices by type of sector over the last 10 years; the consumers’ feelings towards the different sectors. The first result is the continuous decrease in value added in the organic sectors, by distorting competition between suppliers. The example of bananas is emblematic: the value of organic products at the import stage fell by 50% between 2016 and 2019. The second effect is consumer uncertainty, who is not sure that the product is really organic. The third effect is that non-organic labels have difficulty existing. While there is a consensus that organic (compliant) will not succeed in feeding the entire population, the omnipresence of organic (under its various avatars) is an obstacle to the emergence of an alternative supply under good economic conditions. The banana sector, and more precisely that of Guadeloupe and Martinique, has not succeeded in promoting highly innovative cropping systems that are increasingly consuming less and less in terms of inputs. As a result, the market is opposed to the generalization of agro-ecological practices, whereas this would be a considerable improvement in the sustainability of the sector. However, it is to be hoped that things will change because consumers’ mistrust of certain origins (particularly from third countries) is leading to a segmentation of the organic market, which could adopt “two speeds”. The notion of local, associated with organic farming, gives a high premium to the product. Some distributors are interested in this famous 3rd way which would allow them to create a segment between conventional (entry-level) and organic products. For the moment, initiatives are timid in the face of an organic offer that is still gaining ground in the field of communication.

[1] For example, “organic” bananas are only possible in dry tropical climates (or with low humidity), while agro-ecological practices can be spread to all banana plantations around the world.

A system dynamics model to assess the impact of the current global phosphorus supply chain on the world's regions to 2050

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By 2050, food demand for the growing world population is expected to increase by 60%. Phosphorus (P) is one of the three main macronutrients without substitutes used in agriculture, alongside nitrogen and potassium. The biogeochemical P flow also constitutes a Planetary Boundary and is one of the main causes for eutrophication worldwide. As such, the global supply chain of P is a key factor not only in matters of food security, but also when it comes to sanitation and the state of aquatic environments. The concepts of global P scarcity and peak P have been widely criticized. However, global P resources are unevenly distributed throughout the world, which poses pertinent questions with regard to P availability at regional level. At the same time, rates of phosphate rock processing, and P application and disposal, also vary greatly depending on the world region. A cradle-to-grave regional assessment of P is thus needed in order to provide a better understanding of the social, environmental and economic dynamics that will shape the global P supply chain in the coming decades. Such an assessment can also inform progress on Sustainable Development Goals related to food security, sanitation, sustainable consumption and production, and the state of aquatic environments. A system dynamics model is applied in this study, running data from 1961 till 2014 and projecting trends to 2050. The model links the global P supply to social, economic and environmental dynamics at regional level, dividing the world in eight regions. The structure of the model is based on a systemic analysis of the literature and the data originates from open source datasets and the literature. Preliminary results show that Southern Asia, Latin America and the Caribbean, and East and Southeast Asia will account for most of the future global P demand. Most of the population growth, however, will take place in Southern Asia and Sub-Saharan Africa. All these regions lack their own P resources and are thus highly dependent on P imports, which raises questions regarding future regional food security. Furthermore, most increase in P demand occurs in regions where eutrophication already has a negative impact on the environment and the livelihoods of local communities. While P can generally be removed from wastewater in wastewater treatment plants, such infrastructure is critically underdeveloped or non-existent in these particular regions. Moreover, considerable amounts of P enter water bodies through runoff from agricultural lands. This means an increase in P consumption will increase the amount of P in water bodies and further reinforce the eutrophication process. The trend can contribute to the extension of coastal dead zones. The study shows that global P scarcity aside, regional scarcity is a serious challenge for global food security in the coming decades. Moreover, the acuteness of negative environmental and economic impact of the global cradle-to-grave P varies greatly depending on the region. The model can be used to provide insights into how the global P supply chain affects the progress of Sustainable Development Goals related to food security, sustainable production and consumption, sanitation, and the state of aquatic environments. It also offers a better picture on how regional level trends impact the Phosphorus Planetary Boundary.

Assessing environmental benefits of winter cover crops in corn-soybean rotations in the U.S. Upper Midwest

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Corn [*Zea mays* L.] and soybean [*Glycine max* (L.) Merr.] rotations are the most common cropping system in the upper Midwest of the USA. However, such intensive agricultural rotation practice has a significant impact on the local resources, in particular due to high levels of soil erosion, nutrients leaching and run-off, and carbon emissions, as well as an overall loss of soil fertility. One of the most effective strategies to address this problem is the use of winter cover crops: they are able to reduce wind and water erosion, and contribute to a more efficient management of the nutrient cycles, by providing a soil coverage between main crops. In addition, some cover crops can be harvested and provide an extra income for the farmer. Nevertheless, due to the frigid temperature reached over the winter period in the U.S. Upper Midwest, only a few cover crops can survive the winter, limiting the benefit that such field management strategy can bring. In the last years, new winter-hardy cover crops have been introduced in the area, such as winter camelina [*Camelina sativa*(L.) Crantz] and field pennycress [*Thlaspi arvense*L.], but these species have not been extensively employed yet by local farmers. This study aims at evaluating the environmental impact of employing three winter cover crops – winter camelina, field pennycress and winter rye [*Secale cereale*L.] (the most common winter cover crop in the area) – within the corn-soybean rotation in the Upper Midwest. The results of field experiment in North Dakota, Minnesota, and Iowa were used to carry out a life cycle analysis (LCA) study. Impact considered were carbon footprint, eutrophication, human toxicity and ecotoxicity, wind and water erosion, carbon stock depletion, and impact on pollinators. The outcomes of the assessment showed a better performance for all three cover crops compared with the control (no cover crop) on eutrophication, soil erosion, carbon stock depletion, and pollinators, while only winter rye had a smaller carbon footprint that the control. The results of the study will be employed to inform local stakeholders (farmers, consultants, and agricultural extension agents) on the environmental benefits of winter cover crop the U.S. Upper Midwest as a key strategy to move toward a more sustainable agriculture in the region.

Efficiency differences and drivers behind them in Myanmar's state and regions

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Efficiency in agricultural production is crucial for developing countries. This statement is particularly true for Myanmar, where more than two-thirds of the population relies on agriculture for their livelihoods. By using a set of four surveys collected by the World Food Program during the period 2012-2015, this paper measures agricultural efficiency in Myanmar's states and regions using both a Stochastic Frontier Analysis (SFA) and a Data Envelopment Analysis (DEA), while controlling for geographical conditions. The results show that areas that are the traditional focus of agricultural policies (Shan State and the Ayeyarwady river basin) are highly inefficient. To understand this result, the paper analyses how differences in efficiency relate to which source of capital is available for the farmers, ownership of assets, and crop diversification. This analysis sheds light on the role of monitoring, credit constraints, property rights, and the production of market-oriented crops. Finally, the paper analyses the prevailing conditions in individual regions and states and discusses policy opportunities to increase efficiency in the different administrative units.

Is an alternative to private property sustainable in agriculture?

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1. *INRAE*

Since 1945, the European agriculture is losing farmers, in all the member states, while the average farm surface expends. The agro-industrial model seems to triumph everywhere. Yet many indicators notify its limits (soil fatigue, desertification of rural areas, effects of pesticides on farmers' health, poisoning ecosystems…). Facing these observations and the imminence of events threatening this agricultural model, the desire for sustainability calls for other paths developments for agriculture. They suggest creating small to medium size farms, performing agricultural practices that are conservative for ecosystems, labour intensive and connected to local markets. Some new business models already run (e.g. selling through AMAP) but the main challenge remains the access to land, especially for the new comers. Indeed, setting up new farmers is a necessity because the transformation will never be fast enough if you count on the current farmers only. For instance in 2017, land under organic farming stands for between 0.2% (in Malta) to 23% (Austria) of the cropland, i.e. in average 7% of the member-states croplands, from (UE, 2019). Welcoming new farmers is also a social necessity in rural areas. So, this research deals with the issue of the alternative to private property of land, such as experienced by the Foncière Solidaire created by the association « Terre de liens » in France, which collectively buys land (14 700 shareholders in 2019) to lease them to new farmers under long-term basis. The research question is therefore: "Is this alternative to private property of land sustainable?" Sustainability here means the permanence of farms, despite the on-going upheavals. In accordance with the works by Mignon (1998) and Macombe (2003) about the perennity of firms, we suggest that the values are the key, and values leading to perennity describe a certain conception of Justice. In practice, the discourses are consistent with the six axioms of the Grammar of Justice by Boltanski and Thévenot (1991) when implemented to a Local Common Good (Thévenot, 1993). The whole movement cannot last without the association Terre de Liens being permanent itself. We will highlight that the discourse (official communication) of the Terre de liens association calls on Justice, being consistent with the six axioms. The Grammar of Justice axioms are as follows: (a1) There is a common humanity ; (a2) There are different states among people, and they are not stable ; (a3) All the states are accessible to anybody ; (a4) There is an order among the states : The Grands who contribute to the Common Good, and the Petits, who do not ; (a5) To become Grand, there is a necessary sacrifice ; (a6) There is a Common Good which benefits to everybody (Petits and Grands) whatever their contribution. We also highlight that the main challenges are the evolution of regulations, and especially the annual financial laws, which set the rules for fiscal exonerations. Whatever these evolutions, it is likely that the association would achieve permanence because of the high number of actors (communes searching for farmers, applicants to taking or transferring farms, donors, shareholders) who are federated around its "Fair" raison d'être. Yes, there is an alternative to land private property in agriculture.

Modelling of supply chains in the organic fresh food segment in Russia

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The problem of the development of sustainable agriculture includes the social dimension as well as the economic and ecological ones. It's not reasonable to ignore the fact, that in rural areas in Russia are there many social problems including unemployment, low level of education and lack of young people due to migration to cities. In this context, development of organic fresh food segment can have a significant influence on a sustainable development of rural territories. Today, in Russia, the production of organic cereal has more prospects than before due to the export chances because of the global demand on the ecologically friendly products. The area of organic agricultural land in Russia increases in 57 per cent in period 2014-2015. What's more important, the average area of organic land per one organic farm is 4,696 hectares. It means, that large farms are more common in Russia, than small ones. This trend can be explained by to attractiveness of a crop production for export in large agricultural holdings. In addition to this, small organic farms don't achieve an efficiency due to high production costs, high risks and lack of governmental financial support. Short shelf life of organic fresh food should be considered by planning of supply chains. Requirement to use certified organic resources in production processes lead to implementation of the model of the circular economy in small farms. The geographical location of producers plays a major role in forming effective supply chains, affecting not only on transport costs, but also on duration of delivery of fresh food. The aim of the study is to determine effective supply chains in organic fresh food segment based on the modeling of transport costs and duration of delivery. The geographical location of organic farms is determined by economic, ecological and social factors. The effective demand on the organic food is concentrated mostly in European part of Russia. It's explained with the higher income of the population of big cities, such as Moscow and Saint-Petersburg. Economic, social and ecological aspects lied in a basis of selection of regions for the development of organic fresh food production. Authors determined the optimal transport costs and the optimal distance between producer and consumer based on the economic order quantity model. In our model, a fixed volume of production and fixed frequency of supply give the optimal variable transport costs affecting the efficiency of the supply chain. As a result, the authors determined regional spread of organic agriculture in the segment of fresh food near Moscow and Saint-Petersburg. The further question to be investigated in the area of organic fresh food production are optimal measures of governmental support including tax policy, optimal tools of implementation of principles of circular economy, cooperation between producers for co-use of limited resources for increasing economy efficiency in organic agriculture.

Sustainable agriculture for a sustainable society: experiences from agroforestry systems

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Sustainable agriculture is one of the key issues in achieving sustainable development goals. According to the Food and Agriculture Organization from United Nations (FAO) projections, the world agricultural production will have to grow by 70 to 100 percent by 2050 to meet the food demand of a population of more than 9 billion. In addition to population growth, increased life expectancy and climate change impose the need to optimize agricultural productivity. However, this optimization of productivity must be achieved in a sustainable and regenerative manner, reducing water and energy consumption, without harming ecosystems. Agriculture is currently the leading cause of deforestation in the tropics and has been occupying 70% of the world's pastures, 50% of savannas, and 45% of temperate forests. In Brazil, irrigation and agricultural processing represent 70% of water consumption. One of the most productive and regenerative agricultural systems is the agroforestry system (AF), which allows food production (even cattle) without devastating the forest. Besides, agroforestry can use syntrophic principles: nature's mechanisms to combine different cultivars, whose combination does not require pesticides, improves soil quality (through pruning), and produces water. This study aims to analyze regulatory mechanisms through the stakeholder's perspective of agroforestry system cases. The following research questions were formulated: (i), which are the most important regulatory mechanisms contributing to the eco-efficient agroforestry system?, and (ii) what dimensions of sustainability are getting the most attention? The multiple case study was performed on farms and other organizations in Bulgaria and Brazil. Twenty-seven agroforestry experts/farmers working altogether in 24 organizations operated in Brazil and Bulgaria have been interviewed. The study reveals that there is no yet established specific law for agroforestry (or syntrophic agriculture) in Brazil and Bulgaria. However, a few general regulatory mechanisms support or affect the agroforestry system and farms directly or indirectly. One of the challenges of policymakers is to create a specific legislative framework or law for agroforestry. Thus, the eco-efficiency of the agroforestry system and agroforestry farms will increase further. Some financial regulatory mechanisms and monetary incentives (e.g., subsidies or tax deductions) to set up an agroforestry farm could be considered in the legislation. Furthermore, a specific stamp for agroforestry products and a register for agroforestry farms could be established. Thus, the agroforestry farms' products could be further recognized in the market, and farmers will easier cooperate. As a result, we created a comprehensive framework that illustrates the key findings from the research divided into five directions. Our comprehensive framework and outcomes will support further the agroforestry farmers and policymakers.

Keywords: agroforestry, stakeholders, regulatory mechanisms, Brazil, Bulgaria.

Urban And Rural Transitions: Innovation Levers

Decentralized Policymaking when States can form Coalitions: How Does California's Waiver Authority Affect Environmental Outcomes?

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In the void left by federal inaction on climate change policy, many U.S. states have moved to significantly curtail the GHG emissions released by economic agents within their own borders. This, however, is at odds with much of the environmental federalism literature, which suggests that higher levels of government are better equipped to address global pollutants (e.g., Oates and Schwab, 1988). According to this literature, climate action by lower levels of government is likely to be frustrated due to leakage concerns. That said, uniform centralized policies that arise from political processes may fail to reflect the policy preferences of lower level governments.

In this paper we answer the following three questions. First, how does the delegation of waiver authority affect overall environmental outcomes? Second, how are the waiver standard and environmental outcomes affected by the potential for other states to opt into the waiver standard? Finally, how does the waiver standard respond to exogeneous changes in a sub-optimal federal standard? That is, does a reduction in the stringency of the federal standard lead the waiver state to also reduce the stringency of the standard it selects, or will the waiver state choose a more stringent standard to counterbalance the change in the federal standard?

We develop a rich but tractable analytical model of a closed economy with multiple jurisdictions. All jurisdictions except the waiver jurisdiction must either comply with an exogenous uniform federal emission standard or the endogenous waiver standard. A representative household in each jurisdiction is endowed with a mobile factor of production (capital), which is used by firms to produce a consumption good (e.g., vehicles). Importantly, consumption goods sold in each market must use end-of-pipe abatement capital (e.g. tailpipe emissions control) to ensure compliance with the appropriate emission standard. Initially, we consider a global, uniformly mixed pollutant, with marginal external damages from this pollutant that vary across jurisdictions. We then model the waiver jurisdiction's choice of a more stringent standard relative to the federal standard as a one-shot Stackelberg game. Conditional on an exogenous federal standard, the waiver jurisdiction selects a waiver standard that anticipates the coalition of other states that opt-in and the resulting competitive equilibrium. This framework captures the key features of the problem and allows us to decompose and interpret the key economic channels which determine endogenous coalition formation and the resulting waiver standard.

Having established the key economic channels that drive the decision-making process outlined above, we then analyze how the waiver standard and environmental outcomes respond to exogenous changes in a sub-optimal federal standard, with and without endogenous coalitions. We derive conditions under which a weaker federal standard induces a weaker waiver standard in the absence of coalitions, but induces a stronger waiver standard when coalitions can form. Thus, while a weaker federal standard worsens environmental outcomes, the waiver state and attendant coalition can serve as a check-and-balance on sub-optimal environmental outcomes.

Innovating waste governance to address social sustainability issues in emerging economies

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A growing number of studies and technological developments are opening new opportunities for recycling urban wastes (e.g. plastics, glass, tires, fibers) as construction materials. In addition to the environmental benefits of using secondary raw materials, these new applications can contribute to reducing production costs while improving the technical performance of construction materials. However, many of such applications require an industrial transformation process that might make these new materials not accessible to low-income communities due to economic reasons. As several studies have pointed out, particularly in developing countries, poor communities are disproportionately affected by natural hazards (e.g. earthquakes, flooding, landslides) and the low quality of housing is one of the main causes of such high level of vulnerability. In low-income communities and informal settlements many dwellings are self-built and lack a technical design process by qualified architects or engineers. Therefore, having access to better and cheaper construction materials can positively impact the quality of housing and reduce, to some extent, its overall vulnerability to natural disasters. In such context, applications that use low-tech solutions to recycle wastes into construction can become an interesting option for emerging economies and low-income communities. To seize such opportunity, it is essential to design and develop policies and waste management schemes able to 1) divert the flow of waste toward socially-oriented applications, and 2) facilitate the dissemination and adoption of new waste-derived construction materials by vulnerable communities. This research project identifies a new governance model to introduce a specific urban waste - scrap tires - as a construction material to improve the resilience of informal housing and settlements to natural disasters. A new governance system – built on the adaptive governance framework – has been designed and tested on two real-world experiments involving informal and low-income communities in Ecuador by employing a community-based participatory research approach. National policymakers, tire producers, waste management companies, NGOs, academia and local communities worked together to carry out a post-disaster reconstruction project and a disaster risk reduction initiative. This action research demonstrated that 1) using an adaptive governance framework has allowed to merge commonly unrelated topics - specifically waste management policy and vulnerability of low-income communities to natural disasters - and actors to identify new management solutions able to address multiple instances and common interests, and provide benefits to all parts involved; 2) regulatory institutions (policymakers) and “unregulated” sectors (informal and self-builders) can successfully work together; and 3) waste management strategies and policies can become an opportunity to address relevant social sustainability issues, in particular in developing economies.

Localizing SDGs to leverage policies through stakeholder engagement: a new research project in the Metropolitan City of Bologna, Italy

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The Metropolitan City is a peculiar administrative division of Italy with constitutional rank that became operative in 2015 (Italian Law n. 56/2014).

The Metropolitan City of Bologna aggregates the capital with 54 municipalities (51 of which gathered in 7 Unions) and counts 1,014,619 inhabitants, 12% of which are foreigners (ISTAT, 2019). The area, covering 3,702.3 km^2, is interested by a natural diversity and presents a prosperous productive fabric (Infocamere, 2018).

By statute, the Metropolitan City of Bologna has competence with regard to strategic planning; environment and territorial planning; economic growth and social development; mobility and infrastructures, and services to the municipalities. The authority is therefore in charge of identifying and coordinating development strategies for the whole metropolitan area.

Since its early life, the Metropolitan City of Bologna has been at the forefront of Sustainable Development. In June 2017, in the occasion of the G7 Environment Ministerial meeting, it promoted the "Bologna's Chart for the Environment" signed by twelve Italian Metropolitan Cities. The Chart is rooted in the international principles of the United Nations 2030 Agenda and aims at translating them into virtuous local practices. Specifically, it identifies eight topics related to the Sustainable Development Goal n. 11 and it sets out commitments linked to the European Union policy guidelines, indicates measurable goals and targets and defines the "national perspectives", necessary conditions for the Metropolitan Cities to achieve those goals.

Strengthening its commitment, the Metropolitan City of Bologna has placed environmental, economic and social sustainability as first of the foundational principles of the Metropolitan Strategic Plan 2.0 (2018), the operational guidance tool for the authority.

With the aims to guide the future political line and to enhance the grounds of its policymaking, the Metropolitan City of Bologna has commissioned a research project on the metropolitan development according to the SDGs.

The research, started in March 2020, is conducted by a multidisciplinary team made of different actors sharing a holistic approach. It os carried on by Urban@it – National Center for Urban Policies Studies together with two departments of the Alma Mater Studiorum–University of Bologna, namely the Department of Management (DiSA) and the Department of Civil, Chemical, Environmental and Materials Engineering (DICAM), and the Italian Alliance for Sustainable Development (ASviS). The objective is to clearly draw benchmarks on sustainable development at a metropolitan level, based on the SDGs and their targets taken as reference standards.

The research methodology has been preliminarily tested, and aims at drawing a picture of the current state of art on the goals linked to the SDGs as set at the international, European, national, regional, metropolitan, and municipal levels. Further, it foreseen a meaningful stakeholder engagement in all its phases.

Hence, the identification of goals and related indicators as set at higher levels will function as reference points at the metropolitan one. The novelty of this approach is to be found in taking all the SDGs and their targets as standards, therefore encompassing a broad range of sectors which is not limited to those strictly related to urban sustainability. The expected output of this project is to deliver a solid tool to positively affect the strategic planning of the Metropolitan City. Moreover, as desirable outcome, the research intends to draw a pathway to be followed by other Metropolitan Cities.

Resilient Nangang: Co-Producing Educational Programs and Curriculum for Elementary School in Face of Climate Change

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Although the official Adaptation Strategy to Climate Change in Taiwan was announced by the government in 2012, a new government guideline for school education was not in place until 2018. And in practice, it is still yet far from mainstreaming, since there are very limited examples on how this issue can be developed and fit to current curriculum. Given this institutional hysteresis, co-producing knowledge across related stakeholders is very needed for social innovation.

Based on a multi-stakeholder approach, this paper reviews the knowledge co-producing process among three different levels of educational organizations including the national university, community college, and elementary school. The demand of local knowledge and social change, in face of the climate change, created an abundant field for the three partners to work together. It started as an experimental educational program based on the pedagogy of experiential education, active learning and hands-on courses. Later it keeps developing toward a full curriculum for the elementary school students.

Our experience demonstrated how a multi-stakeholder approach to curriculum creation can bring new perspective and dynamics into the classroom. The research validates that a nonlinear and collaborative model will effectively enhance the process of knowledge integration. And four factors, including shaping vision, constant revise, open boundaries, and institutional supports are keys for knowledge co-production in education for climate change.

Socio-spatial understanding of the network of Budapest local centers

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Many towns and villages were amalgamated into Greater Budapest in 1950. Today, the extension area constitutes the outskirts of the city which is called the 'Suburban Zone' in the zoning system of the 'Budapest 2030' Urban Development Concept. Up to now, most of the former settlements have become sub-centers and local centers of the suburbia, where poor infrastructure, missing services and the lack of workplaces indicate stagnation (or even decline).

According to the UDC, the goal is to increase density and develop complex services at the sub-centers and local centers in the suburbia. Instead, we can witness the urban sprawl beyond control, caused by developers and individuals. Every urban designer who is engaged in regulatory planning can see the exploitation of land without respecting the goals of the Urban Development Concept. New developments lead to densification of greenfield areas and the negligence of built-up areas like sub-centers and local centers.

To form a more sustainable environment, planners have to reappraise the valuable heritage of historical urban fabric and map the unexploited resources. In order to understand the resilience of an urban fabric, it is crucial to analyse the hierarchy and the network of the centers in the city. It is important to know what the sufficient terms of centrality are. What kind of functions and institutions are needed? Does it depend on land use, density, or rather on morphology or socio-spatial institutionalized network? What is the importance of cultural-historical embeddedness, and what is the role of various stakeholders? And finally, what is the proper hierarchy of the different scales?

The terminology of the centrality is examined in practical, scientific, historical and international context. Scaling was necessary to find the contradictions and the synergies between the policy documents (strategic, development and regulatory plans), and the comparison of these documents and 'reality' (spontaneous processes) was inevitable. In order to detect the distortions under the different political regimes and economic processes, I compared development and structure plans from the birth of Great Budapest Concept up to present time. To find new intervention formats and adaptive governance methods, it was important to study other European capital cities.

Obviously, there is a big discrepancy between planning and practice. The two-tier local authority system of Budapest obstructs the cooperation between the stakeholders, and the hierarchic system does not provide any flexibility for the local governance. But international benchmarking proved that we can frame smart (agile) management and experimental methods, regulatory social innovations into the Budapest system to reform conventional development policy. The Municipality needs to regain its role as an initiator. Taking cultural initiatives and social innovation into the processes may give new importance to urban spaces and infrastructure.

In order to find a more sustainable approach, it is necessary to understand the limits of growth. In many cases, supplementary developments at a right place and/or time are more efficient than large structural changes. This means that urban designers have to find non-hierarchic planning methods and institutional systems. This innovation can result in organic urban structures that are more resilient than the 'organized' ones.

Urban Green Infrastructure in Transition: Case Study of Policy Adaptation and Transition Management in Taipei

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The advancement of urban green infrastructure (UGI) has been highly recognized and even adopted as key policy target by many cities around the world for climate change adaptation and sustainable transformation since 2010s. Owing that urban transformation through UGI or on it is about reshaping the urban socio-ecological systems in responding to climate change, its implementation and practices are mostly taking the experimental approach. It tends to take place through piecemeal patches of urban spaces with variegated forms of social or technological innovations and hopes to drive for structural change within cities. This attempt of transition management is indeed carried out under a complex and dynamic governance systems that need careful empirical investigation. The purpose of this paper is to explore how UGI has been used as a planning strategy for urban transformation with a context-based analysis. It is intentionally to situate the analysis under Asian city contexts for future comparison with the leading cities that takes the UGI approach for urban sustainable transformation. The paper uses Taipei City as case study to investigate the city's recent development of three types of UGI, which are permeable pavements, ecological parks and urban farms. They are used as examples of three generic types of UGIs, which are the green-grey integration, the old UGI in transition and the new UGI respectively. This study uses secondary data, spatial data, interviews, and field surveys as data sources to analyze the policy cycle, the social technologies, and networks of social practices to reveal the transition management of UGI in Taipei. By examining the policy thinking and planning process of three exemplar UGIs, it is found that learning from leading cities' experiences are significant. Nevertheless, the policy learning process reveals the process of local adaptation as well. It shows the result of hybridizing lessons from multiple origins, as well as the needs of fitting into the local institutional and social contexts. By introducing and experimenting these new UGIs, Taipei municipal governments use public property/assets or vacant/abandon lands as testbeds. The local adaptation processes on these places for the three types of exemplar UGIs shows various governance modes and social-technical exercises. The permeable pavements of the integration of green-grey infrastructure display a top-down initiative with city state and private sector playing major roles. While on the ecological parks and urban farms, the civil sectors are the initiators. Nevertheless, the bottom-up process does require the support from and policy initiatives of local state. In short, a diversified pattern of development on ecological parks and urban farms demonstrates ongoing social and power dynamics of the urban social system to shape various ecological landscapes of urban parks and urban farms.

Urban And Rural Transitions: Resilience And Adaptivity

Develop resilient cities – an example from Pécs, Hungary

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One of the main focus of research worldwide is the resilient and/or sustainable systems. In many cases a system can be resilient and at the same time not sustainable: a misfit within the planet's main system. Kiss and Kiss (2018) stated that resilience in socio-economic systems does not necessarily have the sustainability element (which is given in ecological systems "by nature") – it has to be added to the system. They used Ecological Network Analysis (ENA) to create a resilient system, a system, which has *structural resilience*, where the *sustainability element* is added by the projects. *They have elaborated a methodology, which is able to create a resilient system*. If there is a high level of (bio)diversity, but a lack of relationships between the elements, there is no resilience in the system, the system is very redundant: the system has many reaction opportunities, although it does not have the necessary operating efficiency. On the contrary, either in a case of only a few factors or high level of diversity, if the system is highly efficient, firmly bounded by mutual relationships, no place for change, this is mainly a fully automated system with zero reaction opportunities. The system is not resilient in either case. A "proper" resilience indicator, named *Fitness for Evolution* is also elaborated (Fs) by Ulanowicz et al. (2009). The restoration of non-resilient ecosystems needs appropriately planned interventions, although it is questionable whether – even when interventions promote the formulation of a sustainable and resilient system – the necessary changes can be made in a particular system. If the planned interventions are implemented, will they change the system's operation, or will these efforts only remain marginal, as external forces and/or existing internal processes overcome or neutralise these initiatives and leave the system on its original path? Based on the projects' impacts, an impact matrix can be created for the cities, which can highlight the more important decision points, the places of missing but important relationships in order to make a city more resilient. A system dynamic model is developed based on the flow matrix of ENA to test the result of the interventions. The developed models contain the main impacts of the planned investment and are capable of testing whether the impacts on a system can achieve the desired changes.

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Improving climate change resilience through risk communication supporting effective private risk reduction: Strategy making in the face of complex communicative options and motivation factors

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Climate change driven risks in urban areas increase pre-existing challenges of risk management. Often and for good reasons public risk reduction cannot be offered to all areas due to lacking efficiency or acceptability, because they are hardly compatible with the dense and multifunctional urban fabric (i.e. inundation) or because of the spatially unrestricted or unpredictable pattern of the hazard (i.e. heat, heavy rain). Private action and its effectiveness to reduce risk or damage has been described on several occasions. It is widely agreed, that private risk reduction despite cardinal challenges can play an effective part in reducing risk and improving resilience. However, communication between public authorities and "private risk reducers" lacks a sound basis of reflected communication goals and well-founded communication strategies.

Resilient and social just solution not only protect but also involve the potentially affected stakeholders. We propose, that targeted and well-designed communication strategies offer the potential to leverage the risk reduction potential of private actors affected by climate change induced hazards. On the one hand, strategy design implies that both public authorities and private actors recognize and accept adapted role models to allow for an efficient knowledge transfer and the implementation of effective risk reduction at private level. On the other hand, communication design requires a knowledge basis about communication options and their potential effects taken alone and in combination. However, systematic knowledge about communication options and their motivating or enabling effects remains fragmented and sound knowledge on the potentials of different options rather rare.

We address a part of this gap by systemizing knowledge about potentially effective communication options and their possible effects understood as communication success in motivating private stakeholders to act. The scientifically sound detection of effects of communication is a task addressed by ongoing research the results of which may help to fill the other parts of the knowledge gap described. We present an innovative approach to classify communication measures and provide a first overview of their potential effects. The proposed classification looks at individual and collective effects and on the directionality (mono- to multi-directional) of communication. And we present our approach to strategy design and an exemplary communication strategy designed to address individual and collective motivation factors. Finally, we discuss important design elements for successful communication at the level of strategies and single measures.

Keywords: risk communication, private risk reduction, climate change induced risks, risk management, resilience

Improving heat resilience of prefab concrete residential buildings – vulnerability, adaptation measures and structural implementation

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Rising summer heat is an unambiguous and robust climate change signal. In addition to an increase in mean temperature, it is likely that the number of extreme events is going to increase too. The summer of 2003 in Western and Central Europe as well as the summers of 2018 and 2019 in Central and Eastern Europe are prominent examples of heat summers with unexpected intensity. The associated change regarding the indoor climate of living and working spaces influences not only the comfort of the residents but also the mental performance, human health and mortality of the people living in these buildings. Thus, actions to reduce summer overheating are highly required, particularly in cities and densely populated urban districts.

Due to these facts the research partners within the project HeatResilientCity decided to develop detailed studies for vulnerability assessment of specific residential building types, which exhibit typical structural parameters and building construction methods. These building types include prefabricated concrete residential buildings raised between 1968 and 1990, which were built in large numbers and with a high building density. Using this approach, it is possible to transfer the results to many comparable residential buildings. By implementing the methods (1) dynamic thermal building simulation and (2) indoor thermal monitoring under summer climate conditions, the vulnerability of residential buildings regarding summer overheating, has been analysed both in the initial state and in an adapted level of enhanced heat resilience.

Based on the assessment of the initial state, suitable adaptation measures to reduce the summer heat vulnerability are planned following four basic adaptation strategies: (1) reduction of solar heat gain, (2) improvement of thermal storage capacity, (3) improvement of air change and (4) cooling measures.

Measures which reduce solar heat gain (e.g. external shading devices) achieve positive effects in reducing thermal stress. Therefore, their feasibility should be examined first. Furthermore, measures should be developed which retain the heat so that the maximum indoor temperatures are lowered and the stored heat is released during cooler outside temperatures, e.g. through ventilation. In order to use colder temperatures at night to replace the heated indoor air, measures to improve the air change are capable. Finally, it is possible to reduce the interior temperatures by cooling systems, at best in combination with regenerative energy sources installed at the building itself.

To compare and assess the effectivity of single adaptation measures as well as combinations of various measures, the Multizone Building Model is modified. By using this approach in dynamic thermal building simulation, specific adaptation measures can be recommended for implementation onside. After implementation, the effectiveness of the recommended adaptation measures has been analysed by indoor thermal monitoring. Finally, the described examination process will be presented by examples of different resident building types made of prefabricated concrete slabs, which were built around 1985 in Dresden. Due to the investigation results, various adaptation measures, such as external shading devices and mechanical support for night ventilation, have been recommended and implemented in these buildings.

Summer overheating in densely populated urban districts is a relevant impact on residential buildings and their inhabitants. Thus, an important goal of these research topic is to conduct systematic studies on effective and reasonable adaptation measures, which provide a comfortable indoor climate during summer heat periods for residents both now and in the future.

On the use of macro indicators to evaluate the sustainability of urban development

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Considering global warming and the role of urban areas in energy consumption, cities need to project themselves into the future in order to achieve sustainable planning choices. The scientific community can help by designing prospective models which will provide decision support. To be effective and easily discussed, models outputs can be summed up through simple and explicit indicators. These indicators can facilitate the comparison of trajectories and the evaluation of the modeling hypothesis' relevance with stakeholders. Indeed, to collaborate with urban planners, who are often quite foreign to scientific modelling approaches in France, we understand that a clear visualisation and representation of the evolution trajectories is necessary. Thus, we here propose an approach which consists in computing macro indicators to study urban sustainable development. This methodology can be divided into three phases: a long-term land-use allocation model creating pathways for the global evolution of the main urban sectors, a spatially explicit dispatcher recreating the maps from the run, and a post-processing tool computing the macro indicators. All steps are based on optimal tools but were separated because of deeply different logics. We apply this outline to Bordeaux Métropole, a metropolitan territory in Southwest France. Our first prospective model is based on an optimal bottom-up paradigm. To fulfil a final demand for housing, mobility and jobs, the optimiser can invest in different kinds of archetypes: urban shapes, which allocate the land to different uses (natural, residential or activity, roads, etc.), and buildings, which transform buildable land into housing, offices, public equipment, etc. These archetypes were previously characterized through a statistical study of the data of Bordeaux for the year 2014. The optimisation consists in minimizing the artificial land while answering the demand. The accent is therefore put on the densification. While debatable, as density is not clearly and unequivocally linked with environmental efficiency, this choice was motivated by Bordeaux's situation (the city is located near agricultural lands, such as vineyards). We project the results of the long-term model at a finer geographical scale through constrained maps and then compute various indicators such as the temperature and the overall imperviousness. The computation of the macro indicators which are not available in the model is based on a prephase of data collection and modelling. We present here a temperature case which can help study the UHI phenomenon. We retrieved data from MeteoFrance results that we tried to link with global urban parameters (such as built density, impervious surface, natural area density, etc.) through a bibliographic study, statistical correlations and different machine-learning models. The goal here is to be able to evaluate the temperature by post-processing the outputs of the main model. We ought to study here the impact of the demographic tension of the Bordeaux territory (high population growth scenario with a doubling population between 2014 and 2050 compared to a 35% increase) on the temperature in the next decades. As expected, the preliminary results obtained in the first two steps show a strong densification of the different neighborhoods. The model also shows an intensive use of buildings elevation in certain regions and the moderate use of new urban shapes. The final step which consists in computing the macro indicators has not yet been finalized but the reprojection process already works with the constraints presented above.

Study of Societal Resilience against Natural Disasters: Perspectives of Risk Perception and Prospect Theory

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The increasing frequency of severe natural disasters due to climate change has greatly threatened people's lives and properties in recent years; disaster management has become a key issue for sustainable urban and regional development. To minimize the damage caused by natural disasters, societal resilience to withstand disaster impact is critical for disaster management. Thereupon, the formulation of management strategies to enhance the resilience of a society inevitably requires the understanding of its people, relating to how they perceive and/or respond to disasters in both pre-disaster and post-disaster contexts.

This research seeks to study risk perception and relevant attitudes, which are the fundamental factors of human behavior under the threat of disaster impact, and the perspective of the prospect theory is adopted. According to the prospect theory, people may reveal different risk attitudes in regard to a reference point, which delimits gain and loss domains for a specific problem context of decision-making. Such risk attitudes can lead to the ignorance of the basics of probability theory and the expected return, especially when an extremely small probability of event occurrences is involved; for example, the minimal chance to win the lottery prize can be exaggerated. In terms of preparedness for disasters, people are also dealing with a relatively small probability of disaster occurrences or being impacted by them. Hence, based on the prospect theory, this research is exploring how the small probability (risk) may be perceived by people or communities of different socioeconomic backgrounds, how the perception may affect the formation of their risk attitude toward disasters, and what the reference point is for this peculiar problem.

A Stated-Preference (SP) survey is designed and planned to investigate the risk perception of both the general public and vulnerable populations. The concept of "willingness to pay" is employed to quantify risk attitudes toward natural disasters as how much people are willing to pay for the reduction of disaster risk and expected loss. A double-bounded dichotomous choice model is applied to construct the relationship between risk attitudes, personal attributes, and hazard characteristics, and on the other hand, to identify the reference point regarding the perception of gain and loss upon disaster impact. Accordingly, it may be possible to better capture the behavioral realism related to disaster preparedness and response. The effect of information and how it is disseminated (perhaps via different societal networks) is also the concern of this research and incorporated in the design of the SP survey, especially in terms of how information may lead to different levels of intended or unanticipated framing effects. This perceived bias will be further discussed, including the reason why people exaggerate or ignore the potential risk.

The expected results of this research can be used to develop a solid resilience-enhancement program. Based on the improved understanding of risk perception and relevant attitudes, the associated authorities may be able to determine more effective strategies to strengthen the built environment (including information dissemination mechanisms) and disaster response efficiency, thereby minimizing the damages and injuries caused by disasters.

The role of environmental indicators in assessing climate vulnerability in urban areas

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Urban areas play a pivotal role in adapting to changing climatic patterns and related adverse impacts of climate change. Severe socio-economic and environmental consequences are predicted, consequently, assessment of climate vulnerability is crucial in defining effective urban development actions. According to the IPCC nomenclature, vulnerability consists of measures concerning exposure, sensitivity, and adaptive capacity. Current researches are mainly focusing on changing weather patterns as an exposure-related concept. However, sensitivity and adaptive capacity are much related to socio-economic issues. The main aim of present study is to test the importance of socio-economic indicators and aspects in climate vulnerability assessment of urban areas based on the heavily concentrated features of cities and their vulnerable socio-economic systems. To reveal interrelations between overall vulnerability and socio-economic aspects and indicators, a comprehensive literature review regarding most often applied indicator systems and evaluation methods are conducted. Besides reviewing literature, a test with regards to socio-economic indicators is also performed by calculating the relative importance of such measures by changing the numbers and the weights of indicators in previously calculated overall vulnerability. Thus, the theoretical and practical role of socio-economic issues in climate vulnerability assessment can be revealed and conceptualized. According to the preliminary assumptions, adaptive capacity is much more critical in defining overall vulnerability rather than applying and emphasizing locally changing climatic patterns (exposure). It would be right, especially in cities where socio-economic systems and their preparedness for changes are the primary explanatory factor in vulnerability evaluation. The practical benefit of this research is based on the improvement of decision-making processes by distinguishing relevant and less important elements of given cities to make our urban areas more resilient and sustainable.

Urban climate impact on indoor overheating – a model chain approach from urban climate to thermal building simulation

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Does microscale climate conditions in urban districts vary severe enough that indoor overheating depends on the location of the building within the district? Especially in big cities heat stress for residents will increase in future summers in intensity and duration caused by the global warming trend. To quantify this load for urban dwellers, the resulting room temperatures in residential buildings are to be evaluated. More precisely, the possibility of passive cooling measures, especially nighttime cooling by window opening and cross ventilation, applicable for typical Central European summers, is to be analysed. To evaluate the impacts of nighttime cooling, the knowledge about the diurnal variation of outdoor air temperature and wind speed at the facade of the individual dwelling is highly relevant and depends on window orientation, floor level of the dwelling and the location in the urban setting. To provide the required data, we present a method of combining two time-resolving simulation techniques: First, calculating the diurnal variation of meteorological quantities like the local air temperature and wind vector near the building applying the urban climate model ENVI-met to the interaction between the 3D modelled environment with buildings, vegetation, soil and atmosphere. Second, implement the obtained local meteorological data as input for a 3D building model in the thermal building simulation tool IDA ICE evaluating the thermal comfort of residents in the individual rooms of the dwelling. As reference, a five storey multi-family house from the „Gründerzeit“ epoch in Erfurt (Germany) was chosen and simulated for the daily course of a hot summer day. The district of the building was modelled in the 3D urban climate simulation, taken into account surrounding buildings, trees and infrastructure with a high horizontal resolution of 4 m. Combining both simulation tools, we are able to show that the low differences in outdoor air temperature within the district (around 1 K) shows only low impact of the room temperatures in the building. However, the wind speed variation of West-East wind component in the district is more significant (0.3 m/s to 1.4 m/s in 16 m height above ground) depending on the orientation of obstacles and lead to high differentiations in nighttime cooling efficiency by window ventilation in combination with cross-ventilation. Thus, the indoor temperatures and overheating depends on the location of the building in the city and the orientation of windows, especially when cross ventilation is applied. Finally, the wider opportunities as well as limitations of the applied model chain from urban climate to thermal building simulations are discussed.

Urban And Rural Transitions: Smart Transformations

IoT based mitigation and adaptation planning as a tool for sustainable urban development in Budapest

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Climate change is one of the most controversial and most relevant topics, both in professional fields and in global politics. Day after day, we can read about e.g., climate strikes inspired by Greta Thunberg around the world, the climate conferences of the United Nations or the European Union, or even the increasingly alarming reports published by the Intergovernmental Panel on Climate Change (IPCC). These articles quite often, paint a rather apocalyptic picture of the coming decades and what will happen if humanity is unable to curb the progress of climate change. In contrast, other circles in the scientific world are projecting a completely different future. The Internet of Things can paint a picture of utopian cities where futuristic solutions make people live better than ever. In terms of sustainability, the potential of IoT is still untapped and the consequences are not predictable. The question is whether or not IoT is a technology that can support the transition towards sustainability. Recent research attempts to reconcile these two quite different perspectives and examine whether current and future urban developments of the Internet of Things can help cities adapt to the expected impacts of climate change and mitigate them at the city level. This is increasingly important, especially in the 21st century, as more than half of the world's population is already urban, and by 2050 this proportion is expected to rise to 68%. It is pivotal to develop a more balanced and harmonious settlement patterns all over the world. Cities also play a pivotal role and can be crucial drivers of regional development. Effective urban policies should deliver feasible solutions that can foster the practical implementation of sustainable urban development in the era of climate change and IoT. In this paper, after an overview of the problems caused by the expected impacts of climate change and their possible solutions by the Internet of Things, an evaluation was carried out to examine the mitigation and adaptation aspects of urban planning potential in the case of Budapest. Based on this evaluation in relation to the current urban planning strategic documents (such as climate strategy and the vision of the smart city concept) of the capital of Hungary, unique perspectives focusing on future development were identified that could underpin the dynamics of sustainable urban development. The analysis shows that the Internet of Things offers a large number and variety of solutions to reduce both climate-related emissions and the impacts and risks projected by the climate models. Diverse IoT solutions often have significant advantages over traditional adaptation and mitigation options, requiring less negative trade-offs and almost always having an impact on the well-being and comfort of the urban population. The alternatives promised by the IoT are not intended to replace traditional solutions but are primarily intended to supplement them and increase their efficiency. This is especially true for adaptation strategies, as IoT tools are far from covering the needs of cities for adaptation and vulnerability reduction. It can also be stated that the use and usefulness of the IoT solutions discovered and potentially used in the future depend to a large extent on the territorial, environmental, economic and social characteristics of cities, as they fundamentally determine the characteristics of locally influencing processes and problems.

Public awareness and acceptability on smart water meter

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The world faces the challenge of water scarcity, a non-renewable life-depending resource. However, the Hong Kong public has a low level of awareness on water conservation. In 2015, the domestic fresh water consumption was 132 liters per capita per day, which is greatly higher than the global average of 110 liters. The Hong Kong government has started to experiment with intelligent smart meter, which aims to alert the water leakage, encourage water saving and improve public awareness. Nevertheless, there is a lack of trust between the Hong Kong citizens and the government. What are the public awareness and acceptability of smart meter? What are the major public concerns and worries about intelligent network? How to build public trust towards these sustainable approaches?

To answer the above questions, I have conducted the two-round online survey with a total of 130 respondents. Part 1 aims to understand the socio-demographic background, ways to access intelligent meter and experiences on water conservation. Part 2 aims to discover tenants' attitude towards smart meter and whether they are willing to install. Referring to the Technological Acceptance Model (TAM), the perceived ease of use, perceived usefulness and perceived risk would affect the intention to install the smart meter. Accordingly, I construct the analytical framework by qualitatively interpreting each supporting and opposing factors as well as the logic of their connections. Then I assess the analytical framework by quantitatively measuring and analyzing each factors as well as how important those factors affect citizens' acceptability of smart water meter.

I hypothesize the survey respondents, who have larger water bill and higher education attainment, would have higher tendency on supporting smart meter. Those who access more information regarding intelligent meter, hold experiences on water saving and smart meter in their apartment, would show higher inclination to accepting the smart technology. Afterwards, I have created the data dictionary in excel file and performed both descriptive and inferential statistical analysis. The calculated mean, mode, median, standard deviation and inter quartile range of each question were analysed. The Pearson Correlation test, T-test with equal variance and ANOVA Test for variance analysis were carried out. Afterwards, I make comparison between the α-value and p-value, then determine whether accept or reject the null hypothesis.

The conclusion would be drawn afterwards. Referred to the U.N. Sustainable Development Goal 6: Ensure access to water and sanitation for all. The shortage of fresh water affects more than 40% of global citizens. Above 1.7 billion people living in river basins where water usage exceed recharge. It thus seriously affect the food security, livelihood choices and educational chances for underprivileged. Hong Kong has extremely high domestic fresh water consumption when compared to other cities. To handle the water scarcity, this paper would inform the H.K. government decision-making in terms of adoption of sustainable and smart technologies. As a result, the trustworthy between local citizens and government can be improved. The public awareness and acceptability towards this sustainable approach can be facilitated.

Trends and dynamics in material flow analysis in an urban context. A case study of a city with an emerging economy

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Currently, most of the world's population lives in cities, and this trend of the rapid urbanization of the population affects the increase in the demand for products, goods and services. It is important to know the trends in the flow of energy and materials that enter and leave the city, and this knowledge allows us to recognize key elements in these dynamics to move towards urban sustainability and to be able to face supply challenges in the future. This document presents the recent trends that have occurred in the material flow in the city of Bogotá in 2001, 2005, 2010, 2015 and 2017, in order to compare and identify the changes in the main input flows, wealth production, emissions and waste in the city. This analysis is important insofar as it contributes to establishing strategies and actions aimed at improving efficiency and reducing environmental impacts. The results show that in Bogotá, there was a decrease in some of the material flow in recent years, such as the consumption of water and the generation of discharge, while there was an increase in the consumption of energy and cement and the production of CO_2 emissions and construction materials. Solid waste production remained relatively stable. The findings of this study are important to advance the characterization of the trends in material and energy flow in the city and contribute to the consolidation of a baseline that allows for the definition and evaluation of the different impacts of public policy that promotes the sustainability of the city in the coming decades.

Social Foundations Of Sustainability: Gender, Inclusivity And Human Rights; Health And Well-Being

Bottom-up strategies for inclusivity: experiences of social enterprises providing services for disadvantaged social groups in Hungary

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Marginalized and disadvantaged social groups have been affected by various forms of social exclusion, such as discrimination in the labour market, lower levels of access to social, health and other services, or uneven participation in the life of the community (UN 2016). Decreasing these tendencies and facilitating social inclusion has been the objective of several policy measures both at the national and international levels. However, public welfare systems and initatives have not been able to fully meet these goals, and responses to social exclusion have also emerged bottom-up at the local level, where informal community initiatives and civil society organizations have been working for bettering the situation of disadvantaged groups. In recent years, such initiatives have also included social enterprises – hybrid organizations having social and economic objectives and activities at the same time - which in turn have attracted increased policy interest.

In Hungary – similarly to other European countries – social enterprises have been active in the field of labor market integration, provision of social, health and other services and the development of the local economy (European Commission 2019). These organizations often target disadvantaged groups, such as the unemployed, disabled people, the elderly or the Roma (G. Fekete et al 2017). However, research on the actual operation and activities of social enterprises is rather scarce. The present paper focuses on this under-researched area, the role of social enterprises in contributing to the inclusion of certain disadvantaged social groups by providing social and health services for them.

In this primarily qualitative research, besides analyzing available statistical data, 6 expert interviews were conducted and 4 case studies were realized. Through these means, experiences of social enterprises in the field of social and health services targeting different disadvantaged groups – the homeless, addicts, people with physical disabilities and people with intellectual disabilities – are presented. By analyzing and comparing these examples, the research examines the strategies and everyday operation of social enterprises providing alternative solutions for the problems of their target groups and modifying existing institutional structures in the social and health fields (DiMaggio 1991; DiMaggio and Powell 1983). Thus the research contributes to the deeper understanding of the opportunities, constraints and activities shaping local level solutions for inclusivity in the field of social and health services.

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First results on a future-proof person-centred health transaction network

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The network society is creating new opportunities for sustainable value generation in all areas of our lives: new collaborative methods and tools are increasingly available for use by closely connected individuals and organizations. The new business model in the health ecosystem driving innovation is both data intensive and human intensive providing new assets and exploitation opportunities for future-proof solutions. These developments are inevitably needed, since the largest loss of utility in the complete health ecosystem is caused by disharmony and conflict between the competencies accessible inside and outside of the healthcare system. The key is that healthcare and health services are undergoing a paradigm shift from being medical science- and medical doctor-oriented to becoming person-centred. In this respect, person-centricity needs focus on individual life course that is based on personal story in the customer sphere of the health ecosystem and work-flow based on providers' sphere with appropriate harmonization of the sequenced activities of the two sides. Our continuous research flow was initiated to explore and describe methods for collaborative and sustainable health-value generation, designing a value generation health ecosystem as a community-based, person-centred transaction network according to the theory of co-creation-based service logic, thereby emphasizing the role of value-in-use and network-based transactions. Consecutive exploratory work, participatory research and real-life pilot were accomplished in collaboration with 2700 health professionals and 26.500 customers – both healthy individuals and patients in Hungary. The basis of measurement and management was the assessment of composite health-value indicators in line with the healthcare value chain, while the associated follow-up in changes in health value was demonstrated by medical indicators and health experience indicators. As a result, person-centred transaction network was developed with a focus on designed co-creative sphere harmonizing the customer sphere and the provider sphere. Major result of this joint sphere is the health coaching system using a health coaching platform with human-machine interactions. Further achievements were the methodology of operationalized flowless value chain work-flow based on medical evidences in the provider sphere and personal activity plan with experience sharing platform in the customer sphere. These developments resulted 33% increase in the rate of well managed diabetes, 64% increase in the rate of controlled hypertension, 2,6x increase in treatment completion of the nine months long depression treatment, 12% decrease of fall risk in osteoporosis, 27% decrease in COPD related symptoms and 92% increase in realized change set by the individual health plan. In conclusion, the proposed person-centred community health value generating network is a novel and promising approach to designing the structure of more effective and efficient health services in sustainable collaborative networks. The cost of the effective use of competencies may be reduced, enabling the redistribution of resources for competencies currently not accessible for health generation in any sphere that would further improve the total health value of the population. According to the Social Footprint analysis, Social Life Cycle Assessment and Social Impact Assessment, this community and social network approach would provide the most effective sustainable personal health support. It would also modify the scope of public health activities, shifting the focus from behaviour change intervention to providing opportunities for change by creating community health spheres. Better design of the online spheres that organically join the provider sphere and the joint sphere may also be a means of further development.

Gender-based Differences in Myanmar's Labor Force

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Gender-based differential treatment is an unquantified burden in Myanmar labour markets. Closing this literature gap, this paper uses the Labour Force Survey 2015 to provide the first study that performs an in-depth quantitative analysis of the gender gap. Besides outstanding descriptive facts, this paper adapts Oaxaca-Blinder decomposition into quantile linear models and, using Heckman corrections to adjust for unobservable skills, visualizes gender discrimination in Myanmar across seven facts. The first two facts show that Myanmar's women labour force participation and unemployment rate gap is remarkably high among the region. However, the third fact reveals that both genders have a similar strategy to engage in the labour markets. Regarding the employed population, the fourth fact analyses the distribution of occupations and industries. It provides a first glance into the way the social norms and market dynamics create gender segregation in specific economic sectors. The fifth fact complements this landscape and statistically compares gender wage differences by education, location, age, sector, industry, and occupation. By doing so, it presents the demographic profiles that face higher gender gaps. The sixth fact decomposes the wage gap by quantiles making a case for glass ceilings and progressive pricing discrimination, both between and across industries and occupations. Finally, the seventh fact reflects over discrimination in the opportunities that women face to occupy different positions in their companies. Gender discrimination in the labour markets is a substantial barrier to the economic development of the countries. Hence, by identifying it, this paper aims to give quantitative support to the gender debate in the country, provides evidence-based suggestions for the country to improve each performance across the facts.

Isolating and satisfying community grievances – A study of the implementation of sustainability standards in the Albanian oil industry

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Many business scholars have disregarded corporate social responsibility (CSR) activities as mere window dressing, operating as a smokescreen to hide illegitimate corporate practises. Others have pointed to these activities as hegemonic articulations, as a way to strengthen corporate alliances with and dominance over other actors in society. In this PhD project I look at how corporate hegemony and CSR activities are linked at the local level, focusing on the Canadian oil company Bankers Petroleum Ltd. (Bankers) and their operations in Patos-Marinza, an area in south-central Albania with close proximity between oil extraction and residences. Between 2010 and 2015, I was involved as a consultant and staff member working in Bankers' Community Relations Department in Patos-Marinza. In this dissertation I take an autoethnographic approach, which means that I in hindsight write about and analyse my own role in the subject I am studying. Part of my empirical material are autobiographic narratives that I wrote down shortly after leaving Bankers, with the intent to capture my thoughts as a CSR professional before being socialised into the academic realm. In addition to these autobiographic narratives, my study is based on interviews with Bankers' managers and staff, Bankers' contractors, local government representatives, and residents in Patos-Marinza communities as well as reports and communication material from various actors. Through the lens of the Gramscian concept of hegemony and political discourse theory, I examine two competing discourses in Patos-Marinza. The discourse describing company operations as an 'investment' was Bankers' hegemonic narrative, giving meaning to company activities and incorporating various groups in the Albanian society into a corporate alliance. Young men were employed, farmers gained incomes from land rentals, contractors got orders and local government received taxes. The 'investment' was a narrative aiming at closure, of incorporating 'all' as beneficiaries of oil industry and thus trying to reduce grievances and requests from society by satisfying them. However, the remaining demands from Patos-Marinza communities were a danger to this all-encompassing vision and the constant appearance of grievances interrupted the corporate narrative, threatening to create an antagonistic frontier between the company and local residents. A counter-hegemonic discourse describing company activities as an 'invasion' was articulated, grievances were filed, protest groups formed, oil deposits vandalised, and roads blocked. To deepen my analysis of this antagonistic dynamic I look at three specific grievances raised by Patos-Marinza communities and Bankers' response to these complaints. The first was related to irregularities in Bankers' land rental practises, the second to the poor air quality in the area and the third to reoccurring seismic tremors. These three grievance cases highlight how Bankers' CSR activities supported the extension of a corporate alliance, breaking potential chains of equivalence between various community demands, isolating and satisfying specific actors, and controlling truth claims through dialogues, technology and experts. These hegemonic mechanisms were linked to Bankers' implementation of international sustainability standards and had the effect that they hindered community mobilisation and allowed oil extraction activities to expand. My conclusion is that rather than disregarding CSR as window dressing, it is important to examine what CSR activities does in specific empirical contexts and how demands that could otherwise be linked to put pressure on improved corporate practises are isolated and silenced in the name of responsibility.

Mapping of composite development indicators: Does focus influence country ranking?

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Nowadays, many new global indices are emerging, the justification of which is not always evident. At the same time, indices comparing and ranking different countries in terms of sustainability often receive high media attention. Country rankings illustrate which countries are considered successful (developed) and which ones need to change (developing). This approach is appropriate for judging their transformative potential toward sustainability (Malay, 2019).

The aim of the current paper is the analysis of (1) economic, (2) social, and (3) environmental orientation of nine country level composite indices. All methods and data of the analyzed indices should be (i) freely available to the public and (ii) rank 35+ countries. The chosen eligible indices are: Better Life Index (BLI), Change Readiness Index (CRI), Global Resilience Index (GRI), Human Development Index (HDI), Happy Planet Index (HPI), Inclusive Development Index (IDI), Sustainable Development Goals Index (SDGI), World Happiness Index (WHI) and the newly elaborated Social Futuring Index (SFI).

In our research, we have applied two connected methods. (1) A classification takes place in which experts rated all the indicators of analyzed composite indices according to their economic, societal and/or environmental aspects. (2) The construction of a map of composite indices by the methodology of intenscoping described by Kocsis (2014). In short: the Intenscope is a 2D, three-axis system in which relative differences between the plotted objects (the nine indices in this case) can easily be demonstrated.

Potential outputs of the research include (1) the creation and analysis of a 2-dimensional map, demonstrating the economic-social-environmental orientation of the nine analyzed composite indices; (2) revealing and understanding the fact that country rankings significantly differ by their economic-societal-environmental orientation. The new SFI stands out primarily through its social focus. This reflects the philosophy of social futuring: the initial impulse for futurability is a social one, that also affects the economy-nature relationship. Calculation of SFI can add new dimensions to future-oriented decision making.

Preliminary analysis of the components of the eight indices (w/o SFI) detected 58 economy-related, 89 societal and 28 environmental indicators. Using ratios of these aggregates as a reference point: SDGI and HPI are dominated rather by environmental indicators (economy is less dominated). GRI is far from being an index reflecting societal issues. CRI and IDI are dominated by economy-related components while HDI, WHI is rather about society and economy but it tells almost nothing about the environment (sustainability). The Social Futuring Index – with its social focus – is complementary to the analyzed other indices.

In conclusion, regarding the country-positions in a one-dimensional ranking, the philosophical background clearly determines the outcome: countries, which we know today as 'developed' or 'developing' are best reflected in economy-oriented rankings. However, 'development' should be redefined according to new challenges of sustainability and well-being.

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Perceptions of Sustainability and Economic Activity: an Evolving Relationship

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The key concern of this paper is to examine with reference to the historical context and present-day dilemmas, changes in perceptions of sustainability as a vital facet of economic activity. Equality and sustainability are key concerns of modern society. Thomas Piketty suggests that historically societies have found justifications for the social and economic inequalities that beset them. This presupposes an awareness, at least implicit, of these inequalities and their underlying causal factors. The development path of a society may be subject to similar awareness, but it is only recently that questions of sustainability have arisen, and even more recently that the issues surrounding them have been addressed. Historically societies have generally followed a sustainable path, periodically derailed by external developments, which may have been political (collapse of empires, invasions) or natural (disease, cataclysmic environmental change) or combinations thereof (notably the European conquests of the Americas). These "black swan" events tended to have causes beyond the understanding, or the control, of those affected and could not have been anticipated. Consequently there was no reason to consider questions of sustainability. In this respect previous societies were in a position resembling that of the dinosaurs prior to the great extinction. Human exceptionalism amounted to an understanding (if not always an acceptance) on the part of individuals of their own mortality. However this did not extend to an awareness of possibilities of radical societal transformation and the associated threats and risks, which in extremis could amount to another round of species extinction, this time including humans. Now we are aware, with the advantage of scientific knowledge, information and insights that were unavailable to previous generations. This is closely connected with the technological change that accelerated with the industrial revolution, bringing about radical transformations in economic activity and in society. These changes have in many respects been immensely beneficial, enriching lives and generating opportunities unimaginable to earlier generations. Understanding of the associated challenges, and particularly the limits of the technologies that have delivered these benefits, came later, and is still progressing. Perceptions of economic activity as invariably beneficial, and hence of its growth as desirable and a measure of success are implicit in the focus on GDP as the principal measure of economic welfare, and GDP growth as the prime objective of economic policy. Coupled with this perspective is a certain insouciance regarding the future course of economic activity: typically the future has been discounted at rates that place a low value on the welfare of future generations. Decision-makers face extreme complexities, facing issues with varying time dimensions, in the near, medium and distant future, under conditions of uncertainty which call for anticipation of problems that have yet to arise. Matters are further complicated by inter-linkages between policy areas. These are examined in the historical context outlined above, focusing on the time dimension and differences between its treatment in economic policy and the requirements of sustainable development. The paper goes on to consider the implications for sustainable development of the incidental effects of measures to promote economic objectives.

Social Dominance Theory and Sustainability

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*Our Common Future*has framed much of the environmental discourse around the world. One of the many fruits of that work is the 2030 Agenda for Sustainable Development and its Sustainable Development Goals. The agenda and the goals reflect international cooperation and agreements around how to meet the needs of the present without compromising the ability of future generations to meet their own needs—a concise definition of sustainable development provided by the commission. The report and the subsequent goals share a core principle of sustainability—social equity. *Our Common Future* made clear why equity is essential for sustainability, "A world in which poverty and inequity are endemic will always be prone to ecological and other crises." The historic and contemporary examples of this are legion. Sadly, in the United States and elsewhere, environmental organizations, institutions, and individuals seeking to advance transformation to a more sustainable society routinely neglect social equity. Moreover, advocates particularly avoid consideration of race, ethnicity, nationality and sex discrimination in environmental affairs. Consequently, sustainability discourse is often restricted to ecology and economic development concerns. Until this changes, the United States and other societies facing this challenge cannot become sustainable. To overcome this challenge, environmental organizations and institutions in the United States and abroad must devote more time and attention to understanding social inequity and why and how it persists. This article maintains that Social Dominance Theory provides a particularly valuable framework for examining and understanding "social dominance" (i.e., societal inequities). The article's particular contribution is the application of the theory in an environmental context to illuminate the psychology and social structures that maintain environmental inequities based on race, ethnicity, nationality and sex. As a theory of relations between and among groups, Social Dominance Theory combines social analysis with human psychology. It stands out among theories examining social inequality because of its success in explaining the processes that produce and maintain prejudice and discrimination at multiple levels. When considered in its totality, the theory addresses ideologies, policies, institutional practices, and individual attitudes and relations. It provides a particularly helpful lens for thinking about the prevalence and persistence of environmental injustices in the United States and across the globe. At its core, the theory explains how group-based social hierarchies are sustained where one or more groups has greater power and social status than others. The theory explores how dominant societal group members enjoy a disparate share of wealth, education, quality housing, abundant and high-quality food, and political power. In the environmental context, that means greater access to green spaces, clean drinking water, and higher resilience to natural disasters as well. Correspondingly, subordinate societal group members bear a disparate share of inadequate housing, less and lower quality education, both high risk and undesirable labor, high rates of punishment, and higher rates of disease and morbidity. This means they also face higher risks and lower resilience to natural disasters in addition to greater exposure to pollution and environmental contaminants. These inequities significantly frustrate sustainable social transformation. By applying Social Dominance Theory in the environmental context, the article seeks to develop a valuable framework for supporting sustainable social transformation both in the United States and globally.

Sustainability and women - the Hungarian case of underrepresented women in science

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1. *assistant lecturer*

Women's rights are human rights and therefore fundamental to sustainability. Although some progress has been made, according to UN statistics there are still 250 Million women who had to undergo female genital mutilation, 49 countries lack laws aiming to protect women from domestic violence, women do three times more unpaid work and earn 27 % less than men - just to name a few present inequalities and types of violence women are facing globally.

Before we say it's a "problem of developing countries", we should take a look at some data. According to European Commission's She figures 2015 women's average gross hourly earnings (EU-28) were 17.9 % lower than those of men in scientific research and development in 2010. Furthermore, in academic careers the representation of women is only 13 % at the grade A level of academic staff.

The status of women in Hungary is even worse in many fields. Political and academic participation rates are extremely low. We only rank 27th on the EU Gender Equality Index 2019, and our slower rate of improvement has led to an increasing gap with the EU over time. On the 2019 Women, Peace, and Security Index Hungary ranks 49th after countries like the United Arab Emirates, Kazakhstan, Albania. According to the World Economic Forum's Global Gender Gap report 2018 Hungary, out of 149 countries, was ranked no.102 with the worst score of all European nations.

The aim is to show the existing inequalities and to understand the reasons behind. Reasons for the very low participation rates of women at higher level academic careers in Hungary can be found for example in the very strong economic and social agreement that mothers should stay at home until the child turns three. As cultural values and social institutions in patriarchal societies are not supporting women in gaining power, female scientists often also drop out of their careers for more years, or even forever.

The status of women will be shown here, focusing on academic and sustainability research participation particularly on the decision-making level. Statistics from several sources are used to picture women's objective reality. However, the similarly or even more important aspect of sustainable well-being, namely the subjective reality of women's everyday life will be only partly dealt with. Obstacles to sustainable well-being such as victim-blaming, double standards, or long-term mental effects of violence against women are subject for further research.

Understandings and also suggestions will be given here for achieving Sustainable Development Goal 5 particularly in developed countries and in Hungary such as quota systems or gender sensitive budgeting.

Would You Ride with Me? Discrimination in Shared Mobility Platforms. Results of a Pilot Study

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Ridesharing platforms can be understood as social markets involving one-off, face-to-face interactions in informal settings. Private service providers (drivers) in these informal markets are providers of risky, "high-stakes" offline experiences, which makes the trust between users a crucial resource. Analysing these kinds of informal social markets enables us to explore more diverse everyday interactions, where various minorities may face unequal treatment (Tjaden, et al. 2017). We focus our attention on a Hungarian ridesharing platform in order to understand the working mechanisms of *discriminative selection* by service providers against service users of various minorities, as the literature in this area is limited. In our ongoing innovative research, we are collaborating with the most widely-used ridesharing platform in Hungary: www.oszkar.com.

We carry out an intervention-based research in 2019/2020 to test whether the experimental stimuli have any effect on drivers' behaviour towards minorities. In my proposed presentation, I am going to show (i) the research design the (ii) collaboration of the platform and our research team as well as (iii) our first empirical results of the pilot study and hopefully preliminary results of the first wave.

The relevance of our research:

As in Hungary, the Roma is the largest ethnic minority (making up approx. 6-8 % of the total population), and discrimination against them is widespread. Our primary goal is to test drivers' reactions to requests coming from passengers of Roma origin. Furthermore, we also aim to explore which type of discriminatory models (statistical vs. taste-based) can be better applied to the working mechanisms of ride sharing platforms), partly based on the research design worked out by Cui and her colleagues in 2017.

The research design in a nutshell:

Our large scale (N=1820) randomised experimental research aims to find out how the refusal/acceptance rate of the drivers changes by groups of passengers belonging to different minority groups before and after our intervention, which serves as the experimental stimulus.

Experimental variables are: ethnic origin (Roma vs. non Roma) and review score (high vs. medium).

Ethnic origin will be visualized by photos and confirmed by typical Roma and non-Roma names (both chosen via online surveys). With high (4.8 out of 5) and medium review score (4.2 out of 5) we aim to test whether statistical (due to information asymmetry) or taste-based discrimination (i.e. drivers' prejudices towards Roma passengers) is most widespread in this field. Two waves of pilot studies were implemented in autumn 2019 to try out the experimental situations and various stimulus.

The interventionwill be based on 20-second-long animated video spots covering the topic of inclusivity closely connected to the general values of oszcar.com.

Outcome: The reaction of the drivers will be categorized as *positive, negative, or no-response.*We expect significant differences of outcome by profiles in terms of ethnicity and review score.

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Collaboration And Co-Creation For Sustainability, SDG Initiatives And Scale Of Governance

An interactive platform for sustainability: the case of a simulated hospital in Colombia

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The main goal of this research is to characterize the Simulated Hospital (SH) from the University of La Sabana in Colombia (South America) as an interactive platform for co-creation and collaboration between different stakeholders that seek to be sustainable in the long term.

The SH was created in 1998 as a "clinical simulation laboratory," which had only two classrooms, for medical and nursing students. There, they performed separately in simulated scenarios, some practices that served as support and reinforcement of specific topics. Then, in 2011, new classrooms were opened, and the nursing, physiotherapy, and medicine programs began to work in an integrated way. In 2014, they included the simulation throughout these programs to strengthen the training in specific competencies for these professionals. Subsequently, in 2018, the SH was transformed in a space with characteristics of a "real hospital," where nursing, physiotherapy, medicine, and psychology students work in an interdisciplinary way. Currently, the SH has areas equipped with Gesell cameras, where are developed simulations as births, surgeries, cardiac resuscitation, and neurorehabilitation, among others. Professors monitor these activities from rooms with digital controls.

The SH has collaboration and co-creation practices with internal and external agents. At the internal level, students interact with professors and hospital support staff to attend "simulators" (electronic manikins) and/or "simulated patients - SP." The latter are students from different careers, who acts to represents medical situations previously co-created and specified in protocols, in collaboration with professors, and simulation experts. At the external level, the SH interacts with suppliers of medical products, biomedical equipment, and simulators, certifiers of medical procedures and patient care, national public and private universities, through training and the reception of donations of biomedical equipment. Additionally, it works with associations of professionals from the health sector, the National Simulation Association, and with international hospitals and simulation centers of universities in Portugal, Mexico, and Chile.

According to the above, we proposed the following research questions: Is the SH an interactive platform? If so, what characterizes this SH platform? To answer these questions, we used the case study methodology. The information was collected between March and November 2019 through 10 visits to SH to observe its operation, eight semi-structured interviews that included the SH' director, support staff for simulation scenarios, SP, and teachers. Additionally, we reviewed several documents related to the hospital. Subsequently, the case was analyzed in light of a theoretical framework. Thus from a multilevel perspective (Sears and Baba, 2011; Carrayannis and Gonzalez, 2003), it integrates concepts as interactive platforms and their components (artifacts, persons, processes, and interfaces) (Ramaswamy and Ozcan, 2018; Lee et al. 2012), where stakeholders create and capture value (Lepack et al., 2007) to achieve sustainability (Porter and Kramer, 2011) and increase their competitiveness (Carrayannis and Gonzalez, 2003).

The results show that this SH is an interactive platform, where its artifacts (e.g., medical simulation protocols and simulators), persons (e.g., professors, students, support staff, users and customers, business representatives, and institutional managers), processes (e.g., design of simulated experiences, scenario preparation, evaluation activities, recovery of simulators), and interfaces (delivery and surgery rooms, medical offices, debriefing space, meetings, conferences, etc.) demonstrate an "agencial assemblage" that allows to each stakeholder create and capture value for their sustainability and competitiveness.

Co-created integration? Critical dialogue of the reach and limitations of cross-sectoral innovations projects.

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For decades, the importance of collaboration between industry, academia and public authorities in a so called triple helix have been highlighted (see e.g. Etzkowitz, 1993). Up until approximately a decade ago, focus in this field have been on industrial and technological development and economic growth. Gradually, sustainability concerns have affected the discourse. The triple helix model has been extended to a quadruple helix (Holmberg el.al., 2007) that also includes civil society in the collaboration. Even if it is possible to talk about an emerging field, the knowledge about quadruple helix collaboration still is fragmented and there is a need for more studies and not the least, more problematinzing studies that investigates to what extent and how the more mature innovation discourse can be applied and implemented in a setting that brings new dimensions, new aspects, new practices etc. The aim of this paper is therefore to make these types of innovations projects more visible, to analyze the cross-sectoral collaboration, and finally, to analyze the role of these types of initiatives' role in society.

This paper is based on a study of innovation initiatives aiming to prevent segregation in Sweden. More specifically, it started in 2017, two years after the big influx of refugees from Middle East and other conflicts in the world, when the Swedish Innovation Agency (Vinnova) launched a call for initiatives to develop social innovation labs with aim to combat segregation and stimulate integration. This call was a part of Vinnova's transformation from a focus on technical innovation for growth, towards more challenge driven innovations for sustainable development. Ten projects were granted support for two years work. These initiatives were constituted by cross sectoral partnerships in which first and foremost local public authorities and civil society organizations. Private enterprises also participate to a certain extent.

Some of these projects also had independent researchers attached as evaluators. In addition, a small team of scholars were assigned to facilitate, and at the same time study, an overarching learning process with the aim to strengthen the management of the current as well as future cross-sectoral projects.

The theoretical framework draws on social entrepreneurship and social innovation as well as civil society literature and literature on collaboration more generally. The aim of this particular paper, is to problematize and critically analyze the reach and limitations of the cross-sectoral co-creation process in the particular setting of integration in society, as a crucial aspect of cohesion and social sustainable development. In particular, the different actors' role and conditions for their engagement are elaborated on and related to a multilevel system approach in which policy measures play a palpable, but not necessary an obvious role. The study reveals that prior experiences, sector logics as well as power aspects of relations play vital roles and needs to be recognized as part of co-creation for sustainable development – not the least in relation to social sustainability.

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Eradicating Poverty through Energy Innovation: Co-producing people centered energy transitions through praxis at the grassroots.

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A clean energy transition without addressing poverty and systematic injustices for communities around the world would be a humanitarian disaster and an enormous waste of capital. Sustainable Development Goals (SDGs) would remain incomplete unless these structural challenges are addressed. Therefore, a key element of the solutions agenda needs to be the disruption of energy-poverty nexus through evidence based, innovative solutions at the grassroots, enabling local economic growth, climate resilience and bolstering essential services like drinking water, sanitation etc.; in addition to electricity for lighting, cooking or charging phones.

Driven by the ambition to 'reboot the imagination on the relationship between energy and poverty', so that energy solutions for the poor are not 'second-best choice'; the *Eradicating Poverty through Energy Innovation*(EPEI) initiative was launched by the Center for Energy and Society's Grassroots Energy Innovation laboratory. It comprises of an annual EPEI workshop and the EPEI network of energy access practitioners, community-based actors and academics from all over the globe. The workshop provides a platform for knowledge sharing, deliberating on a variety of efforts happening globally and bringing the social, cultural and marginalized perspective to the fore of energy access discourses. The EPEI network facilitates collaborations, information exchanges and joint projects. The initiative is founded on the belief that constructing inclusive and equitable futures for everyone requires engaged research and practices that involves people in action situations on the ground; to construct energy systems that enable socio-economic-ecological well-being. While engaging stakeholders as equal partners builds rigorous, evidence driven and place-based solution strategies - the process fosters critical reflection and shared knowledge systems for informed action.

The 2018 inaugural workshop in Tempe (USA) laid the foundation for exploring social value of energy in diverse forms and places, making connections between pathways out of poverty and energy use. The 2019 EPEI workshop in Dehradun (India) saw participation from South-east and South Asia, bringing a regional focus and sought to build inter-linkages and deliberate strategies for integrating SDG 7 and other SDGs. The workshop blends panel discussions, brainstorming sessions, short talks and innovation sprints to create an engaging two-and half-day format. The ideas generated during these workshops has resulted in two applied research projects with the collaboration of six EPEI network participants.

To further the inclusion of values-based innovation, technology justice, equitable and just futures for the cross-sections of society, through cross-pollination of capabilities and resources between practitioners, communities and academics - the EPEI format is being expanded to form regional, multi-stakeholder Hubs for capacity building and project design for sustainable energy futures in communities in the Philippines and Brazil.

By explicitly addressing poverty alleviation through energy innovation and developing modalities through which collaborations can happen; the EPEI initiative is contributing new information for actors to reflect on, about their incentives for partnering in the sustainability agenda. Additionally, the upcoming multi-stakeholder Hubs will demonstrate how effective and symbiotic collaborations at a larger scale can deliver higher value for community energy projects and further the goals of sustainable development.

How far can shared ambitions take us? Regional SDG collaboration – shared ambitions but diverse roles, responsibilities, needs and mandates

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Experiences from implementing the 17 Sustainable Development Goals (SDGs) increase day by day at different societal levels and in different parts of the world. This study departs from Sweden, which is considered to be a forerunner in implementing the SDGs, but still faces many challenges – such as how to localize the SDGs (i.e. SDG implementation on a subnational level). As the SDGs are integrated, indivisible and balance the different sustainability dimensions they call for a broader and more inclusive approach than previous initiatives. Hence, collaboration is considered key. On a subnational level this could mean different actors, such as regional and local governments, businesses and civil society, coming together to join forces to implement the SDGs. However, this can be done in different ways. This study explores early experiences from creating a regional collaboration platform for the SDGs. The study aims to explore regional collaboration for the SDGs between diverse societal actors, focusing on how collaboration can be organized. The studied case is a platform for regional actors in the county of Östergötland, a unique and pioneering constellation in a Swedish context. The idea to create a platform originated from prior collaboration between two regional authorities, the county council and the county administrative board, as they saw a great interest for the SDGs from other regional actors. Consequently, they decided to invite three other regional actors to a coordinating group - a municipal representative, a regional business network and the University in the region, in order to initiate and develop an SDG-platform. During the first year, four platform meetings with other regional actors were arranged by this group. The study was done through interviews with members of the coordinating group complemented with observations of group meetings and the first regional platform meeting. The results indicate that the regional authorities were perceived to have a more evident role towards the regional SDG implementation than other actors in the group. This was identified as challenging, as a shared responsibility was thought of as a basis for the work within the group. Furthermore, questions regarding who should take lead in the group and economically fund platform meetings remained unanswered. Another challenge was to identify which other regional actors to invite to the platform and understanding their potential needs connected to SDG implementation. Four different forms and levels of potential collaboration were identified during the development process, namely understanding the common context, co-learning, co-action and strategic collaboration. The level of collaborative potential seemed to be correlatedly dependent on the mandate and commitment, both within the actors' own organizations as well as on the regional arena. In what ways and to what extent the regional politicians should be involved was also considered a challenge. However, several described the group and platform as "breaking silos" were the SDGs provides a reason and a common language. The study concludes in an analysis of early experiences from collaboration on a regional level. The analysis emphasizes the roles and mandate of different actors in regional SDG collaboration and problematizes the broad scope of the SDGs in relation to finding a common purpose and value for all societal actors in such collaborations.

Integrated Research, Engagement and Impact: a Case Study from the Resource Recovery from Waste programme

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The Resource Recovery from Waste (RRfW) programme delivered strategic science to support a paradigm shift in the recovery of resources from waste as a step towards a sustainable circular economy, driven by benefits to the environment and human health rather than by economics alone. It represented a £7M investment by the Natural Environment Research Council, the Economic and Social Research Council and the Department for Environment, Food and Rural Affairs (2015 -2019) in the United Kingdom (UK). RRfW actively engaged with industry, public, third and academic sectors through a series of knowledge exchange and co-creation activities that underpinned our engagement strategy and was fundamental to delivering impact. The programme supported significant steps towards the transition to a circular economy, including: 1) Establishing an integrated policy environment; 2) Including circular economy into the UK's Industrial Strategy; 3) Influencing language and contents of England's Resources and Waste Strategy; 4) Actively shaping the public narrative on circular economy; 5) Changing business' perceptions of their own role; 6) Directly driving change in practice is business, government and academia; 7) Shaping the circular economy research and innovation funding landscape; 8) Supporting the preparation of a national data system for resources; 9) Making significant contributions to academic progress through more than a hundred publications. These impacts were enabled by our integrated approach to research, engagement and impact. This approach was based on participation process management, engaging stakeholders throughout research projects at increasing participation levels. The programme established a clear image and informed a wide diversity of stakeholders via social media and presenting and networking at events. Stakeholders were consulted to develop demand-driven and action-oriented research. A stakeholder analysis identified key actors in control of driving circular economy transition. Understanding of perspectives of key stakeholders on circular economy, their interests and concerns, and their preferred methods for learning and innovation were investigated and published in the form of coherent narratives. The RRfW projects provided an evidence base to build upon. Key intervention points to drive systemic change were identified. All of this provided a foundation for highly targeted shorter research projects to integrate, translate and synthesise outcomes. The programme's main messages – such as the need for a more holistic approach to valuing resources, the importance of policy integration and the demand for better data on resource stocks and flows – were consistently communicated through different activities targeting different stakeholders in the system. The approach of RRfW has been very effective in developing momentum and embedding solutions into practice, and it is recognised as best practice by UK Research and Innovation – the umbrella organisation bringing together all major public funders. This presentation aims to share our experiences and give an insight into how integrated knowledge exchange activities can be used to improve project and programme performance for sustainable transitions. We will also highlight the requirements of such activities in terms of monetary investment and staff skills regarding participatory approaches, communication, project management, and transdisciplinary research. We continue to learn and optimise the integrated approach to research, engagement and impact, and we invite you to share your views and experiences.

Multiperspectivity on the quality of collaboration and co-creation in inter-and transdisciplinary sustainability research: experiences from around Europe

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The complexity of global challenges on social, economic, and environmental level require new forms of knowledge production and new ways of doing research. In the search for sustainability of socio-ecological systems, sustainability science emerged as a transdisciplinary field aiming to generate actionable knowledge and evidence-supported solution options for complexity, uncertainty, and socio-political controversy. Sustainability scientists seek to go beyond descriptive-analytical approaches and enter into dialogue and mutual learning processes with a large variety of diverse actors, in order to strengthen collaboratively the efforts for a transition towards more sustainable societies. While pursuing societal transformation together with scientific breakthroughs, researchers are testing new forms of engagement in science-society interfaces. Inter- and transdisciplinary research approaches, usually with a participatory dimension, are increasingly regarded as most adequate, but there are several gaps experienced, e.g. little training and knowledge about how to conduct effectively these collaborative research processes, being stuck in institutional barriers and traditional mindset of disciplinary "silo" thinking, and the necessity for more empirical knowledge about the quality, effectiveness and impacts of co-creation efforts on socio-ecological transformations. This work aims to explore (i) how have been the approaches in moving forward towards collaborative sustainability research between science and society, and (ii) how to overcome experienced difficulties/gaps in inter-and transdisciplinary research and make collaborative efforts more effective. To answer these questions, a questionnaire survey was chosen with a predominantly open-questions-design. The analysis includes descriptive statistics as well as qualitative content analysis for open questions. The questionnaire was distributed via e-mail among the networks related to the Postdoc Academy for Transformational Leadership - a joint training programme of Humboldt University (Berlin, Germany), Leuphana University (Lueneburg, Germany), the Stockholm Resilience Center (Stockholm, Sweden) and the Dutch Research Institute for Transitions (Rotterdam, Netherlands), – in which scholars and practitioners of diverse inter-and transdisciplinary research projects around Europe meet for exchange and training. The preliminary results suggest that aspects of quality of the collaboration itself are often overlooked in those research processes and that co-creation is often intended to be undertaken, but not necessarily happening, with maintaining existing power structures and the process being dominated by more powerful groups. Furthermore, several institutional barriers impede more horizontal forms of collaboration. In order to prepare academia and society better for mutual engagement, the whole education system plays a crucial role in strengthening the necessary transversal skills and competencies for co-creating a more sustainable presence and future.

Simulating stakeholders' participation: how is the climate awareness development process affected by city stakeholders?

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Most of the world's population now lives in cities, and it is forecasted that 60% of the population will live in urban areas by 2030. Cities are defined as complex system of systems in which the interaction between the infrastructures system, the ecological system, socio-cultural system, economical system and governance system is assembled. Urban areas have been adapting to the challenges their surrounding have posed them throughout history. However, climate change (CC) sets a new global challenge due to its dynamisms and uncertainty that cause direct effects both in the long a short term in the proper function of cities.

As cities recognize their responsibility in increasing the effects to CC and in reducing the vulnerabilities derived from CC, they have attemptnot only to reduce their impact on the environment but also to build resilience to be able to face the irreversible effects of CC and transform themselves into more sustainable cities. However, as complex systems, building climate resilience and becoming a sustainable city presents several barriers. Social, economical and ecological factors that define cities as complex systems need to be taken into account. In this paper, we focus on the social factor and the need to develop the collaboration of the stakeholders' composing a city.

In this context, recent literature highlights developing awareness of not only public entities but also private companies and community groups is key to achieve collaboration. In this vein, the aim of the study is to contribute to the lack of procedures and tools to develop awareness and facilitate the collaboration of all city stakeholders when building climate resilience and becoming a sustainable city. To that end, a triangulation approach has been carried out where the theory from the literature, the expertise from the practitioners taking part in the co-creation process and the example of a real case study have been developed.

As a result, the study proposes a framework complemented by an educational simulation tool that defines a four-step gradual process composed by strategic policies that should be implemented in order to build the city stakeholders awareness. Furthermore, specific actions each city stakeholder might implement are presented. The four-step gradual process explains the evolution of stakeholders awareness from a passive to a proactive behaviour. The policies determine how to go from one step to the other and also how the participation of each city stakeholder should be,specifying who should lead the policies and the defined specific actions. The educational simulation tool that encapsulate the framework and simulate the policies facilitate the understanding of the framework and enable stakeholder realize the need of their committed participation and collaboration.

This research concludes that during the four-step awareness-development process first community groups need to demand a change, closely followed by the leadership of public entities. Once awareness starts to be developed, public entities gain relevance as their role is to guide and foster both community groups and private companies' awareness through incentives and norms. Finally, the engagement of private companies boosts the creation of new sustainable services that enable the adoption of new sustainable habits. Hence, the study concludes with thecontribution of each stakeholderparticipation when developing awareness for CC and how the simulation tool facilitates the understanding and learning of the awareness building process defined in the framework.

Transdisciplinarity for Urban Sustainability Transition: where and how is it being made possible?

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This paper presents the preliminary result of **TrUST**- *Transdisciplinarity* for Urban Sustainability Transition -, **a project** that aims at better understanding how to achieve more efficient and effective **inter/trans-disciplinary** research and education for **urban sustainability** transitions. Contemporary urban challenges are characterised by increasing **complexity** and **uncertainty.** According to the objectives of its Strategic Plan, Politecnico di Torino, as well as many other universities, tried to take the opportunity to turn the interdisciplinary collaboration among different technological and scientific fields into something more systematic. The many **Interdisciplinary Research Centers**are examples of that, but still, effective collaboration and integration among people and disciplines are difficult to achieve. **Collaborative multi-stakeholder processes,**especially when focused on wicked problems, face a number of key **challenges**. There is often contestation between different forms of knowledge, and thus different voices. This is often due to a lack of understanding, appreciation of and learning about the relevance and validity of different knowledge claims, approaches and definitions. **TrUST**'s objective is therefore to identify the **synergies** and **differences** in the current landscape of inter/trans-disciplinary (ITD) **research** and **education**strategies, methodologies and tools in academic urban labs framing the **17 SDGs. TrUST**has two main inter/trans-disciplinary (ITD) research tracks: one about the ITD education, and one about ITD research. This paper focuses on the latter, aiming to explore how urban research labs are currently working on the sustainability transition via an ITD approach. To answer this track, a set of 30 semi-structured interviews within the self-declaring interdisciplinary centres embedded in Universities, public administration, or being independent entities (NGOs or businesses). The semi-structured interviews have been prepared with the help of sociologists, psychologists and ITD experts. These interviews will be carried out between September and December 2019. Results have been transcribed and analysed by a team of experts trying to scout barriers and triggers to ITD effective environments, scouting preliminary data on similar top ten institution around the world.

What corporate governance mechanisms influence the CSR engagement of European firms?

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Among the different functions of a Board of Directors (BoD), most research is focused on analysing its monitoring role, since the main aim of a BoD is to advise on strategy formulation and decision-making. Taking into account agency theory arguments, if there is a conflict of interest between shareholders and managers, members of the BoD are responsible for ensuring the interests of all shareholders. At the same time, several researchers argue that companies should try to satisfy all stakeholders´ demands and not only those of shareholders. Although it has been shown that being a socially responsible company is profitable in the long term, the effects in the short term are not as clear. From this point of view, managers could exhibit opportunistic behaviour and try to minimize CSR actions so that they do not harm their personal results. In this case, the BoD should ensure that companies are committed to society and the Environment, since otherwise markets might punish them.

The aim of this paper was to examine the kinds of Corporate Governance (CG) mechanisms (firm, group or individual level) that are determinant of the CSR practices carried out by European listed companies. In addition, we would like to analyze how institutional level CG mechanisms influence on this relationship.

The sample was composed of 512 listed firms in Europe for which CG data were available on Boardex Database and CSR data and control variables were available on DataStream. The period of the study was from 2005 until 2015, and this is why we employed the data panel methodology.

Considering our results, group and individual CG mechanisms have an influence on companies´ CSR behaviour. Regarding group level CG mechanisms, the presence of non-executives and the nationality mix of BoD show a positive impact on CSR, while the succession presents a negative effect. Furthermore, all the individual CG mechanisms analyzed (the experience on company, past experience and qualifications of managers) have significant effects on CSR. Thus, the larger positive effect is achieved by the qualifications of director followed by the number of boards of listed companies in which he/she had participated. Finally, institutional CG level mechanisms have impact on most CG mechanisms considered. Notwithstanding, more research is needed to identify its role in this relationship.

Although most times the relationship between CG mechanisms and CSR behaviours are focused at firm or group level CG mechanisms, the insights from this research help to move the focus to the individual director level.

"Future is Now: Science for Achieving Sustainable Development" – the Global Sustainable Development Report 2019

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Before leaving office, former Secretary-General of the UN Ban Ki-moon appointed the Independent Group of Scientists (IDS) comprising 15 experts to draft the Global Sustainable Development Report (GSDR). The Report is a key component of the mechanism to follow up and review progress on the recently agreed 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs). It aims to strengthen the science-policy interface and provide a strong evidence-based instrument to support policymakers in promoting poverty eradication and sustainable development. The document is intended to provide guidance from a scientific perspective that supports the implementation of the Sustainable Development Goals and the 2030 Agenda in ways that integrate economic, environmental and social dimensions. It is available for a wide range of stakeholders, including business, civil society, and the public. In the Report, we argue that the value and transformative potential of the 2030 Agenda is more than the sum of its 17 SDGs and 169 indicators. It is not only a unique normative compass, but it also represents a vision of how natural resources could be best shared for the well-being of the 9 billion people who will soon populate this Earth. The assessment is based on a total of 65 global assessments comprising the United Nations flagship reports and international scientific assessments, as well as 112 scientific articles published since 2015 with explicit reference to the sustainable development goals. Not all pathways and transformations towards achieving any given goal or target in the Agenda are equivalent in terms of their implications for the others. The Report presents a global system model comprising six major transformations – human well-being and capabilities, sustainable and just economies, sustainable food systems and healthy nutrition, energy decarbonisation with universal access, urban and peri-urban development, and global commons. Selected transformations are critical if the sustainable development goals are to be met by 2030 in ways that will ensure sustainability for both current and future generations. At the same time, means and levers of transformations include governance, consumption and production (including financing), individual and collective action, and society and technology. At the heart of this Report is a fundamental belief that the purpose of the economic system is to improve the well-being for all within the limits of what the planet can sustain. When we think about the kinds of changes that will be required for the development towards sustainability, it is tempting to focus on the practical issues like financial regulation, taxation or reduction of carbon intensity. Unfortunately, much more needs to happen, and quite quickly, to bring about the required transformative changes. The thermodynamics makes it clear that humans must find ways to balance the economic subsystem with the Earth's evolutionary and morphological processes, or the planet will use its own mechanisms to restore the balance. This paper deals with the ways the elaborated system model could be used to search for policy-relevant solutions transforming the society towards sustainability on global, regional or country level. While the Report as a product focuses on producing knowledge for transformations to sustainable development, IDS views GSDR also as a process that can advance the collaborations between science, policy, and society.

Public Participation And the Role Of Stakeholders

Collaborative infrastructures for a transformative and prosperous future

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By today, it is evident that climate change and unanticipated natural events pose new challenges for humanity and landscapes. Furthermore, already over half of the global population resides in cities (55 per cent in 2018, UN, 2019), making the urban landscape a crucial focus area. Thus, it is crucial to address the complex issues of urban living in order to achieve long-term sustainability. In line with UN Habitat's New Urban Agenda, a roadmap is required to realize the Sustainable Development Goals. Hence this is a moment of particular relevance for scientists and researchers to actively engage in fieldwork, put theories into practise and share their case studies and best practises as benchmarks, providing a link between local and global for our common benefit: converge to global prosperity.

An effective way to tackle the new challenges is to create transformative pathways for wide employment of ecosystem services (ES) and nature-based solutions (NbS) for ecological landscapes. Furthermore, nature is crucial for human physical and mental wellbeing. Hence, it is indisputable that a holistic and interdisciplinary approach is required if humanity desires to thrive and attain a long-term sustainable future. We must acknowledge our interconnectedness on multiple levels and collaborate between multiple stakeholders: from scientists through practitioners, governments to private businesses, the third sector and people. Transformative solutions should be implemented on multiple scales and tailored to local microclimatic conditions, whilst also considering cultural contexts and employing (thus preserving) indigenous knowledge. We should promote and facilitate knowledge exchange across stakeholders, education on ES, NbS and involve them in projects from the early stages to collaborate, creating a sense of shared ownership and responsibility.

Based on a PhD research carried out in University College London, as part of the RELIEF Centre and working with the American University of Beirut's Landscape Design and Ecosystem Management Department, I am introducing a framework that is tested in two fieldwork sites: a neighbourhood in Budapest and Beirut respectively. This transdisciplinary research explores possibilities of establishing place-based values for wellbeing and a good quality of life (QoL) in urban public spaces. It co-defines infrastructural challenges (water, waste, energy, food) and investigates how can these be addressed via NbS and ES which in turn contribute to increasing wellbeing and QoL in an inclusive, diverse and ecological manner. The approach employs participatory methods and gamification in the research framework.

It is at the core of research to engage with local communities, enable them to vote on the infrastructural topic they want to focus on, and co-construct the notions of wellbeing and ideas of 'the good life', building on their knowledge and experiences of the neighbourhood. The gamification element is means to facilitate informal knowledge transfer, provide a sense of ownership and enable people to make their own connections between nature and their wellbeing and to co-construct pathways to urban prosperity in their public spaces.

I am sharing my early findings from both fieldwork sites, offering comparison, preliminary conclusions and recommendations for effective multi-stakeholder collaborations for more sustainable urban environments.

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The emergence of Environment and environmental professionals in Portuguese policy and politics

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The emergence of modern environmental concerns dates to the nineteenth century, with diverse roots, including public health and the conservation and management of natural resources. In Portugal, the environmental movement began with "Liga para a Protecção da Natureza" (League for the Protection of Nature), in 1948, at first from a scientific and academic perspective. The National Commission for the Environment was created in 1971, to prepare Portugal's participation in the UN Stockholm Conference on the Human Environment (1972). Since then, the importance of technical knowledge in environmental policy has been increasing, both due to the growing seriousness of environmental challenges, and the need to integrate interdisciplinary knowledge and multiple social interests in order to build innovative and effective solutions. This paper aims to investigate how the Environment is approached in Portuguese policy and politics, especially the role of environmental professionals in political parties. The goal is to gain a better understanding of how the Parliament and political parties work on environmental policies, and to highlight the importance of the environmental professionals in the formulation of policies. The methodology used was based on interviews with representatives of political parties in Parliament and a sample of 34 key environmental policy actors in the political, technical, NGO and social media domains, cross-checked with literature review. It was possible to gain interesting insights. There is a gap between the manifestation of environmental concerns and their practice. Political parties say they value the presence of environmental professionals and technical knowledge is universally regarded as essential, but they employ very few as advisers. On the other hand, many respondents report that often scientific information is insufficient, or decisions are taken by the imposition of other interests, neglecting technical foundation. The respondents' points of view are guided mostly by their own experience, and not so much by their position or professional field. Although Portugal was innovative in the creation of the Framework Law for the Environment in 1987, much of national environmental legislation was derived from European policy. Today, Portugal faces major environmental challenges, the most cited by the respondents being climate change, consumerism and waste, efficient use of water, circular economy, territorial planning and environmental education.

Unconventional on-shore shale gas development in England and the Social Licence to Operate

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Energy security, the economic crisis, dwindling North Sea gas supplies are some of the drivers for the development of on-shore gas exploration in England. Shale Gas Development (SGD), also known as fracking, has become a divisive issue in recent times; some claim it will bring revenue, jobs and furthermore claim it will help us to reach CO_2 reduction targets by acting as a bridging fuel as we transition to renewable energy. Opponents are concerned about the potential harm to the environment and human health. Furthermore, claim it is not contributing, and possibly hindering, sustainable development and the development of renewable energy solutions. Government ministers and industry claim the UK has a 'Gold standard' regulatory regime, others claim the regulations are inadequate, flawed and difficult to enforce. Recently, the UK Government has issued a moratorium, however further stated that future applications will be considered on their own merits. In addition to regulatory concerns, the industry does not appear to have gained a Social Licence to Operate (SLO); an implicit contract between the operator and other stakeholders which may reduce socio-political conflict and challenges to the activities of the SGD company. This research is investigating the SLO in two key SGD areas of England, Yorkshire and Lancashire. Methods include semi-structured interviews with stakeholders including regulators, operators and residents near potential development sites. Findings indicate little trust in the regulatory regime, regulatory agencies and government. Stakeholder views are linked to risk perception, experiences with conventional onshore gas extraction and involvements with operators and agencies during the planning application process.

Keywords: Shale gas, Fracking, Social Licence to Operate (SLO)

Legal Aspects Of Sustainable Development

Cultures of ocean governance: historical approaches, future scenarios, and implications for sustainable development

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Water covers more than two thirds of our planet's surface, and the oceans represent more than 98 percent of the habitable biosphere. Across time and space human societies have understood the oceans in many different ways – as vast, alien, and mysterious; as an intemperate yet infinite provider; as a resource frontier; as identity and home. Current scientific views highlight the importance of ocean ecosystem goods and services in the rapidly growing 'blue economy' – the sustainable use of ocean resources. As human civilization continues to grow and develop in this century of growing climate chaos, significant environmental change, and increasing political contest, the oceans are becoming the next great frontier for industrial progress and economic growth. Yet these new marine territories also present novel ontological challenges as well as commercial opportunities, and governance approaches will influence and determine environmental dynamics, political conflicts, and social justice outcomes. This paper reviews historical approaches to ocean governance through an analysis of treaties, conventions, and other relevant agreements, and offers an empirical identification of governance characteristics that can be categorised in 'cultural' terms. Future scenarios of development, political contest, and global change are considered in an integrated manner to identify potential challenges, conflicts, and opportunities arising from cultural features of marine territories in coming decades. The paper offers insights into how different governance approaches might affect cultural and biophysical ecosystem services in a climate-changed world, and is immediately relevant not only to SDGs 16 and 17 but also SDG 14 (Life below water) and SDGs 8 (Decent work and economic growth) and 9 (Industry, innovation, and infrastructure).

Right to be heard in tax procedures; how to build a more sustainable tax procedural environment.

Prof. Patrizia Accordino [1]

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Sustainability Issues of the Intelligent and Autonomous Vehicles - Legal Justification

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The presentation deals with the sustainability aspects of the autonomous and intelligent vehicles with special regard to SDGs 7, 9, 11, 12, 13 and 14.

The background of the presentation is the 'sustainability benefit' offered by the more intelligent planning of routes and transportation methods by autonomous vehicles. The research argument and the main aim is to carry out an analysis of the more eco-friendly and sustainable usage of autonomous vehicles by the smart and intelligent planning of the driving method, using fuels, and parking. According to many (however, US-based) sources, intelligent planning could save more energy and can transform transportation into an energy-saving mode. The presentation offers a legal analysis of these methods, their legal opportunities, for instance the issue of permission and the environmental legal issues. The presentation takes into consideration the above-mentioned six SDGs legal content and their potential application to autonomous vehicles.

The approach is foremost legal but the required ecological side is also touched upon.

The findings and the conclusion will focus on the justification that the intelligent planning and network of autonomous vehicles could foster the reach of some SDGs and a more sustainable future. The content of some SDGs could be clarified with such newly invented and highly attentive technical solutions such as the autonomous vehicles.

The Encyclical Letter “Laudato sì” between sustainable development and integral ecology

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Background context: The latest Pope Francis’ I Encyclical Letter “*Laudato sì*” addresses the care of our common home and it is linked to the path already traced by the previous Popes.
Indeed, it is widely acknowledged that the Encyclical Letters *Populorum progressio* by Paul VI, *Sollecitudo Rei Socialis* by John Paul II and *Caritas in Veritate* by Benedict XVI, share the same central idea that is the aspiration to a Human ecology.
The Catholic Church has always shown a deep interest in the creation and its safeguarding.
Due to the Encyclical letter, Pope Francis took another step forward in the previous context highlighting the importance of an integral ecology pointing out how the care of nature, equity for the poor, and social tasks are inextricably connected to joy and inner peace.
As a matter of fact, there is a close relationship between environment (intended as landscape protection and right to health), ecology (which means soil, air and water defense from pollution) and eradication of poverty, care of poor and fair access to planetary resources.
After having stigmatized the culture of waste and scrapes, Pope Francis stated that cultivating and safeguarding the creation does not include only the relationship between us and the environment but also concerns human relationships due to the fact that environmental and human ecology walk together.
Research argument: The paper intends to deepen the topic of the environment and its care by the Canon Law point of view.
Aim: The objective of the research is to clarify how, in the Christian religion, man occupies a privileged place among all creatures and it has to be considered at the center of creation. From this perspective, he has to take on responsibility in protecting all living beings. The concept of “creation”, indeed, not only represents the crucial factor of the Christian religion but also implies rights and duties hold up by the one to whom the creation was entrusted: the man.
Methods: Starting from the analysis of the juridical nature of the environment and deepening the different theories expressed by the doctrine - divergent between an anthropocentric and an ecocentric overview - the author faces the question of a clear definition of the concepts of “environment”, and “creation”, typical of religions, above all those revealed.
The main part of the paper is focused on the contents of the Encyclical “Laudato sì”, paying particular attention to the guidelines and suggested activities such as ecumenical commitment and dialogue in international and local policies.
Findings: Highlighting the outcomes achieved such as the convocation of the Synod on the Amazon in 2019, as well as the measures taken by the Vatican on photovoltaics and, generally, on a more sustainable economy.
Conclusions: The research wants to clarify the need to understand that a large-scale cultural conflict on nature is underway: on the one hand there are the most extreme environmental trend introducing a new deification of nature, on the other hand, there is the theological contribution of Christianity which push us not to reduce nature to a mere substrate of manipulation and use, nor to overlap it on the human beings’ dignity.

The Roles of and Barriers to Policy and Legal Framework for Carbon Capture, Utilisation and Storage (CCUS) in the Asian Pacific Region

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On November 4th, 2016, the Paris Agreement for the first time brought all nations together to share the responsibility of combatting climate change and adapting to its effects. Nationally Determined Contributions (NDCs) represent each country's self-defined mitigation goals for the period beginning in 2020. However, many countries have still been struggling to seek for the best approach to achieving meet their targets and a low/zero carbon society. There has been wide discussion about Carbon Capture, Utilisation and Storage (CCUS) considered as one of the significant approaches to greatly reduce CO2 from the global atmosphere. Particularly, it is believed that application of CCUS will significantly become effective in fossil fuel based CO2 emissions. However, the current status of the world has yet to be widely demonstrated at a commercial scale, and CCUS implementation has still been low. It is a key challenge for nations and investors to understand the technology and benefits, and governments are responsible to prepare both for a relevant policy and legal framework for CCUS, in order to operate practically and successfully at the global and regional levels.

In terms of the emission levels in the Asian Pacific region (APr), during the past two decades, a number of governmental reports have clearly indicated that greenhouse gas emissions from the region, particularly CO2, have been dramatically increased, due to rapid industrialisation and population growth. Four of the ten countries with the highest CO2 emissions from fossil-fuel use are located in the region including China, India, Japan, and South Korea. Subsequently, other fast growth countries within the region, such as Indonesia, the Philippines and Vietnam, have rapidly been growing their fossil fuel based CO2 emissions. The APr includes developed, developing and emerging nations and it models, at the sub-national level, the broader problem of developed/developing country engagement on climate change. There is a need to build strong governance for facilitating more cooperative climate action between developed and developing countries at the regional level beyond the efforts that have been achieved by the European Union and the United States. In order to meet the global climate target, it is inevitable to act regionally and technological solutions should be considered urgently. CCUS could be one of the tools to achieve this, especially dealing with a number of fast growing countries in the APr.

In this regard, this paper aims at suggesting the region will need to act on regional, technological development to reduce CO2. This will address the key roles, principles and barriers for legal framework in order to expand potential opportunities to apply CCUS technologies in the APr. This will also suggest a range of key aspects in order to establish an Asian CCUS legal framework in the region. This study offers a framework of comparative analysis that is mainly drawn from the theories of 'global climate regimes', 'climate club', 'leadership theory' and 'game theory', which it broadens in order to assess any relevant the roles, principles and barriers to developing a regional legal framework for CCUS technologies (i.e. sharing and transferring them) within the APr. This study will not only contribute to overcoming the potential and future barriers to policy and legal framework for CCUS development in the region, but can also be applied in other technological development such as renewable energy development both at the global and regional levels.

“Crowdfunding” between private autonomy and market development (Sustainable development goals 16)

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Background context

Crowdfunding is a recent phenomenon which consists in promoting an initiative by collecting the necessary money through the web. It was born in America as a social phenomenon and found its economic justification in the possibility of collecting large amounts of money from small investors willing to engage in the realization of a project. The known forms of crowdfunding are: the *donation model*, the *rewards model*, the *pre purchase model* and the *equity model*.

Justification of the research/research argument

According to what the European Union has established (European 2020 measure) almost all member states have had to implement policies to incentivize innovative start-ups and to simplify the access to credit for businesses. Italy first issued the Growth Decree 2.0 which modified the T.U. of finance and introduced a discipline for the collection of money by innovative start-ups through the use of online platforms. Crowdfunding was actually introduced in Italy with the Consob regulation. Double legislation is justified by the need to identify a flexible discipline to meet the needs of investor protection. Such regulation contrasts the asymmetry of information existing between the issuer and the investors. This is achieved through a series of pre-contractual information obligations to which the investor is addressed and for which the portal operator is responsible.

Aim

The research aims to identify the rights and obligations of the issuer and those of the operator of the crowdfunding portal. The analysis will not fail to verify how and in what way the non-professional investor (weaker party to the relationship) must be protected.

Methods/approach

The work will first analyze the EU legislation that introduced various crowdfunding models among which the most developed is certainly the equity model. The most problematic aspects, which will be developed in the research, concern not only the phenomenon considered but also other aspects. Among these, the information for which the portal manager is responsible. This, in fact, must provide investors with all information relating to the offer (nature of the investment, type of financial instruments offered, associated risks) so that they can decide on the investment in an informed way.

Findings/results

The analysis will be aimed to verifying what are the rights and duties of the subjects involved in the crowdfunding operation that represents an important opportunity for the development of the internal and international market.

Conclusions

In Italy, and also in Europe, new regulatory interventions are desirable that can regulate the typical crowdfunding agreements but also all those atypical agreements that are widespread in the current historical-social reality. Think, for example, of disintermediate crowdfunding.

Special Theme: Sustainability And Africa

Factors influencing farmers' adoption of Aflasafe bio-control measures in maize production in Nigeria: an analysis of pull mechanism for technology transfer

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Feeding the ever growing world population would be a mirage without intensive utilization of research outputs by smallholder farmers. There is the need to rethink how technology is being disseminated to end users in order to ensure its wide adoption, utilization and sustainability. Pull mechanism marks a paradigm shift from supply driven to demand driven approach to technology dissemination. Aflasafe bio-control was developed to combat aflatoxin in maize at ensuring food safety to the consumers. Aflatoxin contamination in maize renders the crop unsuitable for human consumption and as well undermines the means of livelihood of the producers. This study was designed to assess how pull mechanism is enhancing the utilization of this proven technology among maize farmers in Oyo State, Nigeria. This will be essential to determine its potentials for scale up and sustainability of the approach to technology dissemination. The study determines the awareness of farmers on Aflasafe, sources of purchase of Aflasafe, incentives towards usage of Aflasafe, constraints to farmers' utilization and factors influencing farmers' utilization of Aflasafe bio-control measures. Respondents were selected using multi-stage sampling procedure. Data was collected from respondents through interview schedule and analyzed using descriptive statistics (means, frequencies and percentages) and inferential statistics (Pearson Product Moment Correlation and Regression analysis). The result showed that 89% of the farmers indicated Implementers as the outlet for the purchase of Aflasafe. Also, premium payment and provision of technical assistance were the highly ranked incentives to utilization of Aflasafe among the farmers. The study also revealed that the major constraints face by respondents were low access to credit facility, inadequate sources of purchase and lack of storage facilities. A little above half (54%) of the farmers were found to have fully utilized Aflasafe in maize production. Pearson Product Moment Correlation (PPMC) analysis revealed that there was significant correlation between incentives and utilization of Aflasafe (r-value=0.274; $p \leq 0.01$). The result of the regression analysis indicated maize production experience (β=0.572), output (β=0.531), years of formal education (β=0.404) and household size (β=0.391) as the leading factors influencing farmers utilization of Aflasafe bio-control in maize production. Pull mechanism has proven an innovation in incentivizing farmers' utilization of Aflasafe bio-control in maize production. This is evidenced on the current utilization of the product as a basic input in maize production. The premium payment has demonstrated high potential at enhancing adoption of the technology. Meanwhile constraint such as inadequate credit facility to procure the product by the maize farmers may challenge the sustainability of its utilization among the farmers. The study therefore recommends that governments and non-governmental organizations should be interested in making Aflasafe available to the maize farmers either through loan provision or price subsidy. This will help to sustain and improve the current level of utilization toward food safety and improved economic livelihood to actors in the maize value chain.

Outcomes and Potentials of Volunteer Programs for Sustainable Development and Capacity Development in Transforming Societies: Case of Japan International Cooperation Agency (JICA) Volunteers in Malawi,1971-2020

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A wide range of volunteers, both local and international, has been devoting considerable efforts towards transforming various societies in different parts of the world. Such volunteer works have seemingly made some impacts on societies, particularly enhancing the capacities of both sides of the stakeholder equation - namely locals in the respective societies and volunteers themselves.

Our research examines concrete outcomes and potentials of volunteer works, focusing on transforming societies and enhancement of capacities through the case of the Japan International Cooperation Agency (JICA) volunteer program in Malawi. JICA has been dispatching Japanese volunteers to Malawi since 1971 and the number of JICA volunteers sent to Malawi is the largest compared with any other countries to which JICA has sent worldwide. The researchers started this research prior to the 50th anniversary with a primary focus on concrete developmental and capacity outcomes to draw implications for potential roles of volunteers for long-term sustainable development in the context of Africa.

This research has adopted a set of methods including: 1) literature review; 2) a questionnaire survey targeting former JICA volunteers who worked in Malawi; and 3) interviews and observations through field research in Malawi. In the field research conducted in the northern, central and southern regions of Malawi from November 2019 to January 2020, the researchers interacted with a wide range of Malawian stakeholders who have worked with JICA volunteers in diverse sectors including agriculture, forestry, animal husbandry, health, primary / secondary / technical education, sports, industry, and community development, among others, in the course of this 50-year collaboration.

This research has revealed several key preliminary findings. First, the volunteer program has contributed significantly to capacity development of both locals and volunteers themselves. Both sides affirmed that their experiences of cooperation and interactions have brought about not only development outcomes but also invaluable learning opportunities, personal growth, career development, inter-cultural understanding and positive images of both sides of the two countries, contributing to long-term sustainable capacity development. It has also been found that perceptions of locals who appreciate the contributions by volunteers tend to be more positive than those of volunteers who are seemingly rather skeptical about whether or not they have made any impacts on societies. Furthermore, the research also shows that efforts which have been intended to promote capacity development tend to enhance probability of sustainability of development outcomes. Enabling environments —including institutions, policies, regulations and practices in which locals and volunteers collaborate— also affect potential outcomes of sustainable development as well as capacity development either positively or negatively.

This paper concludes that collaboration between locals and external volunteers evidently and potentially creates significant outcomes for sustainable development and capacity development, contributing to the transformation of societies.

Sustainable Development of South Africa: an in-country perspective

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Globally, most governments have come to accept the need for less exploitative forms of development and have undertaken developmental goals and projects that aim to provide a conducive living environment for future generations. Model projections indicate that the majority of population growth and development will occur on the African continent in the next century. There are progressive factors indicating that sustainable development on the continent requires urgent focus. As such, African governments recognised this urgency and, together, developed the African Union's (AU) Agenda 2063: The Africa We Want, which details developmental goals for the entire continent for the next 43 years. Furthermore, a global collaborative effort resulted in the Sustainable Development Goals (SDGs), set out by the United Nations General Assembly, to prioritise developmental goals for creating and maintaining a sustainable future for current and future generations. Sustainable development plays an important role in supporting South Africa's growing population, contributing to the country's economy and conserving natural resources. The AU's aspirations, together with the SDGs, have partly been incorporated into the government's National Development Plan (NDP), and the country's public and private sector actively supports sustainability measures. Even so, high poverty rates, economic contraction and untenable use of natural resources persist in South Africa. A qualitative review of South Africa's addressment and fulfilment of specific SDGs was conducted, namely SDG 4: Quality Education, SDG 8: Decent Work and Economic Growth, SDG 11: Sustainable Cities and Communities, SDG 13: Climate Action, SDG 15: Life on Land and SDG 16: Peace, Justice and Strong Institutions. This was done in relation to government actions, private and public sector involvement and societal engagement. Published literature and current news were reviewed to explore country-specific issues within these SDGs, to reflect on the measured impact, summarise indices and evaluate the county's commitment to these SDGs. Possible solutions to system challenges are highlighted and research needs are outlined for consideration. In conclusion, addressing the needs of the many, while managing the state of the economy and natural environment, is within the capabilities of South Africa and is thus a realisable goal. Sustainable development within environmental limits has never before been as important to focus on as it currently is. To do so, better prioritisation of development goals and future scenario planning is needed, in conjunction with increased research addressing the core developmental needs. South Africa should not only be investing in development initiatives but should actively be developing normative scenarios for the most favourable future that could realistically be achieved. The development of such scenarios are able to guide as well as frame development initiatives so as to ensure that they effectively work towards a common goal. Proper research-based planning and cross-platform collaboration will enable future generations to benefit from a functioning economy with abundant resources which will allow them to support their needs.

the Effects of Households' Lifestyle on Carbon Footprint in Ibadan Metropolis

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The environment has shown remarkable and negative changes due to increasing anthropogenic activities which directly and indirectly release greenhouse gases (GHG) into the atmosphere. When fossil fuels are used to generate energy, forest trees are cut down and burnt, carbon dioxide is emitted. Human daily activities are also dependent on electricity generated mostly from carbon-based materials.

This research assessed the effects of household lifestyles to on carbon footprint in Ibadan Metropolis, Nigeria. The work sought to**s** profile the components of the lifestyle that described household's carbon emission and estimated the carbon footprints of the components of households; determine the factors that influence the carbon footprint; and whether there is a significant relationship between the components of the households and the carbon footprint.

The study was conducted in Ibadan, the capital of Oyo State. Ibadan is a city located between longitude 70 20" and 70 40" East of the Greenwich meridian and between latitude 30 55" and 4010" North of the equator. The primary source of data was collected with the use of a structured questionnaire containing both open- and close-ended items. The study used a multistage sampling technique in selecting representative households. The first stage involved the selection of workplaces within the local governments' areas. The profile of household components was matched to households' consumption to obtain household carbon emission. The estimation of carbon emission revealed that households mean emission in Ibadan, Nigeria was 250.96 CO2e kg/person/annum. When disaggregated by major consumption categories, results show that direct energy utilization is relatively higher than mobility. Income, family size, accommodation type and commute time to work are the key variables that explained the relative contribution of carbon emission to households' carbon footprint.

The household carbon footprint in Ibadan is not worrisome and does not pose a serious threat as compared to the level of emission in industrialized nations. However, it is essential to investigate this issue because as population increases and incomes improve, households tend to increase their carbon footprint.

Posters

Are energy policies efficient?

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Despite the Paris Agreement efforts to limit temperature increases well below 2 degrees Celsius above pre-industrial levels, CO_2 emissions rose to historic highs in 2018; reached 33.1 Gt and further – minimum of 1% - increase is expected in 2019 (Enerdata, 2019). This was mainly driven by energy demand. The use of carbon pricing to link the external cost of carbon emissions to the generating sources to reduce carbon emissions and attract new investment to clean energy projects is gaining momentum around the world. New carbon pricing mechanisms are gradually being implemented, with ambitious GHG reduction targets announced by governments and business leaders in increasing frequency. As of 2019, the carbon pricing mechanisms implemented, or scheduled for implementation, cover about 11 GtCO2e or 19.6% of the global GHG emissions (The World Bank Group, 2019). This presentation evaluates the effectiveness of currently used policies implemented, including countries under the EU emissions trading system (EU ETS), nationwide carbon tax policies and hybrid policies. Repeated-Measures ANCOVA is used for examining whether there are differences in the GHG emissions per capita of the examined countries over the years. Green House Gas (GHG) emissions per capita were used as dependent variables. The main analytical tool is the Repeated Measures AN(C)OVA procedure. There are three studies in the investigation: the examination of GHG emissions changes in the examined countries; the effect of the different energy policies to GHG emissions; and the effect of the different energy policies to GHG emissions with filtering out main influential factors, such as GDP, unemployment rate, the volume of exports of goods and services and inflation. The reason of selecting those variables is the following: International trade competitiveness is a main concern for all countries, and the widely held assumption is that a carbon tax has a negative effect on both trade and industry competitiveness. As the results show, the per capita GHG emissions increased in all the examined countries during the study period, also in those, where carbon pricing mechanisms were implemented, and the changes are mainly independent from the type of policies applied. When the increase of the emissions due to other economic factors were separated, the emissions still increased for most of the examined policy types, except the countries with hybrid ETS + carbon tax policies. The results highlight the necessary further improvements to GHG reduction programs to meet COP21 climate change targets. However, as the statistics prove, the social economic structure, which are the real cause of the GHG emissions, are not changed by these policies yet.

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Assessing the relationship between Industrial Ecology, Industrial Symbiosis, and Territorial Development over time

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Since Frosch and Gallopoulos (1989) popularised the concept of Industrial Ecosystems by proposing industrial processes to resemble a natural ecosystem, there has been an increase in the literature written about Industrial Ecology. While Graedel and Allenby (1995) wrote the first book on the subject, early developments on the metabolisms of flows of materials were simultaneously proposed (Ayres, 1994) generating a clearer understanding of the concept and its associated methodologies. Further contributions examined the implications and limitations of Industrial Ecology for achieving a sustainable development (Brand and De Bruijn, 1999; Korhonen, 2004) and its links with policy (Allenby, 1999; Chertow, 2008) and territory (Ehrenfeld and Gertler, 1997; Deutz and Gibbs, 2008).

Since the 1990s, there has been a significant increase of the literature on Industrial Ecology and related subjects. The results of a first bibliometric analysis, using the concepts of "Industrial Ecology" and "Industrial Symbiosis" as keywords, demonstrated that the production of academic literature has transitioned from an average of 32 publications per year in the second half of the decade of the 90s (1995-1999) to an average of 288 publications per year during the last 5 years (2014-2018). That means an increase of 17% annually since 1963 (year of the first publication registered by the database of Scopus).

In a previous literature review on the concept of Industrial Ecology, a gap was noticed, namely that few studies connect the impacts of Industrial Ecology and Industrial Symbiosis strategies to the territory upon which they are based. Instead the literature tends to focus attention on only those geographical areas where Industrial Ecology activities and strategies take place, such as eco-parks, eco-industrial parks, and suchlike. It rarely examines larger territories, such as cities, regions and city-regions.

Accordingly, a comprehensive bibliometric analysis was undertaken in order to explore the relationship between concepts of Industrial Ecology, Industrial Symbiosis and territory. Searches relating to the concept of territory focused on four different concept categories: "Regional Development", "Regional Planning", "Urban Development" and "Urban Planning". Those four concepts were recognised as the most frequent and relevant keywords/categories in the academic literature to demonstrate the link between territorial development and the concepts and code words "Industrial Ecology" and "Industrial Symbiosis".

The result of the search showed that annual scientific production of Industrial Ecology literature has increased an average of 11% since 1975, going from an average of 1 article per year in the second half of the 90s (1995-1999) to an average of 10 articles published per year in the last five years (2014-2018). However, a result of 133 articles relating the concepts chosen represents a total of 3-4% of the publications containing only the words "Industrial Ecology" and "Industrial Symbiosis".

The proposed article will develop a fuller bibliometrics analysis on the subject in order to contribute to the development of better ways to capture the benefits of the operationalisation of the concept of Industrial Ecology. The assumption is that territorially based strategies are more conducive for developing the potential of industrial systems to generate more sustainable practices. Industrial Ecology contributes to generate holistic framework to generate sustainable change, not only at the individual firm scale, but as a network of firms that generate a wider industrial ecosystem with the goal to minimise the environmental impact of their activities.

Assessing Water Sustainability in Cyprus

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The complexity for a sustainable, adequate supply of water in Cyprus, while ensuring the enhancement and protection of quality and quantity of aquatic ecosystems, continued to raise concerns in Europe and around the globe. This research's purpose was to find out which solutions are the best practices for sustainable water resource management. Overconsumption of water resources can have dramatic impacts on ecosystems. Cyprus has a semi-arid climate which means that conventional water supply is limited by several factors, and water overconsumption is an additional stressor to the environment. Environmental scientists have been proposing that sustainable management of water use can be achieved through the protection and preservation of aquatic ecosystems, by climate change, and behavioural adaptation and pollution reduction. A water balance for Cyprus was set up. The politically unstable situation due to national jurisdiction causes problems regarding contradictory data because different land areas were included in different data sets. To meet the demand groundwater abstraction was the easy solution since groundwater aquifer supply surpassed the availability of all other sources. Treated water supply in irrigation increased as the available treated water increased throughout the years. The domestic sector was supplied with desalinated water during dry periods because surface water was not enough to meet the demand. Regarding the possible future development for water supply in Cyprus three scenarios were produced. To reduce the water from evapotranspiration so that more water remains in storages, the first scenario focused on climate change adaptation. The outcome from the second scenario which focused on the demand of water in the four sectors was that by including the consumption of the northern area of Cyprus total demand increased and by reducing overconsumption total demand decreased. The sector with the highest water demand was in agriculture. The focus of the third scenario was on the water availability from different sources. The most viable solution that follows the sustainable abstraction levels was the combination of all sources.

ASSESSMENT OF ECOSYSTEM SERVICES IN ADAPTIVE ORCHARD MEADOWS IN VISNYESZÉPLAK

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The concept of ecosystem services has become an important element of scientific research and policy on biodiversity and landscape conservation. Ecosystem services are the material and the non-material assets that ecosystems provide to society. It is important to emphasize that these services are only realized if the entire ecosystem operates appropriately. Recently, there has been an increasing focus on the ecosystem services of agroecosystems as well. Adaptive orchard meadows are complex agroecosystems, which rely on old traditional farming and combine fruit trees with meadows. Farming in adaptive orchard meadows is a complex activity that requires a holistic approach by farmers but, in return, it provides several benefits to the farmer and the local community. Our aim was to prove that these adaptive orchard meadows can provide a wide range of ecosystem services in an area characterized by a good ecosystem condition. In our study, we assessed the ecosystem condition and the ecosystem services of adaptive orchard meadows in an eco-village, Visnyeszéplak, situated in the south-western part of Hungary. In this village, inhabitants attempt to live in harmony with nature. Therefore, all farming activities are nature-friendly. The assessment of ecosystem condition was based on the qualitative content analysis of interviews, the results of a survey of nesting bird populations and scientific data. The following criteria were used for the evaluation: intensity of use, presence of invasive species, habitat and species diversity, soil fertility, water retention capacity and risk of erosion. Ecosystem services were selected and characterized based on the interviews and available scientific data. Only provisioning and regulation and maintenance services were selected. Cultural services were not within the scope of our assessment. Our results show that the village has a mosaic spatial structure and the orchard meadows are comprised of different habitats as well. The bird survey revealed a high biodiversity of bird species. Invasive species are not widespread, indicating a good ecosystem condition. The water retention capacity of the area is extremely poor. The soil fertility is also low and there is a high risk of erosion but, with nature-friendly farming, these conditions have been improved. Ten ecosystem services were identified in these adaptive orchard meadows. Seven provisioning services were found, such as products from bred animals (meat, milk, egg and honey), plant-based services (e.g. fuel wood, fodder and herbs), genetic material from local fruit, domestic animal breeds and others. Three regulation and maintenance services were identified, such as control of soil erosion, pollination and micro climate regulation. Our main conclusion is that nature-friendly farming helps to maintain the good ecosystem condition and it is a good basis for the provision of ecosystem services.

Being engaged in the sustainable consumption

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Sustainable consumption, providing a clean and healthy environment, as well as improving life for the current and future generations, is an integral part of the sustainable development strategy, which is understood as a compromise between the environmental, economic and social objectives of society. However, the modern production and consumption are not sustainable (Reisch, Eberle and Lorek, 2013) and contribute significantly to global challenges such as climate change, biodiversity loss and environmental degradation (IPCC, 2017). Thus it is obvious need of the significant efforts are being made to promote the sustainable consumption. Climate change and global warming are becoming major issues for the future of our planet (Yerdelen et al. 2018).

Sustainable consumption behavior as a complex phenomenon is gaining increasing attention among researchers (Henderson, 1999; Peattie, 1999; Assadourian, 2010; Seth, Sethia, & Srinivas, 2011; Varey, 2012, Verain et al., 2015; Govindan, 2018, et al.). Researchers aim to explain, measure and predict the sustainable consumption.

According to Aitken and Watkins (2014), the sustainable consumer behavior is influenced by many social, psychological, cultural and institutional factors and faces many barriers that make it difficult to choose sustainable consumption, such as price, availability, convenience, quality, habits, product claims, lack of information, and others (Aitken and Watkins, 2014). All of this leads to a gap between consumers' attitudes to sustainability and sustainable consumption behavior (McDonagh and Prothero, 2014).

Research shows that attributes such as universality, benevolence, autonomy, responsibility and freedom tend to be associated with sustainable consumption, whereas values of power, hedonism, tradition, ambition and security are associated with less knowledge and less sustainable consumption (Vermeir and Verbeke, 2006 ; Kadic-Maglajlic, 2019). Access to the clear and reliable information is an important part of the consumer behavior process. Research shows (Muriel et al., 2015) that only a small percentage of consumers have high awareness or understanding of sustainable consumption and are aware of the impact of their decisions on the food supply chain (Dickson, 2001; Verbeke, 2005; Terlau and Hirsch, 2015). The less information and / or the more complex and contradictory the information, the more difficult it is for the consumer to behave sustainably. Uncertainty can encourage the use of social information, which means that users will follow other people to seek relevant information and examples from them. Kadic-Maglajlic et al. (2019) research results also shows that the pro-environmental engagement and pro-social engagement are significant predictors of pro-environmental and pro-social consumption behavior. Also the emotional intelligence boosts the effect of engagement on pro-environmental and pro-social consumption behavior, and it has a significant direct effect on pro-environmental behavior. Authors investigate self-identity and consumer values as determinants of pro-environmental and pro-social engagement in their study. However, research that investigates other determinants and their impact is sparse thought it is suggested the environmental attitude/awareness , the cost (Chaplin & Wyton, 2014) and time perspective (Milfont, Wilson & Diniz, 2012) could also affect the pro-environmental and pro-social engagement that lead to sustainable consumption behavior.

The present theoretical study addresses this research gap by exploring the relationship between the pro-environmental and pro-social engagement and consumption behavior. Therefore, the analysis of the main determinants that induce the pro-environmental and pro-social engagement are presented in the paper. The moderating role of emotional intelligence on relationship between above constructs is investigated.

The method used is the comparative and systematic literature review.

Can green roofs compensate for the loss of biodiversity in cities?

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In an urbanizing world, with a projected 5 billion people living in cities in 2030 (Véron, 2007) the roles and benefits of urban green space can not be denied. As this pattern of urbanization continues, changes in habitat structure and function caused by habitat degradation, loss, and fragmentation will likely reduce the survival and reproductive ability of many species (Winfree et al., 2009).The aim of our study is to check if green roofs can compensate, whether partially or fully, for this loss of biodiversity in cities.

Green roofs do not only have an aesthetic benefit in an urban environment, over the last twenty years more and more studies show their benefits on water runoff and evapotranspiration (Mentens et al., 2006), reducing the heat flux due to insulation (Jim & Tsang, 2011; Kumar & Kaushik, 2005) and they reduce pollutants such as carbon dioxide (Li et al., 2010). It is only relatively recent that comprehensive research has been undertaken on the possibilities green roofs have to support biodiversity. Nonetheless, during the last two decades studies have indicated that green roofs in large cities have a high potential for some species negatively impacted by the loss of habitat (Brenneisen, 2006; Baumann, 2006; Kadas, 2006, Madre et al., 2013). Further studies are necessary to see on what scale the green roofs and other green infrastructures can help prevent the loss of biodiversity in urban landscapes.

We picked out four different green roofs in the three main cities of Flanders, Belgium (Gent, Hasselt and Antwerp). All the green roofs were extensive roofs, which don't require much maintenance and are lightweight with a shallow build-up height. On each roof 4 pitfall traps were installed with a randomizer tool to maximize roof coverage. Each pitfall consisted of a plastic cup that was placed in the substrate and we used propyleenglycol to preserve and kill the captured fauna. Every trap was emptied and reinstalled every month. We started sampling in january 2019 and continued this for a whole year.

We compiled overall abundance of the selected species (beetles, spiders, ants, flies and mosquitos) as well as the total abundances of these species from the different traps on all green roofs. Over all the green roofs we collected for example 1348 specimen of spiders and 33 different species. Many of the species collected on the green roofs are associated with dry habitats. However some of the spiders (P. Vagans, A. Mollis, P. Clercki) caught on a subset of the roofs are also known to be associated with humid to wet habitats.

We must underline that we don't have all the results yet, and so conclusions are really premature. Nonetheless our results show that during the design of green roofs, factors like irrigation and water retention will be necessary to create roofs that will attract diverse set of species (spiders).

Further results can hopefully lead to better recommendations for the optimal design of green roofs, concerning optimizing the biodiversity in cities.

References: see reference list (unable to add due to word restriction limit)

Comprehensive farm-level sustainability assessments for sustainable cocoa production. A case study from Ecuador.

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Cocoa beans – produced in the tropics and mostly consumed as chocolate in industrialized nations – are traded in global value chains. Chocolate companies on the downstream side of these value chains are increasingly held accountable for their entire value chains and thus intensify their sustainability investments. In order for these companies to assess and monitor value chain sustainability, suitable assessment methodologies and frameworks are required. Within agricultural value chains, the farm-level significantly contributes to the total environmental, social, and economic impact of a chain, and thus requires special attention when looking at value chain sustainability. Until now, numerous frameworks to assess farm-level sustainability have been proposed. These, however, show trade-offs between scope and precision, make use of different theoretical reference frameworks and thus apply different sets of indicators, which inhibits the comparison and generalization of results, or focus on single sustainability dimensions. Until now, cocoa production systems have not yet been studied through a comprehensive lens. This study therefore aims at assessing the sustainability of cocoa production systems against a standardized and holistic assessment framework in order to identify sustainability hotspots. In order to reach this goal, the SMART-Farm Tool was applied: A multi-criteria assessment methodology that assesses farm-level sustainability in a comprehensive way. It operationalizes the FAO Sustainability Assessment of Food and Agriculture Systems (SAFA) Guidelines with 58 sustainability themes within the four dimensions of environmental integrity, social well-being, economic resilience, and good governance. We applied the SMART-Farm Tool to collect semi-quantitative data from 195 fine flavour cocoa farms in northern Ecuador. All farmers form part of a Swiss chocolate company's corporate sustainability program. Our results showed sustainability hotspots within each dimension: Farmers' application of partly hazardous plant protection products (22 active ingredients reported), for example, influenced the sustainability theme "biodiversity" in the environmental dimension. Low levels of on-farm value creation negatively influenced the "local economy" theme in the economic dimension. Within the social dimension, missing contracts with farm workers, as well as a lack of freedom of association and collective bargaining represented major hotspots. Farmers' limited awareness of and commitment to sustainability negatively influenced the "holistic management" theme in the good governance dimension. Farmers themselves mainly perceived the low profitability of fine flavor cocoa production as a main challenge, and thus considered converting their cocoa plots to other, more profitable production systems. Despite having received training on diverse topics, including bookkeeping, environmental conservation, and crop management, many farmers did not apply the training contents on their farms. Our results indicate that there is room for improvement in each sustainability dimension to ensure the future of fine flavor cocoa production in northern Ecuador. Chocolate companies can create an enabling environment for smallholder farmers to increase their sustainability performance through value chain approaches like sustainability programs, pricing structures, or incentives. This, however, requires suitable monitoring and evaluation mechanisms within corporate sustainability programs to continuously identifying farmers' main challenges and adjust efforts according to measured developments.

Don’t confuse me! - Insights into householder decision making around recycling plastic waste

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Background: The United Kingdom Government has committed to getting rid of disposable packaging by 2042 and move towards having zero plastic ending up in landfill, rivers, beaches and oceans. Despite an increase in understanding of attitudes towards recycling, and significant efforts by Local Governments and charities to raise awareness and educate householders, approximately 60% of plastic waste is not being separated for recycling in Northern Ireland. **Justification**: At an individual level, considerable knowledge deficits still exist, as do situational, psychological, and socio-economic barriers. While we understand what may predict positive attitudes towards recycling, little is appreciated about the point at which the decision making process around recycling falters, or becomes flawed, resulting in a lack of recycling behaviour or the contamination of recyclate. **Aim:** This research thus aimed to provide greater clarity on the complex psychological, pragmatic, and social factors influencing plastic recycling behaviour. **Method:** In-depth qualitative interviews were used to analyse consumer understandings of what may motivate them to recycle; their own capabilities; and the recycling opportunities available to them, (the ‘COM-B’ system: Michie et al., 2011; Gainforth et al., 2016Semi-structured qualitative interviews were conducted with 20 consumer and 12 Stakeholders to explore individual, pragmatic and social barriers to plastic recycling behaviour. The interviews lasted between 30 and 45 minutes and were audio recorded and transcribed. The analysis combined a phenomenological approach (Smith, 1996) with a semi-directed content analysis approach (Hsieh & Shannon, 2005) allowing the researchers to consider the findings within the context of the COM-B framework and other relevant theoretical frameworks, while also have a degree of flexibility to make sense of and offer interpretations of all the data. Any overarching topics identified will serve to provide a sound representation of the findings (Braun & Clarke, 2006). **Results:** They include; public awareness and consciousness about the plastic waste problem is increasing; shopping behaviours are automated and little thought is given to food packaging at the time of purchase; uncertainly and confusion about disposal of plastic waste leads to cognitive dissonance; and the public expect their efforts to recycle to be reciprocated by local recycling companies making it easy and simple to do. More efforts are needed to provide householders with simple, clear, consistent information so that correct recycling becomes routine and habitual. Food packaging design needs to be simpler, and the whole package should be clearly marked in an unambiguous way indicating that the item recyclable. If food packaging is split up into different components, the advice on the packing needs to provide advice about every part and if it can be recycled. Consumers want decision making to be kept to a minimum, otherwise confusion can lead to annoyance and valuable recyclate will continue to end up in the general waste. **Conclusions**: New insights acquired will lead to a series of recommendations for appropriate behaviour change strategies that encourage the reuse, reduction and recycling of plastics, and help tackle the plastic waste problem. An important innovative component of our research project is that the research findings will be shared directly with the Queens University Belfast Polymer Processing Research Centre (PPRC) design team affiliated with the ACCEPT Transitions project. Eventually the findings will be used to create plastic products that are more likely to be recycled, based on feedback obtained from consumers.
E

Experiences using the cascade model in the Hungarian National Ecosystem Service Mapping and Assessment project

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The concept of ecosystem services (ESs) emerged a few decades ago and since then it has become an important topic in the biodiversity science-policy interface. This concept is assumed to assist in making modern societies more sustainable by highlighting the importance of ecosystems, because they provide a wide range of services to humans. The cascade model is the most widely used conceptual framework for the assessment of ESs, which distinguishes 4 stages from ecosystems to society: 1) condition of ecosystems, 2) capacity of ecosystems to provide ESs, 3) actual use of ESs and 4) benefits to society through the contribution of ESs to well-being. The Hungarian National Ecosystem Service Mapping and Assessment project (MAES-HU, 2016-2020) co-financed by EU (KEHOP-4.3.0-VEKOP-15-2016-00001) and coordinated by the Ministry of Agriculture applies the cascade model as the main framework for the mapping and assessment. The project is still ongoing but some preliminary results already can be shown. 12 ESs were selected for investigation as a result of a prioritisation process including 3 provisioning, 7 regulating, and 2 cultural services. Biophysical models based on existing data and expert based assessment methods were applied and combined with mapping where it was possible. Assessment and mapping were conducted in interdisciplinary working groups. Economic valuation is currently being carried out for only 3 services. Our aim is to show our experience using the cascade model as a framework in MAES-HU. Three criteria were chosen for this exercise, which were evaluated for all the ESs assessed in MAES-HU: 1) whether the different stages of the cascade could be distinguished; 2) whether all these stages could be quantified and mapped; and 3) whether the assessment of the stages were linked to each other. Our preliminary results show that the operationalization of the model was not so easy. The distinction between the first (ecosystem condition) and the other stages was relatively straightforward for all services, but between the second (capacity to provide ESs) and third (actual use of ESs) stages it was much more difficult, particularly for some regulating (e.g. climate regulation) and both cultural (hiking and mushroom picking as heritage) services. Distinguishing well-being from the other stages was also possible for all services. We were able to select indicators for the quantitative assessment of almost all services and stages, except for a few cases. As an example, flood risk reduction at lowlands at the stage of the capacity and actual use was not assessed, partly because the canalized rivers currently do not allow ecosystems to provide this service. Some dimensions of well-being (fourth stage) were only qualitatively described. Due to the lack of data for pollination the difference between demand and potential use was assessed instead of actual use. Mapping was not done for some services due to the lack of spatial data (e.g. hiking at the level of actual use) or the problems of quantification mentioned before. Linking the 1-3 stages of the cascade was possible for most services but to link the first 3 stages to well-being remained a challenge. We think that the cascade model is definitely valuable to show the link between ecosystems and society through the flow of ESs fostering interdisciplinary discussions. Nevertheless, the problems that we experienced in the operationalization of the model indicate how complex the natural and social systems and their interface are.

Framing the tourism industry into circular economy practices

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Tourism is a fast-growing industry. It gives an important contribution to economic development but, at the same time, it is also a significant contributor to environmental degradation and climate change. Considering that many of the tourist activities are based on the availability of natural ecosystems in good condition and accessible to tourists, it is crucial for the long-term success of the industry to develop strategies to mitigate its impact on the environment. Over the last years, Circular Economy (CE) has arisen as a tool to operationalize sustainable development principles and as a crucial guide of action for national and supranational policies. Considering the need for the tourism industry to move toward a more sustainable approach, the main goal of the paper is to figure out how the CE may support the tourism supply chain into this transition. Starting from a literature review aimed to identify CE operationalization principles, the paper tries to evaluate how those principles may be applied to the tourism industry. Once identified CE operationalization principles, the paper offers a brief overview of literature analyzing the potential of applying CE into the tourism industry. As circular tourism conceptualization and implementation are still underexplored, this paper presents a first attempt to frame circular tourism practices into the CE umbrella concept. To build the circular tourism implementation framework, we first employ the 11R framework that has been adapted for tourism sector CE implementation, in order to identify CE practices applicable to this sector. Once the practices had been established, they will be framed to evaluate at which level it is possible to apply it, according to their potential implementation at destination level (decision-makers, local authorities, NGOs, industry associations), firms' level (hospitality, bar & restaurant, tourism facilities, tour operators, travel agencies), and consumers level (travelers). Moreover, it poses the base to the development of a circular tourism framework, whose goal is to identify for each CE principle its potential implementation into the touristic supply chain. The recent proliferation of studies inherent the circular approach has stimulated academic research by opening new currents of research and leaving mostly unexplored others. The application of the CE concept in the tourism sector is still unexplored and more efforts should be done to understand the potentialities of Circular Tourism. The objective of the paper is to create a framework for circular tourism implementation, identifying the interrelations existing between the circular economy and the development of a more sustainable tourism. CE principles and related practices have great potential to ensure a balanced development of the industry, actively contributing to the achievement of long-term sustainability goals. The proposed framework may represent a solid baseline to further investigate the potential impact of CE practices on a touristic destination. As this is a preliminary study, the next step will be to identify for each of the 11 Rs the specific CE practices to be implemented by the touristic supply chain stakeholders. To give soundness to the project, further development will include interviews with relevant tourism stakeholders to test the level of application of CE practices in the tourism sector; the categorization of CE practices in hospitality industry into the framework proposed; and the application of the framework in our pilot project, involving tourism firms in a coastal destination.

Life cycle sustainability evaluation tools within the framework of circular economy: A systematic and critical literature review for agri-food sector

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Circular economy is currently one of the most discussed concepts among researchers, politicians, and academics. Its main principle regards a more efficient use of resources and the decrease of wastes, stressing the necessity of reusing, recycling, and reducing to limit negative impacts on people and environment. Circular economy is about the rethinking of the current models of production and consumption, and agri-food systems, which are responsible for the pressure on the living environment as well as for assuring the survival of many farms in rural areas, must necessarily move toward transition pathways. Exploring the potential contribution of circular approaches to sustainable production in agri-food systems also means understanding how to pay more attention to the social, economic, and environmental aspects of sustainability. However, undertaking such different dimensions is methodologically challenging and calls into question the epistemological foundations of sustainability science and circular economy. One of the greatest concerns is around the combination of different assessment methods and merging their results in a suitable and believable way. To satisfy these purposes, sustainability evaluation tools and, among them, the life cycle (LC) approaches are required to be systemic, multidisciplinary, and multicriterial. LC methodologies, i.e., the Life Cycle Assessment (LCA or eLCA), Life Cycle Costing (LCC), and the Social Life Cycle Assessment (sLCA), are obtaining a growing consensus in the appraisal of the environmental, economic and social impacts of different agricultural systems. In this context, the use of a LC framework, able to capture all sustainability dimensions, can be adapted to evaluate circular economy strategies in an operational and comprehensive way. This study aims at providing a systematic and critical review on the state-of-the-art of life cycle applications from the circular economy point of view. In particular, the main objective is to understand how researchers adapt life cycle approaches for the measurement of the empirical circular pathways of agri-food systems along overall lifespan. To perform the literature review, PRISMA protocol and its recommended checklist items were considered in order to conduct a systematic and critical review by meta-analysis procedures. Specifically, an evaluation matrix has been set up to gather and synthetize research evidence, by classifying papers according to several integrated criteria. The literature search was carried out by means of scientific databases (Scopus and Science Direct). The study carried out a systematic and critical review of the extant literature, highlighting the following features: which LC methods have been used to measure the sustainability of circular economy practices; how they have been integrated or complemented (methodological relationships); the degree of participation of all actors involved along the life cycle; and which synergies have been achieved by combining the methods.

Marine litter: the 21-century problem. Education for sustainability as a tool to act in a case study.

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'Transforming our world' is the 2030 Agenda for Sustainable Development message, where a rethinking of the actual consumption patterns, effective waste management and minimization of anthropogenic waste in the marine environment are foreseen. The deposition and accumulation of solid waste in the marine environment – marine litter (ML) – is an emerging global problem with significant environmental, social and economic impacts. Considering that unsustainable human land practices are the major source of marine debris, the solutions to tackle the problem lie on land. However, the current solutions do not produce the desired effects, either because they constitute extrinsic motivations either because they focus downstream of the problem. Therefore, actions to overcome ML must have an awareness-raising character, tackle the problem at the source, encompass a holistic approach and cover a broad range of actors. In this way, the following communication aims to present the research plan and the methodological approaches to raise public awareness, as well as educate the population about the thematic and its impact on the blue economy of Madeira island. This insular region is strongly dependent on tourism, and the increased number of people on the island leads to an additional amount of litter. This situation, along with the fact that the marine resources are important for the region's economy, is the reason why Madeira was chosen as the place where the study will be carried out. To the best of our knowledge, this is the first study exploring education for sustainability as a tool to overcome ML problem in Madeira. Additionally, and contrary to what is usually done, the research intends to target a broad range of individuals, encompassing not only students but also the general public, fishermen, coastal users, tourists and stakeholders. For that, OSPAR methodology will be followed to characterize and quantify the ML items commonly found on the South coast of Madeira, being this step complemented with semi-structured interviews and statistical analysis concerning waste production and management. After a deeper comprehension of the production and deposition of debris in the 'World's Leading Island Destination', an integrated educational approach targeting different groups of people will be developed and assessed. The mobilization of stakeholders and the definition of local strategies to tackle the problem are also among the work's aims, considering that literature reports that insufficient communication among the parties exacerbates the ML issue. After the implementation of education for sustainability programs, changes in attitudes, behaviors and routines are expected, thus making the assessment of the effectiveness of this educational approach necessary at two levels: 1) analyze if there were alterations in the consumption patterns through the adoption of a circular economy strategy, ultimately translated in a decline in waste production; 2) evaluate if there was a reduction in the number of debris in the marine environment, owing to the increased ocean and environmental literacy. Finally, since this investigation is being developed on an island, it will be easier to verify the effectiveness of the implemented educational strategy. If the hypothesis that education for sustainability is the key to tackle ML becomes validated, the work can then be replicated at the national and/or international level. Furthermore, this approach, if proven correct, will stimulate the sustainable development of the regions.

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Private financing of investments in natural capital

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Evaluations of the progress towards sustainable development and climate goals call for more active engagement of private capital in improving the state of the natural environment. The research to be presented focused on investigating the institutional conditions to intensify the role and contribution of private financing. Alternative to public funding, private financing of investments in natural capital needs market mechanisms and business models with aligned biophysical and monetary flows. Conceptually, via such mechanisms defined environmental goods and services are sold and purchased by sellers and buyers at agreed price. Also, to integrate environmental assets in the economic system there is a need for a coherent framework, which allows transactions to take place between providers and beneficiaries of environmental goods and services. These markets need to be managed, or governed, so that such transactions can take place between incentivized, or pursued buyers and sellers. At the same time, to support policy, environmental assets, as well as transacted goods and services (stocks and flows, respectively) need to be accounted for in the statistical system. To investigate global initiatives that address these issues, empirical research was carried out using primary sources from key institutions and secondary sources, such as scolarly articles. The presentation would introduce and discuss the following main initatives and institutions: WEALTH program, System of Environmental Economic Accouning, Payments for Environmental Services scheme and the AgoraNatura platform. The World Bank's WEALTH program is aimed at developing metrics for sustainable growth to complement GDP. The concept, founded in environmental economics, provides means to assessing the sustainability of economic growth by measuring the change of the Total Capital, or WEALTH of nations, encompassing produced, human and natural capital, as well as net foreign assets. The methodology to generate and analyze the change of Wealth accounts replaces composite indicators, that had been developed earlier to synthetize various aspects of sustainability into a single indicator. National Wealth accounts have been built and maintained by the World Bank since 1995. The methodology to update the accounts of environmental capital has been constantly improved aiming at ensuring that natural resources are mainstreamed in national economic accounts. WAVES, a World Bank led project applies the System of Environmental Economic Accounting (SEEA), a UN developed global standard to account for naterial natural resources, which is foreseen to incorporate ecosystems and ecosystem services accounts. Valuation and creating bio-physical and monetary acounts of ecosystems and ecosystem services are key elements of integrating natural capital in national statistical system, i.e. the National System of Accounts. The Payments for Environmental Services, PES, scheme is a Coasean policy model with over 500 implemented programs worldwide over the past three decades. PES is a financial instrument for investments in natural capital, which is part of Wealth. AgoraNatura, recently in the pilot phase in Germany, is a marketplace that offer platform for transactions between buyers and sellers of ecosystem services, individually, or as part of a PES program.

Relations between Sustainability and Ecosystem Services Concepts in Agriculture

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Sustainability as a concept and term has been used for decades by scientists to call attention to the negative effects of human activities. It aims to harmonise the environmental, social and economic aspects of different human activities, including farming. The concept of Ecosystem Services (ES) is a relatively new term mainly used by nature conservationists to communicate the value of ecosystems and particularly that of biodiversity to other stakeholders, e.g: farmers in the agricultural context. Sustainable agriculture is a theme that has been discussed in the scientific literature for decades. It asks questions like how to apply theoretical principles in the practice, and how to harmonise between the environmental, social and economic dimensions. According to the FAO (Food and Agriculture Organization) definition sustainable agriculture should conserve the environmental and biological resources in the meantime being technically appropriate, economically viable and socially acceptable. Ecosystem services are benefits that nature provides for humans. This concept has a different approach on the environmental and social aspects of ecosystems. It is a good concept to promote the contribution of biodiversity and ecosystems to agriculture, while sustainability is a good concept for farmers to reflect on their own decisions, on their farm management to see how they interact with the natural cycles, processes. The aim of this study is to show the connections and overlaps between the two concepts in the agricultural context by analysing different frameworks: on one hand the SAFA (Sustainability Assessment of Food and Agriculture Systems) framework developed and published by the FAO in 2013 to describe and assess sustainability in agriculture, on the other hand the MEA (Millenium Ecosystem Assessment) and the CICES (Common International Classification of Ecosystem Services) framework which aim to classify ecosystem services. Both concepts have been developed parallelly to overcome the deteriorating effects of human activities on our environment and ecosystems. For both concepts indicators, models, and tools have been worked out to assess them also related to agriculture. There are differences among the two concepts in terms of theoretical base, aims, and method for assessment but this study reveals that there are a lot of promising common points as well; overlaps on the level of principles and theoretical base just as on the level of measurements in the context of agriculture as well. The sustainability of farm management and practices strongly correlate with agroecosystems' ability to provide ES. There would be a way to harmonise these concepts in the agricultural context as well to strengthen the communication between scientists of various background which would increase their efficiency in having an impact on farm management. This harmonization also means that a lot of farm-level indicator result could be interpreted on the level of both concepts attaining more stakeholders. There is a need to integrate the different approaches in agriculture in a holistic way in order to tackle the multiple crises that farmers and finally the whole human society is facing today, also to help the transition process in which transforming societies are at the heart of the change. This study aims to contribute to this harmonization in the context of agriculture.

TACKLING CLIMATE CHANGE, RESILIENCE FRAMEWORK FOR URBAN AREAS

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Climate change is a global challenge that must be tackled as it directly affects all social, urban and ecological systems at any scale, being critical for urban areas. According to latest UN projections, it is forecasted that by 2050, urban areas will accommodate around the 70% of the world's population. Climate change impacts are one of the main causes of the urban disasters, being the cause of substantial human and economic losses and compromising the citizen's welfare and the sustainable development of the cities. Note that climate change poses both short and long-term challenges. Moreover, it presents a context of uncertainty as projected climate change impacts are based on scenarios that are variable, dynamic and dependent on many factors, some of them difficult to predict, such as the success of the adaptation strategies overtime. In the last two decades, cities all over the world are acting against climate change impacts, adopting different approaches to deal with climate change issues: mitigation, adaptation and resilience. In this sense, resilience-based strategies provide a holistic approach considering both predictable and unpredictable threats. All these resilience strategies recognize the importance of urban critical infrastructures as they provide essential services for the citizens and for the proper functioning of the city and, also, they are crucial for the resolution of the crises. However, the integration of critical infrastructures in the city resilience strategies is difficult because critical infrastructures are complex systems, strongly interconnected among them and usually belong or are operated by private companies. The objective of this research is to provide cities with a framework for building their climate change resilience paying special attention to the urban critical infrastructures. To that end, we present a five-stage framework with fifteen policies that evaluate and enhance climate change resilience at city scale, considering urban critical infrastructures and their providers. In detail, we focus on the governance aspects of the framework. Based on the analysis of the academic literature and on the city resilience and climate change strategies, we study the governance of the urban critical infrastructures and what it implies for the effectiveness and improvement of the resilience policies. In this sense, we consider both their role in the definition of the strategies and policies and in their adoption and implementation. The aim of this framework is to help city managers in the definition and adoption of mitigation and adaptation measures against climate change, that lead to a more resilient and, therefore, sustainable cities.

The quest for nuclear fusion energy: main players, investments and forecasts

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In the 1950s, fusion energy was postulated as a virtually unlimited source of clean energy, but for the last 70 years none experimental reactor could produce stable energy more than they consume. However, recent technological advances have encouraged the creation and financing of new technology-based ventures for fusion energy. Despite the full energy potential of nuclear fusion, the companies involved in this development have been scarcely studied by academic researches. This study identifies new technology-based ventures oriented to nuclear fusion energy, its investments and main temporal milestones to technological development. This exploratory study was conducted in a snowball sampling, starting with the search for the terms "nuclear fusion", "fusion energy", "fusion power" at the *Google* search, with syntax-directed to three major business news portals (*Forbes.com, Bloomberg.com, and Bussinessinsider.com*). The search returned dozens of news that were analyzed aiming the identification and characterization of companies publicly engaged in the development of nuclear fusion reactors. Additionally, the websites, video channels and social networks pages of the companies were consulted for complementary data. After content analysis, 7 main for-profit organizations were identified, namely: *General Fusion* established in Canada (2002), attracted more than USD 200 million in funding, is developing a spherical device aiming to produce energy in 5 years; *Commonwealth Fusion Systems* (CFS), founded in USA (2017), spun out of MIT, funded by USD 115 million, aims to produce and trade energy until 2025; *TAE Technologies*, founded in USA (1998), has more than 800 patents filed and backed by over a half billion dollars in venture capital, expects a net gain reactor in coming years; *Lockheed Martin's Compact Fusion Reactor* (CFR), based in the USA, the world's largest manufacturer of military products, holds the patent for a compact reactor under development for civil and military purposes; *First Light Fusion* was spun out from the *University of Oxford*(UK), in 2011, with a preview of its reactor to 2024, has raised over USD 25 million in investments;*Helion Energy* founded in USA (2013), promises to generate power at a cost of 4 to 6 cents per kw/h in the coming years, funded by nearly USD 20 million; *Tokamak Energy*, a spin-off of the *Culham Center for Fusion Energy*, in Oxfordshire (UK), working on a spherical reactor (model ST40), plans fusion until 2025, funded by over £ 50 million. In addition to private investment, research has also shown that over USD 20 billion has been invested in public projects, especially in the international ITER consortium (France). China also has a major public financed project (HL-2M), promising remarkable milestones in 2020 and coming years. The conclusions point out that articulation between universities, governments, and firms is inseparable in the development of fusion energy. Mainly, basic research is developed in universities and government projects, on the other hand, new companies develop technical solutions (design, materials, operations, etc) for technology improvement. The USA, UK, and Canada host the standing out the 7 ventures analyzed. Public investments (tens of billions of dollars) surpass private investments (hundreds of millions of dollars), however, private companies estimate a similar conclusion of their results over time (2020 and beyond), in fact, from these businesses perspectives, the 2020s will be the time for the availability of the fusion energy. Future studies must deepen the understanding of these new technology-based ventures and their stakeholder's interactions.

The role of carbon capture, storage and utilization in the global energy transition: long-term optimization of the energy system and transformation of the industry

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Because of the concern aroused by climate change, most of the countries have engaged their energy transition. In order to stem global warming, it is necessary to reduce human greenhouse gas emissions and thus achieve carbon neutrality through all economic sectors. Industry appears as a difficult sector to decarbonize. Carbon capture and storage (CCS) technologies are raising interest because of their potential in decarbonizing industry. These technologies have been studied under various aspects such as costs, technical methods, acceptability, resources potentials or regional variability, but more generally related to the electric sector. The purpose of this study is to explore the value that CCS can bring to the world energy system focusing on the decarbonation of industry and the utilization of carbon dioxide (CCUS). It involves socio-economic and climate models at the regional and world scales and the assessment of the subsequent infrastructure needs and costs associated to evaluate the realistic nature of the various scenarios. In order to study the deployment of a set of new technologies, it is first required to well know and understand their differences and specificities. Thus, summarizing the findings of the literature about the utilization of CO_2 is an important primary step and it needs to be done all along the study. The analysis is developed with an Integrated Assessment Model, TIAM-FR, a linear programming TIMES family model. TIAM-FR is a bottom-up techno-economic model representing the world energy system. For each area and time period, it depicts the energy system with a detailed description of different technologies and economic sectors, also characterized by the energy carriers and GHG emissions. Driven by end-use demand, the model aims at supplying energy services at minimum global cost by simultaneously choosing the best investments to apply to the energy system, dealing with environmental and technical constraints. The enrichment of the various CCUS technologies into the model proposes new optimal pathways to reach the 2°C and 1.5°C mitigation ambitions. The enhanced oil and gas recovery is already commercialized but other CO_2 use technology pathways are currently in development such as thermochemical CO_2 conversion, electrochemical and photochemical CO_2 conversion, carbonation and cement uses of CO_2 and biological CO_2 uses. The results shed light on the most strategic investments the global energy system should consider in terms of technology but also on the geographical areas, the intensity and the time distribution along the 21^{th} century. To assess the results, we focus on indicators such as avoided emissions, costs and investments. Especially for cement industry, iron and steel industries, refineries and hydrogen industries, the results provide and optimum distribution of CO_2 between the use into the processes, the selling or the storage assuming incentives. Finally, a sensitivity analysis provides important information on drivers such as incentives rates, costs and efficiency of capture, transport and storage. This work will bring enlightenments and recommendations on the ways to achieve the decarbonation of the industry by synthesizing all the findings in the utilization of CO_2, incorporating them into an IAM, and the assessment of the results.

The Role of Personality and Values in Collaboration on Sustainability Issues

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Environmental sustainability challenges being multi-dimensional and complex, they require the collaboration of actors from various fields for co-creation of knowledge and problem-solving. Yet, the levels of local and worldwide collaboration on these issues are still far from ideal. Personality traits and personal values are known from numerous studies in diverse fields to affect personal interests (including interest in environmental issues) and political allegiance, as well as group collaboration processes such as team effectiveness or the ability of groups of different constitutions to understand and collaborate with each other. However, the question of whether personality and value differences can also affect collaboration in the context of environmental sustainability has to our knowledge not yet been researched, though it seems likely to be of importance. For instance, as was found in the case of political allegiance studies, individuals who are more refractory to take environmental issues into consideration might do so because they place more importance on other elements of their lives, such as the well-being of their family, and unconscious differences in value systems between different individuals could make it difficult for them to find common ground or compromise. This study aimed to begin to explore the role that personality and values play in collaboration in the context of environmental sustainability issues. We deemed the qualitative approach and collaboration quasi-experiments as most appropriate for such an exploration. Participants were recruited from Tyumen (Siberia) and Moscow, Russia. As the Russian population is known to give particularly low priority to environmental issues, using Russia as a study case provides a challenging and potentially more telling context. First, for the collaboration quasi-experiments, groups of three participants were placed in a room and asked to complete a series of five tasks of about thirty minutes each, requiring them to produce a consensus solution to an imaginary complex problem involving social, environmental and economic issues. Tasks varied in terms of spatial scale (local or national), emphasis on the issue at hand (social, environmental, or economic), and the role played by the characters (citizens, activists, members of the government). Groups were formed based on age (twenties or above 35) and political experience (none or extensive). Second, individual in-depth interviews were conducted with each participant, in which they were asked to relate their life story and the influence of various factors on their development (family, relatives, friends, teachers and other acquaintances, school, interests, hobbies, activities, studies, work, vacations, traveling, political views, interest in politics, dreams for the future). Finally, each participant was asked to fill out the HEXACO and MBTI personality questionnaires and the Moral Foundations value questionnaire. Data collection is currently ongoing; data has been collected on two groups of six participants, and several more will be collected until enough data is obtained. The data obtained thus far are rich and should provide a good basis for our qualitative analysis. We expect this study to provide a worthwhile preliminary survey of the role of personality and values in collaboration on environmental sustainability issues.

The transition from linear to circular economy: the experience of SMEs in a Latin-America country

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It is well known that the circular economy (CE) offers the possibility to build environmental, social, and economic prosperity by recirculating resources and energy through innovative materials, designs, processes, systems, business models, and technology. Nevertheless, the transition from the linear model to the circular model is a challenging goal for all the countries, particularly in economic terms. Thus, for instance, according to the Organization for Economic Co-operation and Development (OECD), the investment in environmental protection has steadily increased since 2000. Still, they varied significantly across OECD members in 2012, from under USD 50 per capita in countries like Turkey, Mexico, and Chile to over USD 200 per capita in countries like Italy, Netherlands, and United Kingdom (OECD, 2018).

This challenge is even more acute for Latin American countries, given their complex social, economic, and political conditions. Moreover, about 95% of companies in the OECD member countries (OECD, 2017) are SMEs, which implies they have limited financial resources despite they are the backbone of economic growth.

Nonetheless, most of the studies in the field of CE have focused on theoretical contributions and diagnostic studies of SMEs. Some studies have analyzed the opportunities and barriers for SMEs (Garcés-Ayerbe et al., 2019; Rizos et al. 2014, Silva et al. 2018); however, researchers have not treated the Latin-American SMEs transition to CE in much detail. To fill this gap in the literature, this study aims to provide empirical evidence about the CE implementation in SMEs of a Latin-American country that recently became an OECD member, Colombia. Thus, the research questions for this study are: How existing SMEs can make the transition from linear to a circular economy in Latin-American? And which are the practices that SMEs use to overcome the barriers of the circular economy?

With the aim to answer the research questions, this work presents a multiple-case-study with three SMEs from Bogotá (Colombia) and the surrounding region, in 2019. SMEs were selected through the "snowball" method because there is not a database to identify the SMEs interested in transforming their firms. Consequently, the SMEs are a manufacturer of recycled tire rubber floors, a manufacturer of metal building structures, and a laundry. They were selected through informative meetings about circular economy and postgraduate students attending the "Sustainable Development and Circular Economy" class.

The first findings show that SMEs can begin their transition with simple and low-budget practices such as the design of a green purchasing manual, the replacement of office supplies, biodegradable detergents, lead-free or plant-based paint, and proper separation of materials for recovery. Then, as they become proactive, they assess new circular business models opportunities, carry out technological modernization for the efficient use of energy and water, and the reduction of emissions and particulate matter, and the use of clean energy.

In conclusion, this research allowed companies to deepen the circular economy, carry out the transition processes, and identify business opportunities. Secondly, we validated a step-by-step implementation method of the CE in SMEs using three real cases that show how to identify, plan, and capitalize on the opportunities of the circular economy. Furthermore, as a result of this research, the circular economy will no longer be so far from the reach of SMEs, especially in the Latin American context, and these companies could begin to change from linear to circular business models.

The University of Bologna Annual Report on the United Nations 2030 Agenda: from a reporting tool to a networking approach to sustainability

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The University of Bologna is a large sized multi-campus system with 87,758 students, 5,733 human resources, 1,162,596.81 square meters of facilities, and 932 years of uninterrupted functioning.

In the past decade, the University has been paying holistic attention to the harmonization of its governance to control its direct and indirect impact on the surrounding economy, society and environment. To this extent it has implemented a variety of researches, documents, and tools to provide a solid ground to draw on a clear guideline for its future. The Alma2021 on-line portal, setting out actions to implement the Strategic Plan; the Social Responsibility Report; the Gender Equality Annual Report and the Gender Equality Plan, and the multi-campus environmental sustainability report are some of the most significant examples testifying the University commitment.

Hence, three main considerations have initiated a debate to fully embody sustainability in the governing activity, with collaboration as common denominator. First, synergies that increasingly generates interactions between the cities and departments where the academic activities are set are pivotal. Second, the University intention of becoming a major laboratory of ideas for sharing with other players active in the field of industry, business, and cultural investment through a multi-stakeholder net of partnerships. Third, the importance of consolidating the dense web of relationships with Institutions of Higher Education (HEIs) all over the world.

Thus, since 2016 the University of Bologna has been implementing an innovative strategy of measuring its performance through the Agenda 2030, its 17 Sustainable Development Goals (SDGs) and targets, by publishing an annual report which tackles the three dimensions of the University: teaching, research and third mission (https://www.unibo.it/en/university/who-we-are/report-on-un-sdg).

The Report provided an effective push to reshape institutional and management strategies, to better plan, monitor, and strengthen accountability towards stakeholders. The innovation in adopting the UN SDGs as a reporting framework carries two main elements: the political choice behind the full inclusion of the 2030 Agenda in the University strategy, and the setting of the SDGs as driving standards, rather than mere parameters of analysis.

Following the Report third edition, the novelty of the Bologna approach has thus demonstrated findings on two grounds.

Internally, the emerging pattern shows a shift from a process of basic literacy on sustainability to a political action of inner dissemination of the culture of sustainability, transitioning from a subsidiary report to a comprehensive AlmaGoals initiative (https://site.unibo.it/almagoals/en). From a research context to an operative approach: the new Strategic Plan 2019-2021 has been significantly impacted by the Report, courses and curricula have been marked according to the SDGs they tackle, and new programmes on sustainability have been activated.

Externally, the University has reinforced its accountability towards other actors. The experience generated a competitive push that encourages other universities to create new partnerships, as shown by the establishment of the Italian University Network for Sustainable Development (RUS), and different entities to question and then measure their own impact with a similar approach.

Through the recent experience of the University of Bologna, its challenges and learned lessons, this contribution intends to showcase how a reporting framework on the SDGs can in first place lead to a shifting of paradigms

in the Governance, and then positively impact the Institution accountability through praiseworthy practices of interdisciplinary collaboration within the University, among HEIs and with stakeholders from the private and the public sector.

Towards a Sustainable Entrepreneurial Mindset: Using the Sandbox Innovation Process to Tackle the SDGs

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With the ever-clearer notion of compromising life-support systems on earth, environmental issues assume greater prominence within a global agenda. The SDGs are the current proposal for this trajectory adjustment. With a broader scope, the SDGs are a functional, long-term, highly flexible and interconnected framework. Complex problems for sustainable development, such as energy, food, urbanization, and climate resilience, are some of the interdisciplinary agendas that require unprecedented mobilization among different actors of governments, businesses, academia, and civil society. How can we mobilize these actors and develop solutions for these complex problems?

In this paper, we explore the possibilities of the so-called Sandbox Innovation Process to address challenges in the area of sustainable entrepreneurship by incorporating the SDG framework. The Sandbox Innovation Process, further developed by the Leuphana University of Lüneburg in an EFRE-funded project (European fund for regional development), aims to build an innovation community through a structured open innovation process in order to tackle regional challenges. It is a practice community that can foster the integration of different actors and harnesses the dispersed collective capacity of social groups. In a joint research project, we aim to combine this innovation process with a framework that incorporates the SDGs. By this, we enable the participants to develop an entrepreneurial mindset of "Think global (SDGs), act local (Sandbox approach)!". The research object, in this case, in this case, is a particular workshop format, executed with the general public, that aims to foster this mindset with these elements:

1. Creating an atmosphere of trust
2. Matching groups with a high level of diversity (e.g. age, gender, social background)
3. Collection of local challenges (fostered through a preparation exercise using the ZMET-approach to collect visual data of each participant about the challenges).
4. Introduction and reflection of the SDGs in the plenary
5. Further understanding the local challenges and their relations to the SDGs through focus group discussions based on the ZMET-approach
6. Ideation phase using various creative tools
7. Rapid prototyping of the developed concepts
8. Presentation and discussion of the prototypes in the final plenary
9. Afterward: supporting the development of sustainable business models

With this approach, we collect a) visual data about local challenges and how the participants connect these to the SDGs, and b) prototypes and presentations to examine whether the SDGs were tackled in this format. We conduct further evaluation of the workshop results via content analysis over the record of activities, especially the SDGs layering process and final plenary. In a multiple case study design, we examine this approach in various countries, starting with Germany and Brazil, in order to consider contextual constraints.

The results are currently conformed into a framework able to posit a suitable easy-going tool for SDGs and innovation iterations. The preliminary results show that the SDGs framework is able to work as a meta-layer able to adapt to many different contextual constraints. The workshop approach is connected to active methodologies for learning and promoting innovation, and benefits from the global agenda represented by the SDGs. There

are still some workshops running and results will be updated. Our research reveals how people can become key drivers for innovation solutions aligning the “Think global (SDGs) act local (Sandbox)” perspective with an effort that is enjoyable, insightful, low cost and highly effective in many contexts.

Universities as laboratories for change: Exploring pathways to a circular economy of plastics

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In recent years, the plastic crisis has been identified and received considerable public attention. Due to its versatility, low cost, convenience and seemingly easy disposal (out of sight, out of mind), plastic is omnipresent in everyday practice and is a significant element of the global production industry and economy. A circular approach to plastics calls for complete life cycle design thinking, which needs to be complemented by changing and adapting societal plastic behaviour e.g., to avoid single-use plastic. Historically, universities have shown great capacity and power to initiate societal change. The root of such changes lies in social practices, which are seen as a fundamental unit of social existence in practice theory. Practice theory is used to understand social change as it enables distinctive insight on the adaption process. Emphasis is put on experiences that create tacit and unconscious forms of knowledge and socially construct legitimate behaviours and norms. This paper draws on a PhD project focusing on the University of Hull as an example of a large organisation and cross-section of the population. The University is used as a test-bed by engaging the university population with a circular economy of plastics, focusing on social practices on campus. The project is part of the UKRI-funded project 'Evolving a Circular Plastics Economy' a transdisciplinary collaboration that develops enhanced circularity in plastics use by facilitating the co-design and execution of specific innovations by an interdisciplinary team of academics partnering with over twenty stakeholders (including ISDRS). University campuses can be breeding grounds for knowledge and skills and could be an apt platform for societal change via their educational role. In addition, universities have the potential to play a primary role in implementing, testing and bringing forward circular economy approaches on the local to regional scale by providing an appreciable demand for circular products and services. This study will examine the introduction of plastics designed with circularity in mind on the university campus as well as engaging the community with various R hierarchies like refuse, reduce, reuse. In doing so, the research aims to investigate the integration of a circular plastics economy in campus life and the position that universities can take on as institutions as much as places of (knowledge) production, consumption and education to drive sustainability. Data collection uses semi-structured interviews and focus group discussions with university students, teaching staff and employees. Practice theory is used to unravel opportunities and challenges for universities catalysing a circular plastics economy and identify how organisational and individual understanding, values, behaviour and expectations of plastic evolve on campus. The analysis aims to move beyond descriptive understanding on what people say about their plastic behaviour but strives towards grasping the underlying assumptions and overarching ideas that are implicitly and explicitly contained in plastic framing which prevails and sustains behaviour. The study will show how the university population apply their understanding of use of plastics, what social practices are changed and adapted and identify key factors for the long-term success.

What determinates CSR disclosure in healthcare companies?

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Although determinants of CSR reporting have been widely analyzed in previous literature, the evidence from healthcare providers is scarce. In addition, there is a paradox around CSR and this sector because its main activity is linked directly with CSR.

As it was previously discussed, the development of CSR in this sector is really recent but this approach has been adopted by many companies. At this particular, it is needed to point out the large increase in the number of companies that publish a CSR report between 2015 and 2017 according to last KPMG report.

Consequently, the aim of this research is to analyze what are the determinants of CSR reporting in healthcare industry, and particularly, to examine if they are the same than in other industries. The theoretical support is found in Stakeholder, Agency, Legitimacy, and Good Management theories.

The sample is composed of 79 listed companies from healthcare provider industry from 2008 to 2016. All variables and data are extracted from DataStream database. The data are statistically analyzed considering Data Panel methodology, and later fixed or random effects are chosen depending on Hausman test.

Our findings suggest that global CSR behavior, health and safety engagements, and also CSR reporting initiatives of healthcare companies are positively influenced by companies' size and the existence of a CSR committee. Furthermore, financial performance does not show any statistical significant effect on CSR.

In addition, the cultural environment in which each company belongs has an effect on companies´ CSR commitment and reporting regardless the measure used (CSR country index, Varieties of Capitalism or Governance Environment Index).

“You cannot teach an old dog new tricks” – savings on carbon emissions of the “ISDRS Conference 2020” related travel

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Travel is an essential part of modern society. Since the very first time Edison started his steam engine, there was a tremendous amount of innovation directly or indirectly affected by transportation and these innovations in turn affected our way of thinking about and using it. It became a necessity, but it also had a substantial effect on the environment by producing about 6.7 $GtCO_2$ emissions, which accounted for 23% of the total energy-related CO_2 emissions in 2010 [1].

But the COVID-19 pandemic changed everything. Cheap international flights could be a thing of the past, with many airway companies cancelling most of their flights and public transport companies are thinning their services, running with only a handful of passengers. Through this, people started to realize that travelling is not as essential, as they thought. Business meetings are held in online chatrooms, while large office buildings remain tenantless, or with only a few essential workers. Meanwhile, cities experienced that pollution approached an all-time low with clean air and water as cars and various public transport vehicles disappeared from the roads and waterways of cities.

This pandemic also affected the ISDRS Conference 2020. The conference was planned to be held in Budapest, the capital of Hungary, with several hundred participants form over 33 different countries, ranging from Japan to Colombia. All these people would have taken the journey to the heart of Central Europe to attend a conference about sustainability.

The organizing committee originally intended to create an on-site conference that would be as sustainable as possible, but due to travel restrictions, the event was changed to one taking place in an online space instead. In regards of this, we wanted to showcase how much the participants did for the environment just by choosing to not travel to the conference site, and instead taking part in an online conference.

Using a set of calculation factors developed by the Department for Business, Energy & Industrial Strategy of the United Kingdom (last updated in 2019) [2], we calculated how much CO_2 a participant would have emitted if they had travelled to Budapest. Where possible, we calculated using environmentally friendly transportation methods, for example trains or other means of public transport, but we always took care to create a theoretic route and transport mix that people would use in practice as well. To demonstrate plainly just how much CO_2 the travel to an international conference like this emits, we also used a given methodology to showcase how many young local fruit trees would need to be planted in order to compensate for the amount of CO_2 emitted.

This poster serves to show just how much of an impact the individual person has on the environment, even with the most simple of their acts, and we hope it can help to create even more sustainable events in the future.

Full Papers

Research Methods & Methodologies

Methodological Agility *for* Sustainability Transitions in the Context of the Anthropocene

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Abstract

The concept of the Anthropocene has some far-reaching ontological, epistemological, ethical and methodological implications for our intellectual/academic endeavours. Never before in human history have we been required to face the consequences of our own human actions on a global scale. In view of the overwhelming empirical evidence of the anthropogenic causes of climate change and global warming, the historical assumptions about the immutability of all natural laws and processes are no longer necessarily valid. Not only has it now become quite plausible to accept that human actions are responsible for interfering with and indeed changing some of the earth's four-billion-year-old natural processes – such as, for example, the earth's temperature self-regulating mechanisms – but also that this interference and these changes have occurred to such an extent that we can no longer speak of them as purely 'naturally' occurring processes. In the Anthropocene it no longer suffices to produce knowledge on or about nature that is concerned only with the understanding (*Verstehen*) and explaining (*Erklärung*) of the anthropogenic causes of the Anthropocene; we are also, at the same time, challenged to produce practical knowledge that can contribute to changing (*Verändern*) our thinking and actions responsible for (causing) the Anthropocene in the first place. This implies co-producing transformative knowledge for undertaking sustainability transitions in different socio-ecological contexts across the world. However, transformative knowledge is not just about co-producing strategic knowledge of how to practically navigate said sustainability transitions. Inextricably linked to this are ethical questions related to the way we should act appropriately, fairly and justly in the context of the Anthropocene today – with no action arguably being the most unethical response. In short, this means co-producing theoretical, practical and normative knowledge which addresses the complex challenges facing us in said sustainability transitions in the context of the Anthropocene today. Dealing with these complex challenges at the ontological-epistemological-ethical interface has far-reaching methodological implications, warranting a range of trans-disciplinary responses. However, there is an inherent risk in presenting trans-disciplinarity as a methodological panacea. It is much better to imagine trans-disciplinarity as one amongst a number of context- or domain-relevant methodological responses – including mono-, multi- and inter-disciplinarity – on the understanding that trans-disciplinarity is much more specifically focused on and interested in tackling societal challenges that are considered too complex to be addressed strictly from *within* single disciplinary boundaries. The methodological agility that this implies should not, however, be confused with the much more onerous Kuhnian notion of 'paradigm switching', which is simply too arduous an undertaking for the nimbleness required when facing ever-changing problem situations in the Anthropocene today. In light of the above, the fundamental focus of this paper is on developing such an agile transdisciplinary methodology – with an explicit interest in contributing to the understanding of facilitating said sustainability transitions in the context of the Anthropocene today.

Keywords: trans-disciplinarity; methodology; methodological agility; complexity; sustainability transitions.

1. Introduction

Humankind is now living in a new geological epoch of the Anthropocene (Crutzen et.al 2002). This development brings with it pressures which force us to consider how human activity has impacted on, and is in turn impacted by, the natural and the geophysical domains. In this regard, Chandler explains that Ontopolitics in the Anthropocene require us to radically *re*think the fundamental philosophical paradigm that science is about humankind's knowledge and mastery *over* Nature (Chandler, 2018). The traditional paradigm of scientific enquiry – as articulated in the thoughts of Thomas Kuhn (Kuhn, 2012) – has contributed greatly to this mastery over Nature by creating an artificial bifurcation between the physical and social sciences, and further within these schools more disciplinary silos such as physics, chemistry, biology, sociology, anthropology, psychology etc. – each, in turn, with their own multiple sub-disciplinary specializations. Whilst this paradigm has contributed

to developing comprehensive knowledge and understanding of the world on their own – within their specialist foci – the individual disciplines do not lend themselves well to the tackling of complex dynamics involved in the connections and interactions between Nature and Society today. Challenges which are posed by the complex dynamics in socio-ecological systems (SES) problems such as climate change and extreme weather conditions are good examples[1] of current events compelling us to recognise Nature as an active agent that *inter*acts with social systems and vice versa. In other words, Nature and Society can no longer be seen merely as *static background*[2] *against which things happen*, nor can it be systematically analyzed and explained within the strict boundaries of individual disciplines alone.

In the Anthropocene, such mono-disciplinary approaches and practices will no longer suffice. Instead, what is needed are radically different approaches, which amongst other things, as Chandler suggests, involve new forms of governance and intervention, enabling on-going *inter*action with the system in the form of mapping, sensing and hacking, because systems and the *inter*actions between them are in consistent flux (Chandler, 2018). For academia to keep abreast and contribute to societal improvement, the scientific paradigms have to shift. To respond to the challenge of real-world problems, and contribute to sustainability transitions, interdisciplinary and cross-disciplinary collaboration are even more critical than before (NAP, 2005). Academic actors have to engage across silos, and beyond the institution to work with relevant societal agents in an on-going transformative feedback loop.

The Sustainable Development Goals[3] (SDGs) calls for mobilization across global and local levels, and involves academic actors and societal agents, in an emergency response to the planetary challenges facing us in the context of the Anthropocene. Never before in human history have we been required to mobilize ourselves around a common set of goals, whilst facing the consequences of our own human actions on a truly planetary scale.

This ambition require us to situate our work at the interface of disciplines and other forms of knowledge creation. The trajectories of actual sustainability transitions are however, occurring *asymmetrically* across different countries / societies, and the African continent in particular. Socio-political-ecological context and constraints impact on capacities to respond, and therefore necessitate the adoption of different transitioning strategies at different rates and paces. In this context of emergent and ever-changing conditions, the fundamental challenge facing science and academia is that we can no longer be satisfied with merely producing knowledge *on* or *about* Nature, nor can we remain concerned *only* with our *understanding* (*Verstehen*) and *explaining* (*Erklärung*) of the anthropogenic causes of the Anthropocene. Academia needs to also produce practical-strategic knowledge that can contribute to *changing* (*Verändern*) our thinking and actions.

This, in turn, implies working through a different scientific paradigm that can better support the co-production of *transformative knowledge* (Bergmann et al., 2013; Hadorn and Pohl, 2008; Pohl and Hadorn, 2007) capable of undertaking context-sensitive sustainability transitions. This need for acknowledging and working with contextual specificity when engaging with sustainability transitions is discussed in-depth by Swilling in his book "*The Age of Sustainability*" (Swilling, 2019). Swilling's core argument is that not only are there different kinds of sustainability transitions happening in many different parts of the world today, but that there are also significant differences *within* these different contextual settings and specific kinds of sustainability transitions. So, for example, when dealing specifically with *urban transitions*, it is not surprising

[1] To this list of extreme natural events, we can certainly also add the current global pandemic of the Coronavirus – as yet another good example of reaffirming the inextricable interconnectedness of Nature and Society, rather than their forced detachment as two completely separate (ontological) realities in terms of the old Cartesian two-world theory.

[2] The fundamental differences between Newton & Einstein's conceptions of space, time and gravity can also be quite helpful to illustrate this important point even further. For Newton space, time and gravity were not only separate realities, they were also fixed. Gravity, in particular, was for Newton like a static stage upon which actors interact with each other, but not with the stage itself. All of this, of course, changed radically in Einstein's revolutionary idea of dynamic curved space time (CST). In his general theory of relativity, the actors (celestial bodies) interact with CST, and vice versa. It is this dynamic conception of mutually constitutive contextual interactions that is especially important for understanding and engaging with complex phenomena / events in the Complex Domain (as will be explained in more detail below).

[3] See: https://www.un.org/sustainabledevelopment/

therefore that "in the absence of an alternative generally applicable urban imaginary due to the diversity of urban contexts, the International Resource Panel (IRP)[4] report recommends the proliferation of *urban experiments as the catalysts of context-specific urban transitions*" (Swilling, 2019).

This call for a proliferation of urban experiments as the catalysts of context-specific urban transitions poses fundamental challenges not only to academia, but more specifically, *to how* methodological decision-making processes are being conducted when engaging with context-specific sustainability transitions. Just as there are no generally applicable urban imaginaries for undertaking urban transitioning processes, there are no methodological panaceas available for researching context-specific transitions. In all instances, situating the problem in context will provide us with a way to develop appropriate methodological responses.

To this end, this paper develops and presents the notion of *methodological agility* – as a means for understanding and navigating the *switching between* different research methodologies when facing radically different kinds of real-world problem situations (contexts). This paper discusses the adoption and adaptation of the multi-ontology Cynefin framework, as a useful sense-making and decision-making framework for developing contextually-specific methodological responses. More specifically, we will discuss mono-disciplinarity, multi-disciplinarity, inter-disciplinarity and trans-disciplinarity, and their respective relevance for different (Latour, 2007) contexts and ontologies.

2. Methodology and Discussion

In order to develop and present the notion of methodological agility as systematically as possible, we will be following an enfolded type of modus operandi. This means that 'methods' and 'discussion' will not be treated as two separate sections in this paper, under two different and sequential headings (first 'methods', then 'discussion'). Instead, the explanation and discussion of the different aspects of the multi-ontology decision-making framework, at the core of methodological agility, will be *enf*olded into each other in the relevant sub-sections below, in the following manner: Section 2.1 will focus on the fundamental aspects of the Cynefin multi-ontology decision-making framework. This will then be followed with a transposition (in section 2.2) of Cynefin into a *methodological* decision-making framework for the purposes of being / becoming more methodologically agile when facing changing and radically different kinds of contexts. Given that the latter are different not just in degree, but in kind means that the focus will then shift, as said, to both explaining and discussing four domain-relevant methodologies in terms of four ontologically different contexts / domains, namely: mono-disciplinarity in / for problematics in the Clear Domain (section 2.3), multi- and inter-disciplinarity in / for the Complicated Domain (section 2.4) and trans-disciplinarity in / for problem situations in the Complex Domain (section 2.5). The Conclusion of the paper (section 3) will follow immediately upon completion of section 2.

2.1 The Cynefin Framework: For Multi-Ontology Decision-Making

"Cynefin" (pronounced phonetically kunɐv-in) is a Welsh word denoting a place of multiple belongings, in the sense of a cultural holding space where people continuously negotiate their different identities. This definition is also close in meaning to two other important concepts, namely: (a) Bourdieu's use of the notion 'habitus' (Bourdieu, 2008; Costa and Murphy, 2015; Goh, 2012), and (b) the notion of dynamic formative contexts (Bateson, 1972; Ciborra and Lanzara, 1994; Crawford and Mills, 2009; Garfinkel, 1991; Unger, 2014, 1998). When all of these concepts are taken together, Cynefin signifies the social places and spaces where people are continuously assembling and re-assembling the social or society (Latour, 2007) – whilst, in the process of doing so, continuously negotiating and adopting different roles and identities.

However, and more importantly for our purposes, the Cynefin framework goes *beyond* the phenomenological level of lived experience, by positing the notion of the *ontology of context* for exploring different contexts in terms of their fundamentally

[4] For more information on the UN's IRP Weight of Cities report, please visit this website: https://www.resourcepanel.org/reports/weight-cities

different kinds of causal dynamics or cause–effect relationships[5]. In order to better understand the latter, the Cynefin framework distinguishes conceptually among four[6] distinct contexts – also referred to as *domains* – at the following two levels: practical (Clear, Complicated, Complex and Chaotic domains) and abstract (meta-theoretical Ordered and Unordered) systems. Taken together, this framework facilitates performing research *within* the Clear and Complicated domains as concrete examples / manifestations of Ordered systems and the Complex and Chaotic domains as examples / manifestations of Unordered systems. Figure 1 is a graphic illustration of the framework:

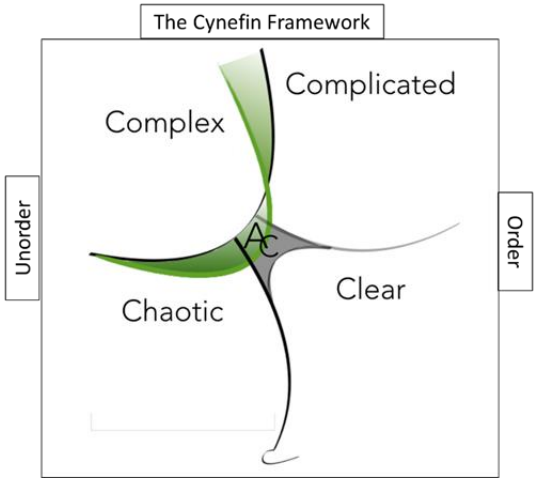


Figure 1: *The Clear and Complicated domains are illustrated in this graphic as examples of the more meta-level Ordered domain and the Complex and Chaotic domains as examples of the Unordered domain*

2.2 The Adopted / Adapted Cynefin Framework: For Agile Methodological Decision-Making

The Cynefin framework, as mentioned, has been developed (Snowden and Boone, 2007) as a dynamic multi-ontology decision-making heuristic which can, and has, been used for many different purposes. For our methodological purposes, however, we have explicitly adopted and adapted this framework for navigating methodological appropriate-ness in an agile manner – as depicted in Figure 2 below:

[5] Acknowledging that the fundamental differences between the four domains are in fact *ontological* due to the differences in their (underlying) causal dynamics is to agree with Aristotle's fundamental point about the link between knowledge and understanding the causality of things: "We do not have knowledge of a thing until we have grasped its *why*, that is to say, its *cause*" (Aristotle, 1961). In other words, understanding and explaining some of the salient features of the fundamentally different kinds of causality between the four domains is critical for our purposes here in the sense that we will be dealing with these as ontological differences first, before proceeding with a discussion of their epistemological and methodological implications and strategies.

[6] As depicted in Figure 1, there is also a fifth domain – Aporetic / Confused (A/C) domain – but this is strictly speaking not a separate *ontological* domain with its own discernible cause–effect relationships. Rather, this denotes more of an in-between epistemological space, or vantage point, as it were, from where the sense-making of the other said domains takes place.

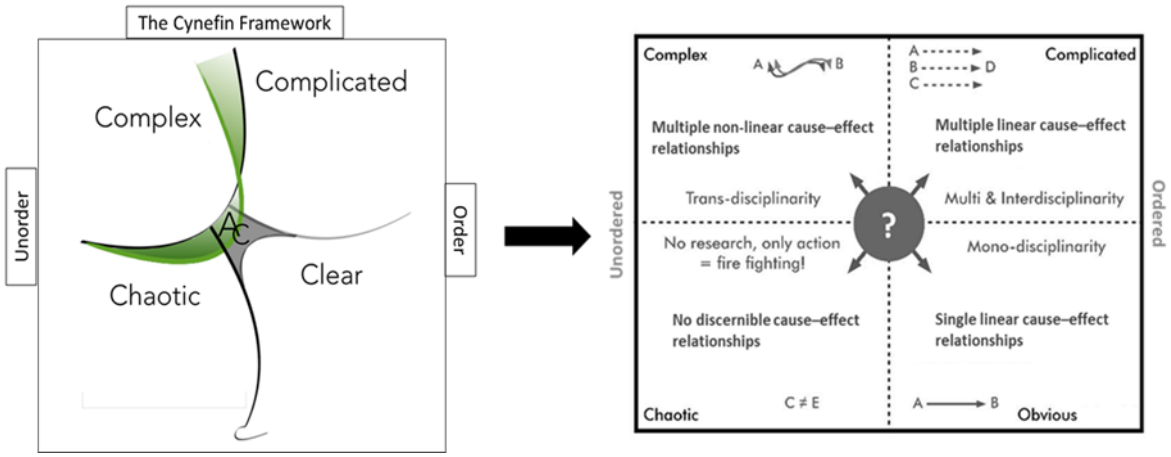


Figure 2: *The arrow signifies the process of adopting and adapting the Cynefin framework for the purposes of situating / contextualsing mono-, multi-, inter- and trans-disciplinarity as four equally valid domain-relevant research methodologies.*

This transposition of the Cynefin framework into a *methodological* decision-making framework allows us to utilise Cynefin as a meta-methodology decision-making framework, which can facilitate context-appropriate research to be conducted, and improve operationalisation of research. In the next sections, this paper expands on each domain in more detail, and discusses the methodologies that correspond with each domain.

2.3 Mono-Disciplinarity for Problematics in the Clear Domain

In the Cynefin framework, the Clear Domain is characterised by self-evident systems where linear causality is straightforward. In this domain, there are clear-cut epistemic objects (Cetina et al., 2005; Knorr Cetina, 2001; Knorr-Cetina, 2013), which can be described as 'known knowns' (Snowden and Boone, 2007), presenting high levels of certainty and predictability. In other words, there is very little doubt that an effect (the manifest problem) has a very particular cause – i.e. the nature of things can only be explained in this particular way and in no other way(s). In such cases, there are well-established explanatory theories, with a strong pre-disposition to using an appropriate epistemological strategy of categorisation – i.e. ordering problems in terms of the different types of knowledge(s) produced by the individual disciplines, using tried and tested disciplinary concepts, theories, principles, practices and methods. In this regard, a good example is the principle and practice of parsimony, also known as Occam's Razor (LLC and LLC, 2010; Sober, 2015) – dictating that 'entities should not be multiplied unnecessarily', or put differently: 'when there are two competing theories that make exactly the same predictions, the simpler one (with the least assumptions) is the better one.'

Problematics in the Clear Domain are normally characterized by linear causality, or linearity for short. This means that events / occurrences that are caused by single, clear-cut and repeatable cause–effect relationships, in which, if conditions are held consistent, action / interaction A will cause B, and the same action or combination in A will *always* cause B. This causality is repeatable, and self-evident through simple measurement and observation.

In this domain, mono-disciplinarity is a domain-relevant methodological and institutional approach. The nature of the problem might lend itself well to *dis*aggregation, reduction and categorization into parts of the whole problem. This allows different disciplines to work on each part separately and to arrive at suitable insights through a single discipline lens. It also helps if the challenges are seen as *unconnected* problems, and where there do not exist complex interrelationships *around* and *between* the phenomena. In this mono-disciplinary mode of doing research, the individual disciplines therefore do not see any requirement for knowledge *co-production* – i.e. no need for crossing disciplinary boundaries in order to come up with integrated perspectives for the *explaining* (*Erklärung*) and *understanding* (*Verstehen*) of the clear-cut issues at hand. See Figures 3 and 4 below for a more detailed graphic illustration hereof:

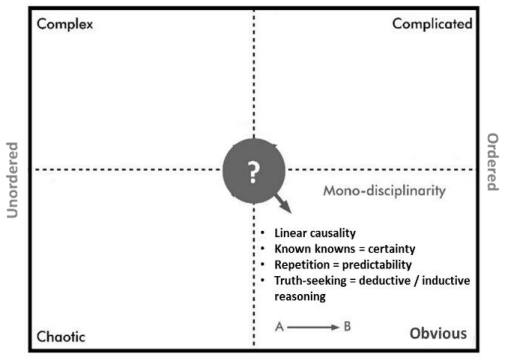


Figure 3: *Focusing only on the Clear Domain, characterized in the main by single, repeatable linear cause–effect relationships (A causes B) which can be successfully theorized by the individual disciplines concerned by using the well-established deductive / inductive logics and principles for developing discipline-specific epistemic objects – i.e. problem statements, research questions, hypotheses etc. – without any interaction and collaboration between the individual disciplines or any relevant social actors.*

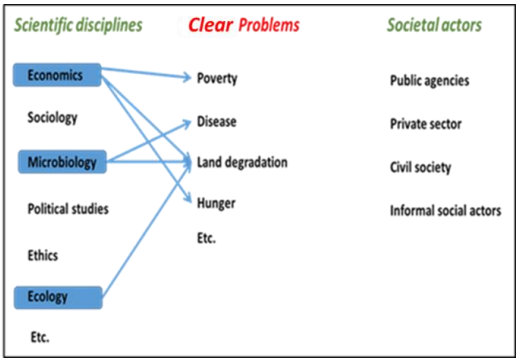


Figure 4: *The blue arrows linking the three disciplines concerned (highlighted in blue boxes) with the different problems / issues here, signify the gist of the mono-disciplinary approach in the Clear Domain, where the individual disciplines are not only working on separate issues, but also working separately from each other – without any form of interaction and collaboration between them or with any of the relevant societal actors.*

When problems are identified as situated in the Clear Domain, the predominant research practice is for single-discipline experts to work *within* the strict boundaries of their individual disciplines – with very limited, if any, interaction with other disciplines, and, almost certainly, no interaction with any societal stakeholders outside of academia. Bringing the perspectives of social actors / stakeholders *into* the research process is widely considered as redundant or counter-productive to the research process – for doing so can only lead to 'contaminating' the 'objectivity' of the knowledge (Popper, 1979, 2005) produced in the research process – thereby making the problem situations at hand unnecessarily 'complicated' or 'complex'.

2.4 Multi- and Inter-Disciplinarity for Problematics in the Complicated Domain

The difference between the Clear and Complicated domains is one of degree, and not of kind. Linear causality is applicable in both. However, where the Clear Domain is characterized by single linear cause–effect relationships, the Complicated Domain is characterized by multiple linear cause–effect relations, and strong assumptions about the conditions around those causal relationships. For example, that water boils at 100 degrees Celsius is an accepted truth; however, there is also an assumption of the atmospheric conditions being held consistent at sea-level. This "truth" changes in lower atmospheric pressures as the environmental conditions alter the causal relationship. These linear causal relationships are illustrated in Figure 5 below, indicating that any one cause or combination of A, B or C can be the cause of effect D. In other words, there is a shift from one-to-one linear causal relationships in the Clear Domain, to many-to-one[7] or even one-to-many linear causal relationships in the Complicated Domain – the linear relationships of causality are traceable, and repeatable.

Given the multivariate nature (Bai et al., 2010) of the Complicated Domain, it is not always immediately clear which of the many different causal relationships are actually the most significant in any given situation. This gives rise to epistemic objects

[7] In this regard, and with the necessary changes, the notion of 'over-determination' as used, for example, by Louis Althusser (Althusser, 2005) could be employed successfully here. From this perspective, problems (effects) in the Complicated Domain are determined (caused) by multiple causes any one of which alone would be sufficient to 'determine' (cause) the effect. This, in effect, means that there are a surplus of causes, more than what are necessary to cause the effect – and this, in turn, means searching for the 'ultimate' or 'final' causal factor amongst all the 'competing' possibilities. Because of his ideological and intellectual commitment to Marxism, Althusser posited that 'in the final analysis' such 'ultimate' causes can *always* be found / located in the contradictions (material causes) of the economic system of the capitalist mode of production.

which can be described as 'known unknowns' (Snowden and Boone, 2007) – with less certainty and predictability than in the case of 'known knowns' in the Clear Domain, but certainly not as unpredictable and uncertain as in the case of the Complex and Chaotic domains. Experts, therefore, undertake an epistemological strategy of **analysis** to test and identify which of the multiple linear causal relationships are more significant ones, and to understand how these are significant**.** In practice, this means that the complicated nature of the problem situation at hand can be thoroughly revealed through sufficient, in-depth analysis of the multiple linear causal relationships at work. This can be done through hypothesis testing, and hypothesis elimination or validation –using, for example, inductive and deduction reasoning.

Where in the Clear Domain, single-discipline expertise would be the appropriate methodological approach, in the Complicated Domain there is a need for either multi- and inter-disciplinary expertise, or both. In other words, in the Complicated Domain there are two domain-relevant methodological approaches possible with varying degrees of collaboration and interactions between individual disciplines. If taking a **multi-disciplinary** approach (see Figure 6 below), individual disciplines are no longer working on separate issues as in the Clear Domain, but rather working on the same issues. However, they are still working *independently* from each other with each discipline still using its own stock of ideas, concepts, principles, models etc. with which to develop hypotheses for unravelling the complicated nature of the problem situation at hand. This mode of working independently on the same issues, without the need for collaboration, is made possible by the linearity of the causal relationships – enabling individual disciplines to hypothesize and theorize on the predominance of multiple causal relations in this domain – but always as determined by the disciplinary perspectives of independent disciplines. In this mode, the expert analysis of the complicated situation at hand will be provided by the principal investigator of the research project, charged with the responsibility of coming up with some or other integrated perspective and explanation of the multiple causal dynamics at work – normally at the end of the research – when all the participating disciplines have had a fair chance to complete and submit their own discrete research findings.

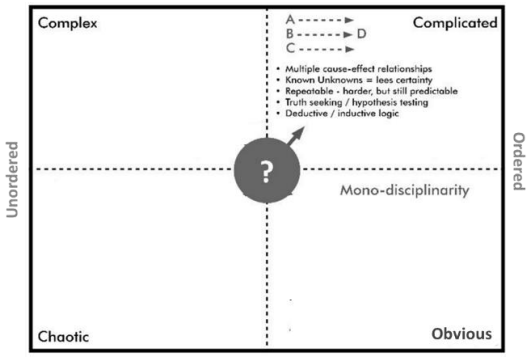


Figure 5: *Focuses only on the salient dynamics of the Complicated Domain, characterized mainly by the multiple, repeatable linear cause–effect relationships (A, B, C causes D). Of these different causal relationships, it is not immediately clear what the degree of significance is of each. This is something which can be successfully theorized by the individual disciplines if allowed to work separately, using the well-established deductive / inductive logics and principles for developing discipline-specific problem statements, research questions, hypotheses etc. – without any interaction and collaboration between the individual disciplines or any relevant social actors.*

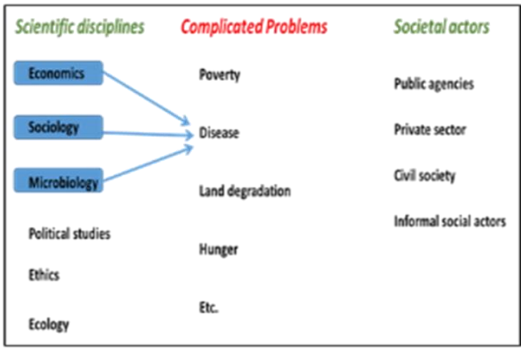
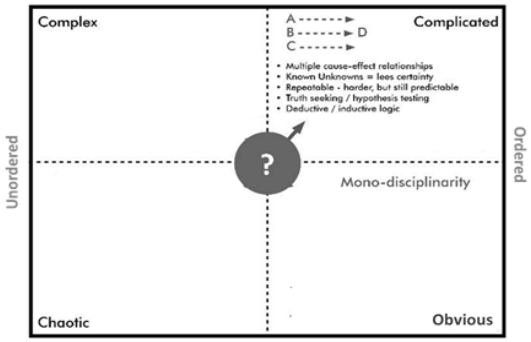


Figure 6: *The blue arrows in this figure denote two important aspects of multi-disciplinarity: (a) the different disciplines now focusing their efforts on the same issues in the complicated problem situation at hand situation, and (b) the disciplinary certainty that comes with this, assuming that through sufficient analysis of the repeatability in the same problems at hand will produce sufficient understanding / insight into the predominant causal relations to be focused on. The listed disciplines, highlighted in the blue-coloured boxes, signify the fact that they are still working separately from each other, with no interaction / cooperation between them or any of the relevant social actors listed here.*

However, where **inter-disciplinarity** (see Figure 8 below) is adopted, individual disciplinarians start to realise that working strictly within their own disciplinary boundaries presents limitations for dealing with the multivariate dynamics at play in the Complicated Domain. Collaboration with each other provides more opportunity for developing integrated hypotheses at

different stages during the research process, allowing them to better investigate these multivariate dynamics. This collaboration can take many different forms, but normally entails some form of exchange of information and methods amongst the relevant disciplines – i.e. borrowing concepts, perspectives and practices etc. from another discipline in order to come up with a more enriched / multifaceted / integrated *inter-disciplinary understanding* (Verstehen) and *explanation* (Erklärung) of the complicated causal dynamics of the problem situation at hand – something which cannot be achieved in theory and practice by the individual disciplines working in isolation from each other. However in both approaches, there is limited, or no, engagement and inputs sought from social actors or stakeholders. The subject matter at hand is seen as being separable from the environment and context



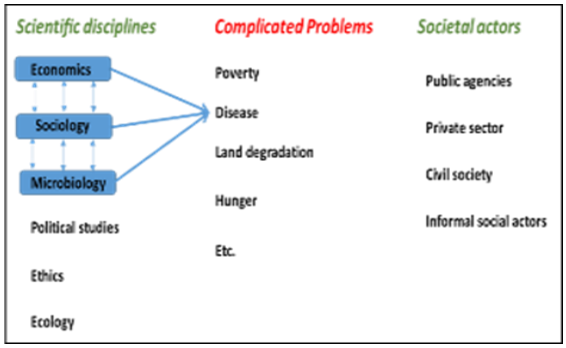


Figure 7: *Focuses only on the salient dynamics of the complicated domain, characterized mainly by the multiple, repeatable linear cause–effect relationships (A, B, C causes D). Of these different causal relationships, it is not immediately clear what the degree of significance is of each. This is something which can be successfully theorized by the disciplines working together and cross-pollinating ideas, theories, concepts, data and frameworks. There is a process of collaborative hypothesis development, and testing. This is, however, done without any interaction with social actors who might be a part of the problematic.*

Figure 8: *The solid blue arrows in this figure denote the shift taking place in the inter-disciplinary methodology in which the different disciplines are now focusing their efforts on the same problems / issues at hand. The smaller blue arrows (between the highlighted disciplines) signify the second important feature of this approach, the fact there is now some form of interaction / collaboration between the different disciplines mentioned – exchanging some information, insights, practices and methods. However, the absence of any lines or arrows to and from the listed social actors signifies the fact there is still no engagement with them in an attempt to bring their embodied understanding of the issues at hand into the research process.*

2.5 Trans-Disciplinarity for Problematics in the Complex Domain

In the Complex Domain we encounter a shift from linear to non-linear causality – meaning that events / occurrences in this domain are no longer caused by direct cause–effect relationships between A (cause) and B (effect), but rather by bi-directional or circular feedback loops occurring between A to B and back from B to A again (Colchester, 2016). It is also important to be mindful that the nature of A and B are not static, and that A or B might become something completely different as it becomes embedded in this and multiple other feedback loops. The nature of the connectedness of things in the Complex Domain means that there are multiplicities of on-going relationships between unknown variables that account for their *emergence* that is typical of complex systems. As mentioned above, the differences between the Complex (Unordered), and Clear and Complicated (Ordered) domains are ontological in nature – and, thus, display differences in system type (Ordered vs. Unordered), and not just in degree. See Figures 9 and 10 below for some simple graphic depictions of this:

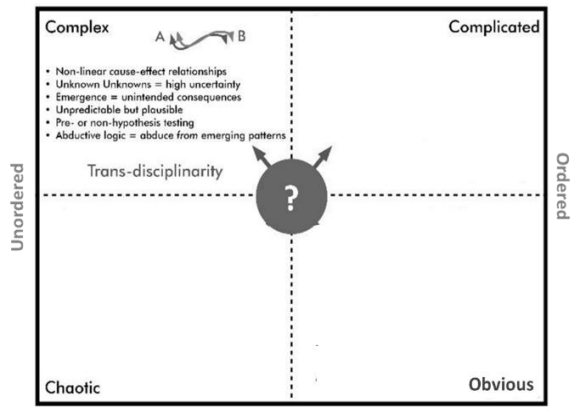


Figure 9: *The wave- like arrows between A and B here signify bi-directional non-linear cause–effect relationships producing / responsible for emergence / emergent events in the Complex Domain, which are non-repeatable and unpredictable, the limits of which (enabling boundaries) are both driving and guiding our epistemological endeavours in this domain.*

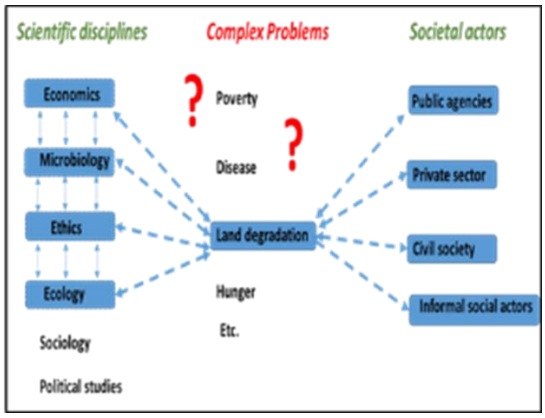


Figure 10: *The two red question marks here signify the uncertainty / complexity of the complex problems (referred to as unknown unknowns in Figure 9) in the Complex Domain. As a result, the blue dotted lines to the left and right of the complex problems also denote some uncertainty in that it is not immediately clear which disciplines and social actors should be brought into the research process. This may only become clearer during the unfolding research process, which, in turn, means that the participants will enter and exit at various stages of the dynamic research process.*

In complex systems everything is seen as irreducibly connected (Boulton et al., 2015; Cilliers, 2008; Cohen and Axelrod, 2000) – making it more useful to think about the nature of things *relationally* rather than focus on the things themselves. In the Complex Domain, causality can never be reduced to some or other ultimate cause (Funtowicz and Ravetz, 1994), because in complex systems there are no centralized power nodes responsible, as it were, for the ultimate / final causality of things. Instead, it is because of their fundamental interconnectivity in emergent complex systems that things always happen through a multiplicity of intense local and external interactions. This, as said, rules out the possibility of reducing causality to just a limited number of sources or locales (nodes) with more concentrated or stronger causal relations and powers than others in the system[8]. In fact, the very notion of causality – i.e. *what* causes *what* in space and time – needs to be seen and understood more as a distributed phenomenon, something which is part and parcel of the dynamic, emergent property of complex adaptive systems (Juarrero, 1998, 2002, 2010). Or, put differently: the *system itself* is characterized by non-linear causality (Rosen, 2005); seeking causality might become futile, as the system can better be described as one of dynamic correlation (Beck, 2015; Chandler, 2018; Latour, 2012, 2017).

Non-linearity gives rise to epistemic objects which can be described as 'unknown unknowns' (Snowden and Boone, 2007) – with far less certainty and predictability, when compared to 'known knowns' in the Clear Domain and 'unknown knowns' in the Complicated Domain. However, non-linear causal relations are not completely random / ad hoc events as in the Chaotic Domain. They certainly do produce some patterns[9] which can only be detected after the event, and therefore not predicted in advance. This means that the task of sensing or sense-making of such emerging patterns cannot be conducted by disciplinary experts, with their theoretical knowledge systems, *only*. It requires epistemic engagement *with* social actors, so-called

[8] In the Complex domain, the abovementioned overly abstract concept of 'over-determination' as theorized by Althusser (Althusser, 2005) is no longer useful, because in this domain things are determined (caused) by the net effect of their multiple (small / local) non-linear interactions – making it both theoretically and practically impossible to try and locate some or other 'final' cause(s) with more concentrated and stronger causal powers than others in the system.

[9] The characteristics of which can described as rhizomatic-like - as in the case of Bramble bushes which produce a lot of growth (causality) in different directions with patterns, but without central controlling power nodes (e.g. central roots) (Braidotti, R., 2005; Deleuze and Guattari, 2004; Genosko, 2001; Kurtz and Snowden, 2007).

'ordinary' or 'lay' people so as to incorporate their practical / embodied / tacit / experiential knowledge of the complex problem situation at hand as the knowledge developed would be incomplete without it.

Working strictly in mono-, multi- and inter-disciplinary ways in the Complex Domain is, therefore, ontologically speaking inappropriate. Since we can no longer make sense of the complex nature of emerging problem situations within the epistemic boundaries of theoretical knowledge *only*, we are compelled to go *beyond* (the 'trans' in trans-disciplinarity), and engage with non-academic actors and their everyday ways and means of knowing / understanding things in the Complex Domain. This means working collaboratively in the trans-disciplinary mode by bringing such pre-theoretical knowledge *into* the research process – from the very outset of defining / developing problem statements and research questions (epistemic objects).

However, working collaboratively does not ipso facto imply trying to assemble all the relevant 'legitimised' stakeholders (Scholz, 2011; Scholz et al., 2006) into the same room, as it were. The reason for this may be very practical in that such representatives, with a mandate to speak and make decisions on behalf of others, may not always be ready and available for engagement in collaborative research processes – in which case, different and more appropriate approaches are warranted, capable of working with individuals in many different places and spaces – at the same and/or different times. Such approaches are known in the literature as **distributed cognition / ethnography** (Enfield and Kockelman, 2017; Hutchins, 1991; Snowden, 2016a, 2016b). When adopted and adapted for the purposes of dealing with complex problem situations in the Complex Domain, this would certainly signal a radical departure from the well-established mono-, multi- and inter-disciplinary practices of developing epistemic objects (including hypothesis-testing and -integration) by certain disciplinary experts, located in academia, *only*.

One way of working practically in such a distributed and agile manner is by using narrative-based research methods – of which SenseMaker™ is a very good example of an approach which has been specifically designed and used for the purpose of working in a distributed and agile manner in the Complex Domain (Deprez et al., 2014, 2012; Matheou and Bhagani, 2014).

2.6 Chaotic Domain – no research, only action

The Chaotic Domain (see Figure 11 below) is, ontologically speaking, radically different from the other three domains in the sense that things happen in a completely ad hoc manner with no discernable causal relationships. The domain of Chaos can be seen as the extreme end of the spectrum between the Ordered and Unordered systems, with it representing complete un-ordered and randomness. It is in the absence of any causal relations that things manifest themselves in a completely random manner.

In this domain, we are facing epistemic objects known as 'unknowable unknowns' (Snowden and Boone, 2007), basically rendering any form of systematic / substantive research in this domain impossible – at least in terms of the said four methodologies. Chaos is also, ontologically speaking, a very temporary state, as complete randomness requires massive energy to create, and are impossible to maintain (Prigogine and Stengers, 2018). In the Chaotic Domain, the main focus is on rapid strategic action-taking, specifically aimed at bringing the chaotic events under beneficial control as quickly as practically possible. When such strategic action-taking proves to be effective, parts of the system will likely transition into the other domains. Systems that undergo chaos become fundamentally different, and there is an irreversibility to the system-level disruption. All research is therefore, likely conducted in retrospect, and the appropriate approaches can be determined by using the framework as a meta-methodological frame.

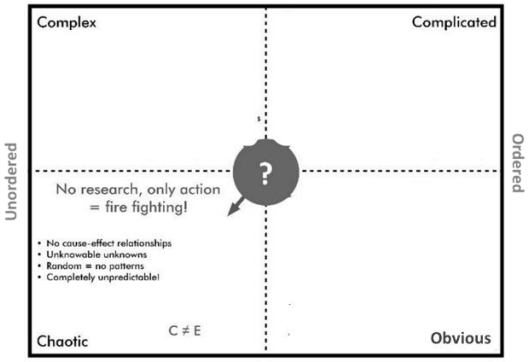


Figure: 11: *The by the 'C ≠ E' symbol signifies that in this domain there are no discernable cause–effect relations – meaning that things happen / occur in a completely random / ad hoc manner in the Chaotic Domain. This, in turn, makes it basically impossible to conduct systematic research of any kind in this domain. Instead, facing the very urgent consequences of random / ad hoc events, the strategic focus in this domain is squarely on taking appropriate real-time action(s) in order to bring the situation under control as quickly and effectively as practicably possible.*

3. Conclusions

Issues in any of the four domains are both ontologically and epistemologically speaking dynamic. This means, on the one hand, that they can change or be changed when acted upon *during* any of the four research methodologies. Also, on the other hand, it means that even when things do not actually change, that it is still possible that our perceptions and understanding of them might change. Either way, what is required is *both* inter- and intra-methodological agility – i.e. the ability to switch methodologies not only *between* the Clear, Complicated, Complex and Chaotic domains, but also to work with different approaches *within* any of the said four of methodologies of mono-, multi-, inter- and trans-disciplinarity.

When applied to working in the trans-disciplinary mode *within* the Complex Doman, inter- and intra-methodological agility means, inter alia, the ability to work with and switch between formal multi-stakeholder[10] processes (Maani, 2016) and working with individual social actors, in their informal settings[11]. Inter- and intra-methodological agility offer different approaches to respond to Chandler's call to *re*think the onto-politics of the Anthropocene. When engaging with sustainability transitions in complex real-world environments, research cannot be conducted in these areas at a distance. On the contrary, to *re*search in this field is *to act in it*, and to impact on it – thereby, developing anticipatory awareness for both s*haping* and *being shaped* by the non-linear causal dynamics at work in such complex contexts. This, therefore, calls for methodological strategies that allow us to act more authentically in these real-time and rapidly changing contexts. Developing real-time feedback loops that harness the emergence of complex systems will allow for greater domain authenticity, and align research in these contexts with the theory and praxis of sustainability transitions. Methodological agility allows us the ability to appropriately flex without forcing a complete Kuhnian-like paradigm shift, or 'Gestalt switch', when facing the challenge of switching methodologies in response to rapidly changing contextual conditions and circumstances impacted upon not only by the embedded research processes themselves, but also by multiple other social change processes continuously assembling and re-assembling society – which may occur at the same and/or different times, rates and paces and, very importantly, intensities as the said research processes.

[10] In other words, working with so-called 'legitimised' stakeholders with a mandate to make decisions on behalf of others.
[11] For example, using distributed cognition and learning narrative-based approaches such as the SenseMaker® method.

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Assessing Sustainability - Part 1

Assessing circularity and sustainability

A survey-based analysis of companies with circular economy practices

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Abstract

The circular economy (CE) concept has become a major trend among companies, promising new business opportunities and a decrease in harmful environmental impacts. Though research on circular business models has recently increased, only few scholars have investigated whether CE practices also yield the sustainability results they promise. Therefore, establishing the empirical *status quo* of circularity and sustainability assessments provides a way forward and enables targeted improvements of applied assessment approaches with academic findings. This paper presents the results of an empirical analysis conducted through a qualitative survey in the Netherlands and Italy, where the major part of research on the nexus of circularity and sustainability assessments has been produced. The survey was distributed online to over 800 representatives of companies. Purposive sampling was employed to target only firms associated with national and international CE networks, assuming these companies already implement and assess CE best practices at varying levels of maturity. They thus can be defined as "front-running CE businesses". Within a three months' timeframe, 155 companies provided information on their understanding of the CE concept, its relationship with sustainability, as well as the assessment approaches used for the monitoring and reporting of CE and sustainability aspects. The survey answers show that companies view CE as one of the tools to achieve sustainable development improvements, particularly in the environmental domain. Yet, the respondents are ambiguous towards the question of whether CE can also provide economic benefits to firms. Furthermore, self-developed sustainability indicators were the most frequent assessment approach on a company level, while Life Cycle Assessment related methodologies prevailed on a product level. Given the qualitative nature of the survey, the observed tendencies are to be scrutinised through semi-structured interviews in a next step. Further research advancements will also include the survey distribution in other European and non-European countries to enable regional comparisons.

Keywords: Circular economy; qualitative survey; sustainability assessment; measurement; empirical study

1. Introduction

Our current linear model of economic development is often described as unsustainable and non-compatible with our planet's finite boundaries: it depletes natural resources, generates waste, produces harmful emissions, and gives rise to a complex web of interlinked environmental and social concerns (Sauvé et al., 2016). In the past years, the concept of transitioning to a Circular Economy (CE) as a radical solution to overturn such negative trends has increasingly gained popularity in academic-, policy-oriented and business communities. A CE can be considered an umbrella concept, drawing inspiration from a diverse set of resource management concepts and ideas from environmental- and sustainability sciences that have been introduced since the 1960s (Blomsma and Brennan, 2017). While many CE strategies exist, and academic discussions on the impact of such strategies appear to be increasing (Millar et al., 2019), the core of the concept can be described by its aim to retain material value through the process of closing material and resource loops. These actions work to decouple economic growth from resource consumption, with the goals to reduce harmful environmental impacts, stimulate economic growth and, according to some interpretations, generate positive social impact (Korhonen et al., 2018; Schroeder et al., 2018). Many authors have focused on the construction of hierarchical frameworks that list several resource-related strategies (R-strategies) that assist in moving towards a CE (Reike et al., 2018).

Due to CE's previously mentioned core of decoupling economic growth from resource extraction and the many opportunities for profitability that are thus promised by CE, companies are increasingly implementing CE practices (Howard et al., 2019). These companies are, according to some authors, expected to drive the transition due to their production activities, which are

often based on the extraction and transformation of natural resources (Urbinati et al., 2017). Still, literature that studies how companies engage with the concept of CE, and whether CE practices also yield the sustainability results they promise, is relatively scarce. Most academic literature appears to still focus on the conceptual development of CE and its relation to natural resources management and R-strategies in a given context, while less attention is given to CE implications in the context of e.g. managerial sciences and company level interactions (Merli et al., 2018). In addition, it has been signalled that empirical academic work using a medium- or large number of cases (N>10) in CE research is quite uncommon (Kirchherr and Van Santen, 2019).

This paper constitutes the first output of a larger research project which aims to address how front-running companies engaged with CE interpret and adopt CE practices. In this research project, front-running businesses are defined as companies which can be considered early adopters of CE practices and which are involved in cross-sectoral initiatives to further the advancement towards a CE. To strengthen the understanding of how these front-running companies interpret, implement and assess CE practices, cross-sectoral empirical evidence was collected through a qualitative survey (Jansen, 2010). Special attention is paid to the connections between CE and sustainability, as well as the assessment of both circularity and sustainability in a company context. The overarching aim of this survey is to deepen the understanding of company engagement of early adopters with the CE concept, and to provide empirical evidence resulting in impact-oriented knowledge and best practices to be shared and applied between both academics as well as practitioners.

The primary goal of this research paper is to briefly summarize the research process and present a descriptive analysis of the results from companies in Italy or the Netherlands, two countries that are generally considered to be on the forefront of the transition to a CE (Ghisellini and Ulgiati, 2020; Kristensen and Mosgaard, 2020). In a later stage, additional countries will be added to the research process. Additional focus is provided to the theoretical foundation in section 2, and to the survey method, described in section 3, that was employed in order to obtain empirical evidence of company engagement with CE. After a presentation of preliminary results in section 4, the discussion section 5 points out interesting findings by linking results from the different survey themes, and by connecting the findings to literature discussed in section 3. Moreover, and perhaps most importantly, the discussion will also briefly describe questions that have emerged from these results, and summarize some of the next envisioned steps in the research process to answer these emerging questions (i.e. through interviews). The project is still ongoing, with additional planned research outputs expected to arrive in late 2020.

2. Theoretical overview

To better contextualize the present research and justify its academic approach, literature on three central research aspects is reviewed. First, a short overview of the different interpretations of the connections between CE and sustainability is provided. Next, previous work related to the assessment of CE at the company level is reviewed briefly. Lastly, this review considers previously conducted company-level CE surveys from academic literature.

2.1 CE and sustainability

The connections between the deep and multifaceted concepts of CE and sustainability, or Sustainable Development (SD) are contested, and no academic consensus on how exactly these concepts are related appears to have been reached. Some authors have evaluated the relationships between CE and sustainability. For example, Geissdoerfer et al. (2017) identify different conditional, beneficial and trade-off relationships between CE and SD. Millar et al. (2019) took a critical approach and challenged the proposition that implementing CE is driving positive impacts in terms of SD. Another critical perspective is offered by Sauvé et al. (2016), who considered that both concepts are subject to various epistemological problems, complicating research and obscuring academic discussions. Kirchherr et al. (2017) reviewed a large number of available CE definitions and found that only a marginal amount of studies connects CE to all three dimensions of SD (society, economy and

environment). In summary, the connection between the two concepts appears to be undecided and strongly dependent on the interpretation of CE. While the connection has been studied from an academic perspective, there is little research on how companies understand the link between the two concepts and how this understanding is operationalised in business practices.

2.2 CE and sustainability assessment

Recently, the question of how to assess 'circularity' at company level has received much attention in academic literature. Various review papers have inventoried and described different methods, tools, and general approaches to evaluate CE. Two first examples are the works by Corona et al. (2019) and Moraga et al. (2019), who find evidence that often-used methodologies consist of mass balance approaches such as Material Flow Analyses (MFAs). They also highlight that Life Cycle Assessment (LCA) is often used by other academics as a relevant methodology to assess CE, although LCA only covers the environmental domain, excluding potentially relevant socio-economic effects. The usefulness of LCA is further described by Mondello et al. (2020), stating that CE decision making processes at the company level could be assisted by the LCA methodology. It is relevant to note that, when using tools based on Life Cycle Thinking, the impact of CE solutions on the environment (or other SD dimensions) are assessed; other authors apply a different perspective and rather see the goal of the assessment to evaluate 'the degree of circularity' (see e.g. Howard et al., 2019; Linder et al., 2017; Saidani et al., 2019).

Another relevant review of micro-level CE assessment approaches is presented by Kristensen & Mosgaard (2020). The study collects and reviews micro level indicators for a CE, describing the 'type and scope' of the available indicators, and also categorizing them by the nature of their output (singular indicators, analytical tools and composite indicator sets). In addition, the indicators' connections to nine CE strategies are described. The relations between sustainability, or SD, and the inventoried indicators are also investigated. The authors find that most of the indicators are focused on the economic dimension of sustainability, followed by the environmental one, while the social dimension is very limited. Most of these studies inventory and analyse micro-level CE assessment approaches from academic literature, which poses the question of whether these proposed approaches are actually practicable by companies.

2.3 Previous company-level CE surveys

A number of scientific works have previously investigated the topic of how companies interpret or use the concept of CE through collecting empirical evidence using a survey approach. This short review briefly summarizes them, focusing on the methodological approaches applied throughout the surveys. Their main characteristics are summarized in Table 1.

Table 1. *Main characteristics of previous CE-survey papers*

Reference	Main research interest	Sampling approach	Survey responses	Geographic region
Mura et al. (2020)	CE practices, enablers, and barriers	Random sample of SMEs	209 (+45 interviews)	Italy
Ghisellini & Ulgiati (2020)	CE practices, cooperation strategies	Purposive sampling (wide range of organizations selected based on occurrence three CE reports)	292	Italy
Bassi and Dias (2019)	Factors that influence CE practices	Uses Flash Eurobarometer 411 database; multi-stage random sampling of European SMEs	10,618 interviews	Europe
Gusmerotti et al. (2019)	Level of implementation of CE, drivers of CE	Random sample of manufacturing firms	821	Italy
Ormazabal et al. (2018)	Implementation of CE, drivers & barriers, symbiotic relationships	'Convenience sample' of SMEs	95	Navarre and Basque Country (Spain)

Fonseca et al. (2018)	The level of CE application and the motivations, knowledge and ways of promoting CE	Random sample using commercial database of companies	99	Portugal
Jonker et al. (2017)	Circular Business Models (CBMs)	Sampling process not specified; selection includes organizations, initiatives, individuals	500+	Gelderland and Overijssel (the Netherlands)

Starting with a recent study, Mura et al. (2020) focus on the practical implications of CE involvement of Italian small and medium-sized enterprises (SMEs). Another study with a focus on Italian organizations was conducted by Ghisellini & Ulgiati (2020), who analyze research cooperation strategies among the organizations, which include research centres, universities, and both non-profit and for-profit companies. The characteristics and CE business models of these organizations are extracted from previously conducted surveys by other scholars. Bassi and Dias (2019) aim to assess factors that might influence CE practices in all sectors of European SMEs. The study uses a very large database provided by the Flash Eurobarometer 441 (European SMEs and the circular economy) conducted in the 28 EU Member States (European Commission, 2016). A similar large-scale approach, applying a sophisticated statistical approach in analyzing the results, was conducted by Gusmerotti et al. (2019). Other studies have been carried out in Portugal, Spain, and the Netherlands. Ormazabal et al. (2018) used a survey that focused on SMEs in Navarre and the Basque Country in Spain, while in Portugal, Fonseca et al. (2018) aimed to address the 'lack of awareness concerning CE among Portuguese companies'. An online survey and subsequent statistical analysis are used to address the study's key research aims. Jonker et al. (2017) present a whitepaper in which they demonstrate their interest in business models for a CE. Their study includes an empirical part, which uses a pilot survey with the topic of studying the development of Circular Business Models in the provinces of Gelderland and Overijssel in the Netherlands. Their pool of participants is large and diverse including CE-involved SMEs, initiatives, and individuals participating in the questionnaire. Approximately 40 of them were subsequently interviewed by the researchers.

In summary, we identify two popular research themes: i) the practical application of CE strategies, and ii) the drivers and barriers that are important when implementing these strategies. However, the contested connections between CE and sustainability laid out in 2.1, and the tools to assess company-level CE briefly presented in 2.2 have not been discussed in the previously reviewed literature. Next, most of the reviewed studies use sampling approaches that are random or primarily based on convenience, and most of them include organizations in their base of respondents that are not necessarily involved with any CE activities. Therefore, the N of the (random) sample was often much higher than in the current study, requiring more advanced statistical analyses to interpret the results. Moreover, most of the studies indiscriminately surveyed companies on all levels of implementation of CE practices, making it difficult to identify best practices for companies striving towards a CE. Lastly, the geographical scope of the analysed research is limited to a region or a country, preventing the generalisation of results beyond borders.

3. Methods

Given the importance to include the empirical examples of circular companies and their assessment approaches, the method here proposed is a qualitative survey (Jansen, 2010). As opposed to a conventional survey, a qualitative survey does not focus on the frequency of certain respondent's characteristics within the sample population, but analyses the variety of these characteristics. The explorative nature of this method allows for capturing a wide array of perspectives on CE, the link to sustainability as well as assessment approaches applied by firms.

3.1 Sampling procedure

Building on the studies discussed in 2.1, this paper aims at establishing insights into the connection between CE and sustainability, and identifying approaches companies apply to assess CE practices, rather than a general overview of CE practices in companies. Therefore, the sampling method employed was purposive sampling (Hibberts et al., 2012), as opposed to random sampling, which allows for the identification of best practices from respondents who are already engaged with the

research themes. Because CE is a fairly recent concept, the number of self-identified circular firms is limited (Kalmykova et al., 2018). Hence, the authors focused the sample on companies within existing CE networks, as these firms are projected to be front-runners in conceptualising and applying CE practices. The first round of survey distribution is focused on Italy and the Netherlands, two front-running countries with regards the implementation of CE practices (Ghisellini & Ulgiati, 2020; Kristensen & Mosgaard, 2020). Given the future inclusion of France and Portugal, a more generalized, European view on company-level CE participation is enabled, while still allowing for zooming in on, or even comparing, country-level particularities that might cause differences in CE engagement.

The sampling procedure followed is depicted in Table 2. Special attention was awarded to avoid a sampling bias, especially given the purposive nature (Hibberts et al. 2012), meaning the probability that some of the respondents are chosen is lower than necessary to be representative (Bautista, 2012). Therefore, CE experts in the Netherlands and Italy were consulted to ensure adequate coverage of CE networks. Furthermore, to minimize the coverage error, occurring if companies are missing within the sampling frame, the researchers consulted updated member lists online or directly contacted the CE network coordinators.

***Table 2**. Sampling protocol.*

CE networks considered	Atlante Italiano dell'Economia Circolare (IT), Piattaforma Italiana degli stakeholder sull'economia circolare (ICESP) (IT), Circular Economy Network (IT), Mercato Circolare (IT), Circulair ondernemen (NL), Ontertekenaars van Grondstoffakkoord (NL), Circle Economy (NL), Holland Circulair Hotspot (NL), Circulaire Coalitie (NL), Ellen MacArthur Foundation CE 100 (international) and Circular Economy Club (international)
Inclusion criteria for companies	• Company is part of a local or international CE network • Company in international networks has primary business operations in either NL or IT • Organisation's legal form is a company according to local law • Organisation has an official website
Survey delivery and responding period	• Delivered online via Survey Monkey, with personalised email invitation and customised links • Three reminder emails sent out within intervals of three weeks • Three months total responding period: July – October 2019

3.2 Survey development and content

The survey was drafted according to the seven-step framework for social scientists by Gideon (2012). Special attention was attributed to the fact that it was an online questionnaire and was sent out with an email invitation (Lozar Manfreda & Vehovar, 2008). It was developed in a participatory way, involving seven researchers, two private partners of the research project specialised in sustainability and life cycle-based assessments and circular companies respectively, as well as four large multi-utility companies, a production firm, and a coordinator of an industrial cluster for testing survey.

The survey covered three relevant topics related to company-level CE engagement requiring additional empirical evidence:

- understanding of CE concept and the link between CE and sustainability,
- companies' goals of implementing CE practices, as well as drivers and barriers playing a role in this implementation process,
- CE and related sustainability assessment approaches for circular companies.

For additional information on the creation of the questions for the individual parts, refer to Walker et al. (2019). The current paper focuses on the first and last topic presented above; the former topic sets out the context of what companies are expected to assess, given their CE understanding, as well as the link to sustainability. The latter part of the survey describes assessment

approaches applied, their categorization into circularity or sustainability assessment tools as well as potential needs of companies with regards to developing and applying such tools.

3.3 Data description

The survey was sent out online to a total of 809 companies and was completed by 171, of which 155 responses were valid. This represents a survey response rate of 19%, which is considerable for business surveys (Dillman, 2011) and well above of the response rate in the aforementioned CE studies. From these 155 respondents, 46% are based in Italy and 52% in the Netherlands. 2 respondents are part of Italian or Dutch CE networks while being based outside of these countries: 1 from Luxemburg and 1 from Austria. Further descriptive statistics, regarding the company size, department of respondent and company sector of the sample are provided in Table 3, Table 4, and Table 5, respectively.

Table 3. *Size of companies.*

Company size category	Number of respondents	Percentage
1 to 9	69	45%
10 to 49	33	21%
50 to 249	19	12%
250 to 500	6	4%
501 to 1000	6	4%
1001 to 5000	13	8%
5001 to 10'000	3	2%
10'001+	6	4%
Total	**155**	**100%**

According to the EuroStat classification scheme for SMEs (Eurostat, 2018), around 45% of the respondents represent so called micro-companies, as depicted in Table 2. Any company larger than 250 employees is considered a ‘large company’; this category makes up the second largest subgroup in terms of company size with 34 companies. From Table 4 it is evident that the survey has reached both decision makers that have management-level responsibilities, as well as employees that are closely involved with sustainability and CSR activities.

Table 4. *Department of respondents.*

Department category	Number of respondents	Percentage
General Management	60	39%
Sustainability & CSR	31	20%
Marketing & Sales	23	15%
Research and Development (R&D)	18	12%
Production	13	8%
Accounting and Finance	4	3%
Purchasing	3	2%
Customer Service	2	1%
Quality Assurance	1	1%
Total	**155**	**100%**

Using the statistical classification of economic activities in the European Community (NACE) (Eurostat, 2008), companies were asked to indicate in what sector they perform their primary business activities. Though the second largest group in Table

4 is the category 'Other service activities', which is mainly designated for repair services (Eurostat, 2008), it became evident after analysing the answers of individual responses that some companies in this category are in fact consultancy firms. According to the NACE subcategories of industry sectors, consultancy activities should be classified under the sector 'Professional, scientific and technical activities'. This measurement error (Bautista, 2012) will be taken into account in the further analysis of the results in the discussion section.

Table 5. *Industry sector of respondents.*

Industry sector category	Number of respondents	Percentage
Manufacturing	41	26%
Other service activities	37	24%
Water supply; sewerage, waste management and remediation activities	16	10%
Professional, scientific and technical activities	15	10%
Construction	11	7%
Wholesale and retail trade; repair of motor vehicles and motorcycles	6	4%
Agriculture, forestry and fishing	5	3%
Accommodation and food service activities	4	3%
Electricity, gas, steam and air conditioning supply	4	3%
Information and communication	4	3%
Real estate activities	3	2%
Transportation and storage	3	2%
Arts, entertainment and recreation	2	1%
Human health and social work activities	2	1%
Total	**155**	**100%**

4. Results

This section presents a descriptive analysis of the results from the survey. Firstly, the section describes the 'circular' characteristics of the sample, namely: the respondents' position in the value chain, what CE practices they currently (or plan to) implement within their company, and, the respondents perceived maturity of their CE products and/or solutions. Following this, the analysis will detail results on the respondents' interpretations of the conceptual connections between sustainability and CE and identify the assessment approaches being applied at a company and product level within front-running CE companies.

4.1 Circular characteristics of the sample

Respondents were presented with a diagram detailing seven stages of the value chain adapted from Kalmykova et al. (2018). They were asked to indicate which stage (or stages) of the value chain where the main business operations of their company are situated. Respondents in the sample are most likely to situate themselves in *Recycling and Recovery* (79 respondents), closely followed by *Manufacturing & Remanufacturing* (77 respondents), *Distribution and Sales* (74 respondents), *Design* (72 respondents), *Materials Sourcing* (53 respondents), *Collection and Disposal* (45 respondents) and lastly *Consumption and Use (with reuse and repair)* (41 respondents). Furthermore, respondents are more likely to operate in more than one value chain position, with only 31% respondents considering their company's operations to involve just one part of the value chain.

Respondents were asked what specific CE practices (strategies, solutions or business models as adapted from Kalmykova et al. (2018)) have been or are planned to be implemented within their company. The respondents were presented with a list of 15 CE practices and there was no limit to the number of practices the respondent could select. As depicted in Figure 1, the most commonly applied CE practice is *Recovery of products, materials or energy from waste*. This was closely followed by the practice of *Increasing energy and material efficiency through reuse, reduction and repurposing*. The least applied CE practices in the sample include *Providing a sharing platform for consumer goods*, *Repairing products*, *Remanufacturing or refurbishing goods* as well as *Product service system models*.

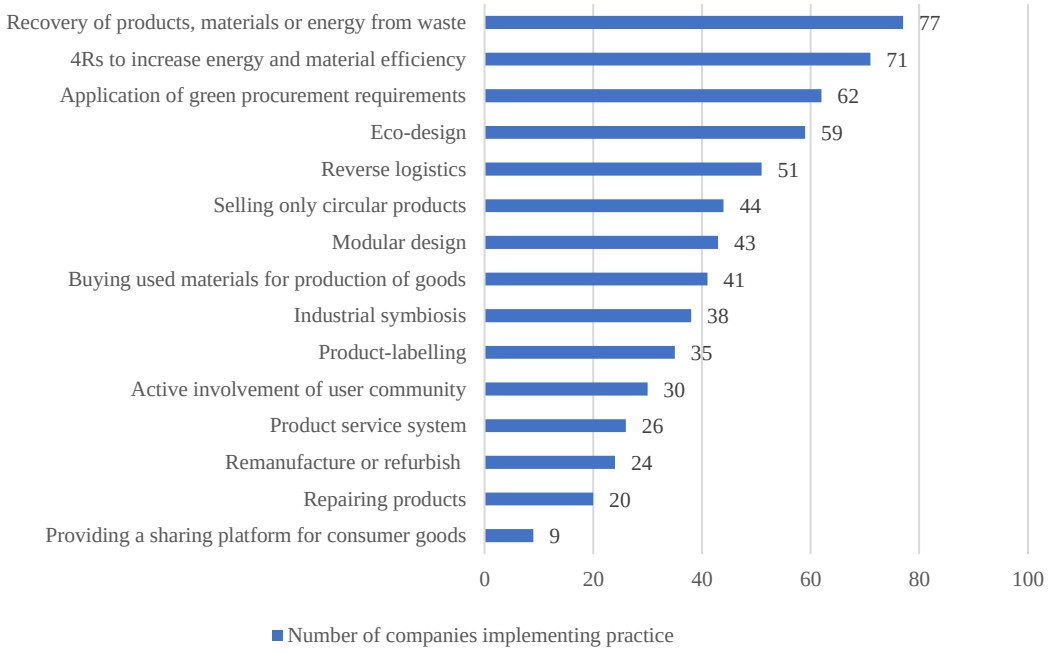

Figure 1. *CE practices implemented or planned by respondents, n=141.*

Regarding the number of CE practices implemented or planned, 72% of respondents indicated they have implemented or planned to implement more than one CE practice. In fact, the most frequent number of CE practices within each company was four, with 19% of companies featuring this.

Companies were asked to rate the perceived maturity level of both their company's products (goods and services) produced with CE practices and/or the overall maturity of the operational solutions involving CE practices. Respondents selected one of four stages of maturity as seen in Figure 2. Overall, companies are more likely to have implemented circular operational solutions for more than 2 years than circular product solutions. Results also show that the sample consists of companies with a range of perceived stages of CE implementation for their products and operational solutions.

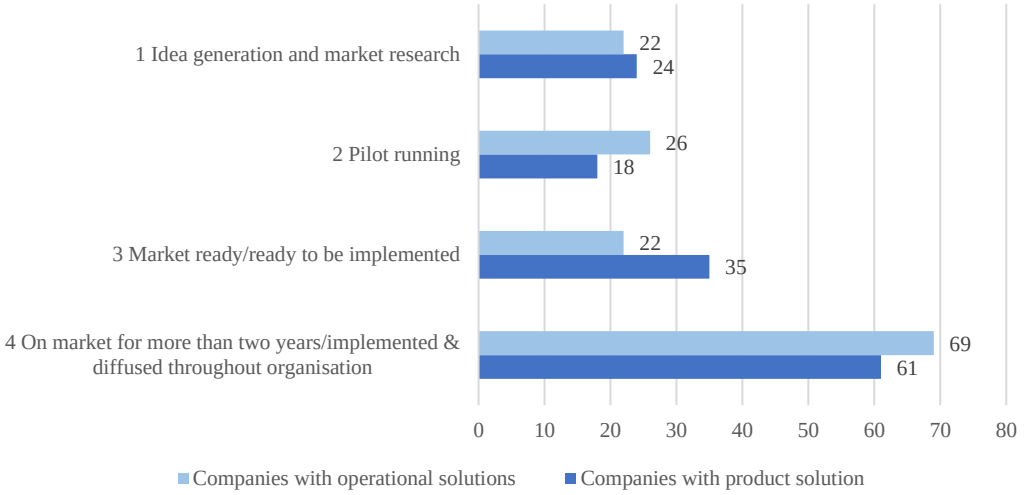

Figure 2. *Respondents' perceived maturity of circular products and operational solutions, n=139.*

4.2 Circular economy and sustainability

In the survey, various questions were dedicated to gaining insights into the respondent's perceptions of the concept of CE and its connection with sustainability. Figure 3 displays a list of seven characteristics attributed to CE which were presented to the respondents. Overall, respondents most strongly agree that the statement *Products are designed in a way that eliminates waste* has the highest level of importance when characterising CE. Interestingly, companies were least likely to characterise the concept of CE with *Businesses shifting towards offering PSS rather than selling products*. Also, eco-efficiency was perceived to be slightly less important than material efficiency, though responses for both characteristics had a high standard deviation (as seen in Table 6). Besides the seven characteristics mentioned in the survey, several respondents acknowledged the importance of the bioeconomy and the concept of sufficiency to the characterisation of CE through the use of the additional comments section.

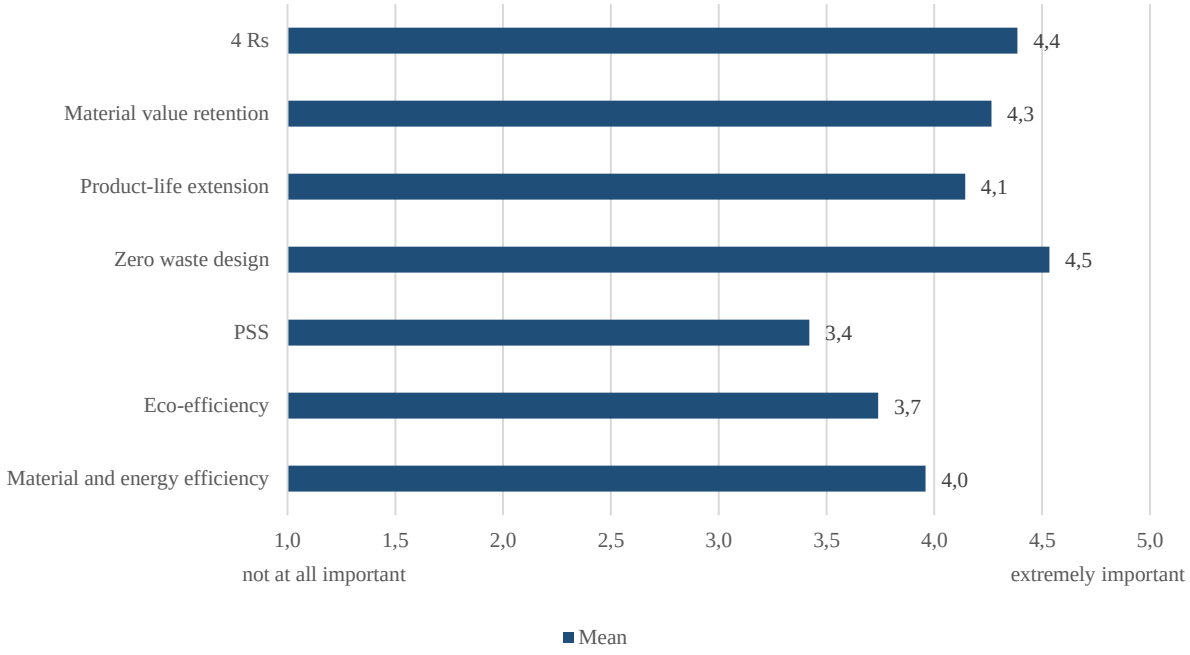

Figure 3. *Respondents' understanding of CE concept, assessing importance of characteristics with scale from 1 (not at all important) to 5 (extremely important), 'I don't know' responses were excluded from average, n=155.*

Table 6. *Respondents' understanding of CE concept with survey statements linked to CE characteristics.*

Statements	CE characteristic	N.*	Mean	Standard deviation
During the life cycle of a product (production, use, end-of-life) materials are reduced, reused, recycled, or recovered	4 Rs	153	4,4	0,94
Goods are produced in a way that enables the maintaining and recovery of value of materials such as gold and other scarce materials	Material value retention	151	4,3	0,88
Goods are produced or services are provided in a way that increases the durability of products, before their disposal	Product-life extension	154	4,1	0,97
Products are designed in a way that eliminates waste, because after their end of life, they re-enter the value chain as material input	Zero waste design	150	4,5	0,73
Businesses offer a service to users, instead of selling their products to customers (e.g. renting a car, instead of selling it)	PSS	150	3,4	1,22
More goods and services are produced while causing less negative impact on the environment	Eco-efficiency	146	3,7	1,19
More goods and services are produced while reducing material resource or energy use	Material & energy efficiency	146	4,0	1,17

* excl. 'I don't know' responses

Respondents were asked to indicate their level of agreement with six statements describing the effect of CE on the three pillars of sustainability (environment, economic and social). The results (as seen in Figure 4) indicate that the respondents agree on the concept of CE having a positive relationship with all three pillars of the concept of sustainability. It becomes clear that most respondents agree that CE is *one of the tools* to help achieve the UN sustainable development goals (SDGs), while they do not necessarily agree that it is the *main tool* to achieve them. Answers further indicate that the association of CE with the environmental pillar of sustainability is the strongest, followed by social benefits and economic profitability. Interestingly, it became apparent that respondents do not necessarily think social equality is equally addressed within CE. While not visible from the mean, but from looking at the standard deviation (as seen in Table 7), the second and last statements were also the most contested, with several answers indicating that respondents both strongly disagree and strongly agree.

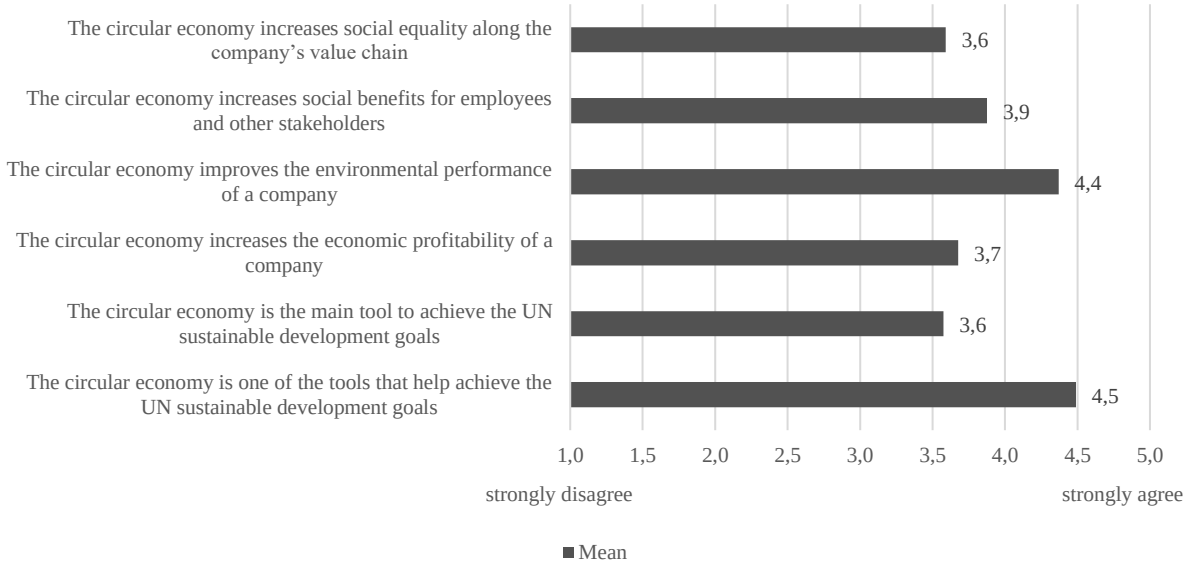

Figure 4. *Respondents' understanding of the link between CE and sustainability, indicating level of agreement with scale from 1 (strongly disagree) to 5 (strongly agree), 'I don't know' responses were excluded from average, n=155.*

Table 7. *Respondents' understanding of the link between CE and sustainability*

Statements	N.*	Mean	Standard deviation
The circular economy is one of the tools that help achieve the UN sustainable development goals	153	4,5	0,69
The circular economy is the main tool to achieve the UN sustainable development goals	151	3,6	1,06
The circular economy increases the economic profitability of a company	152	3,7	0,89
The circular economy improves the environmental performance of a company	154	4,4	0,76
The circular economy increases social benefits for employees and other stakeholders	146	3,9	0,91
The circular economy increases social equality along the company's value chain	142	3,6	1,10

* excl. 'I don't know' responses

4.3 Assessment approaches to CE and sustainability

The final section of the survey was designed to establish insights on whether the connection of CE and sustainability is also reflected in the assessment approaches and monitoring frameworks applied within front-running companies implementing CE. In addition, it was designed to determine what are the most commonly applied assessment approaches across the sample.

Respondents were presented with a list of 22 assessment approaches commonly applied by companies, including single indicators, indices and integrated approaches. They were then asked to indicate whether each approach was applied at a company level and/or product level, or if there were plans to implement each approach in the future. As seen in Figure 5, the 22 approaches have been implemented at varying frequencies for both the company and product level. Within this sample, 36% of companies (56 companies) have not applied any of the approaches on either a product or company level.

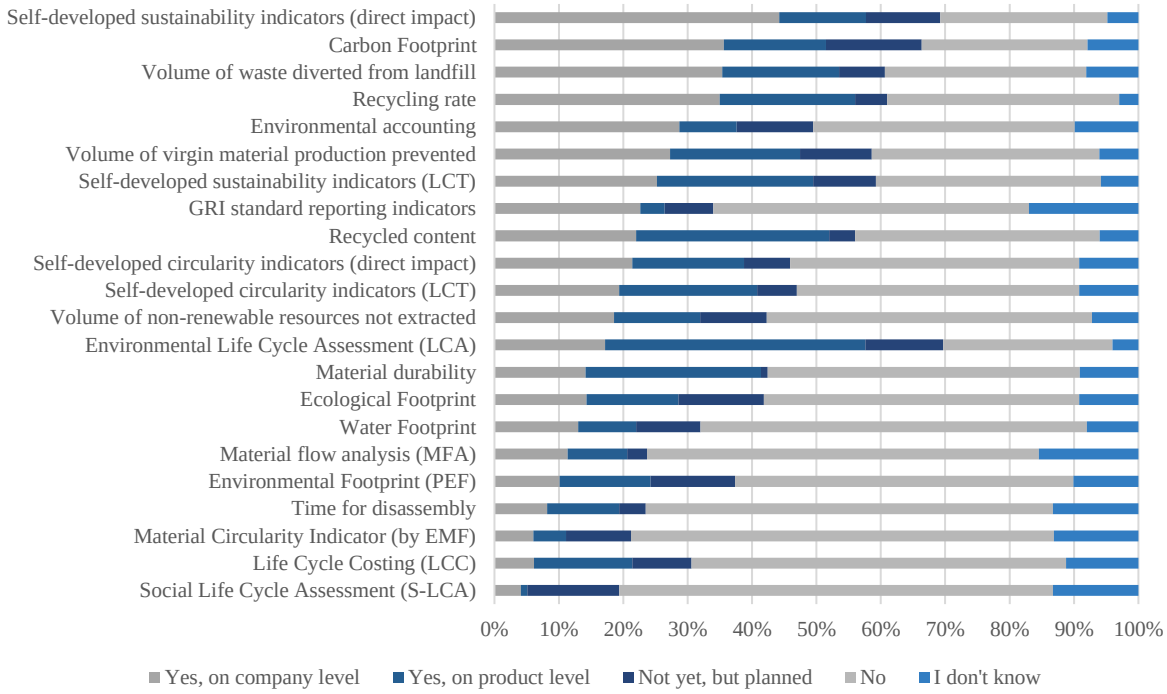

Figure 5. *Application of assessment approaches on company or product level, n= 106.*

For approaches applied at the company level, the most commonly applied approach is *Self-developed sustainability indicators based on direct impact*. Looking at the frequency of approaches applied per company, 46% of respondents (71 companies) do not apply any approaches on a company level, 10% (15 companies) apply only one approach and the remaining 44% (69 companies) apply two or more approaches. Concerning approaches applied at the product level, the most commonly applied approach is *Environmental LCA*.

Analysing the frequency of approaches applied at each company on a product level, results highlight that, 53% (82 companies) of respondents do not apply any approaches, 7% (11 companies) of respondents apply one approach and the remaining 40% (62 companies) applied two or more approaches. It is interesting to note that *Social-LCA* is the least commonly applied approach on both the company and product levels. However, it is the second most common approach mentioned which is planned to be implemented (with Carbon Footprint being the approach most commonly planned to be implemented).

Zooming in on each of the assessment approaches, Figure 6 displays the share of companies who currently do (either product or company level) or currently do not apply each of the 22 approaches. In an additional question, companies who implemented one or more assessment approaches on the product level were asked which parts of the product life cycle are included within their assessment. From those companies, 38% (36 out of 94 companies) consider processes along the entire life cycle of the product, including the use phase within their assessment.

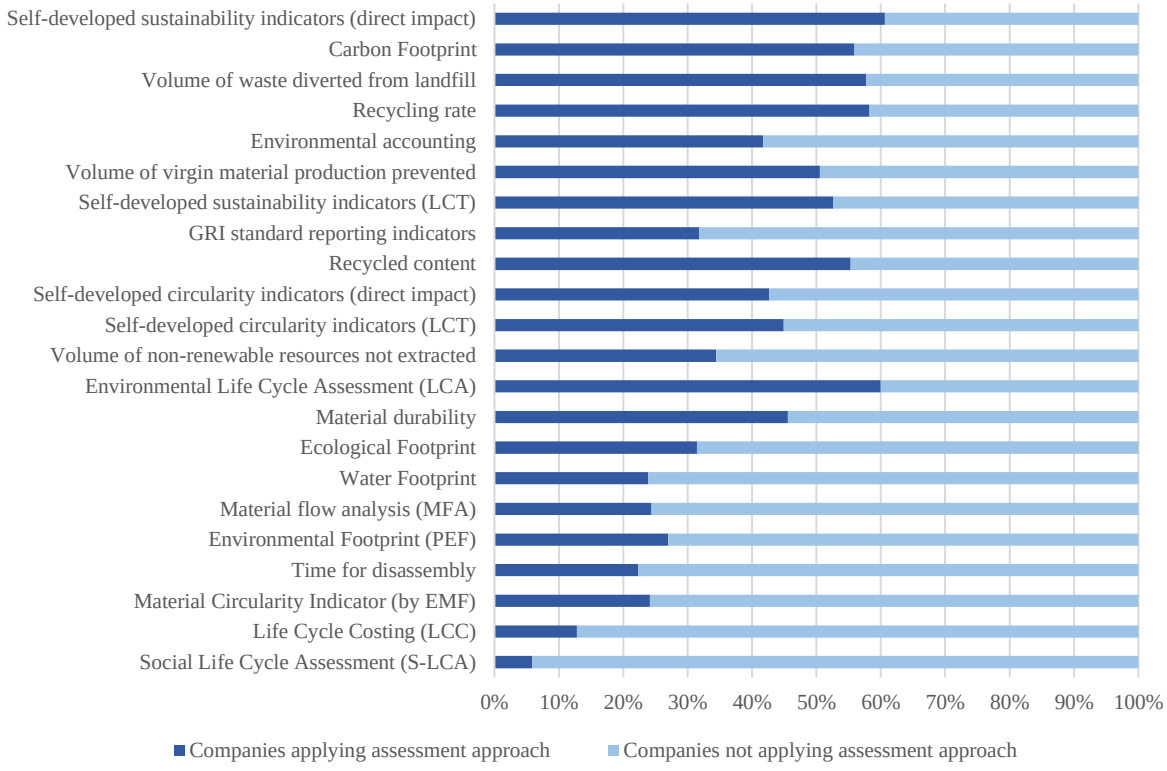

Figure 6. *Overall application of assessment approaches within the sample.*

Finally, respondents were asked which phases of assessment their company would benefit from external expertise when implementing sustainability assessment approaches or circularity assessment approaches (as seen in Figure 7). Overall, respondents indicated that expert input would be beneficial at each of the eleven phases of assessment listed for both sustainability and circularity assessment processes, except for *Internal communication of results*. Moreover, they indicated that external expertise would be slightly more beneficial for the implementation of circularity approaches than for sustainability approaches at the majority of the assessment phases.

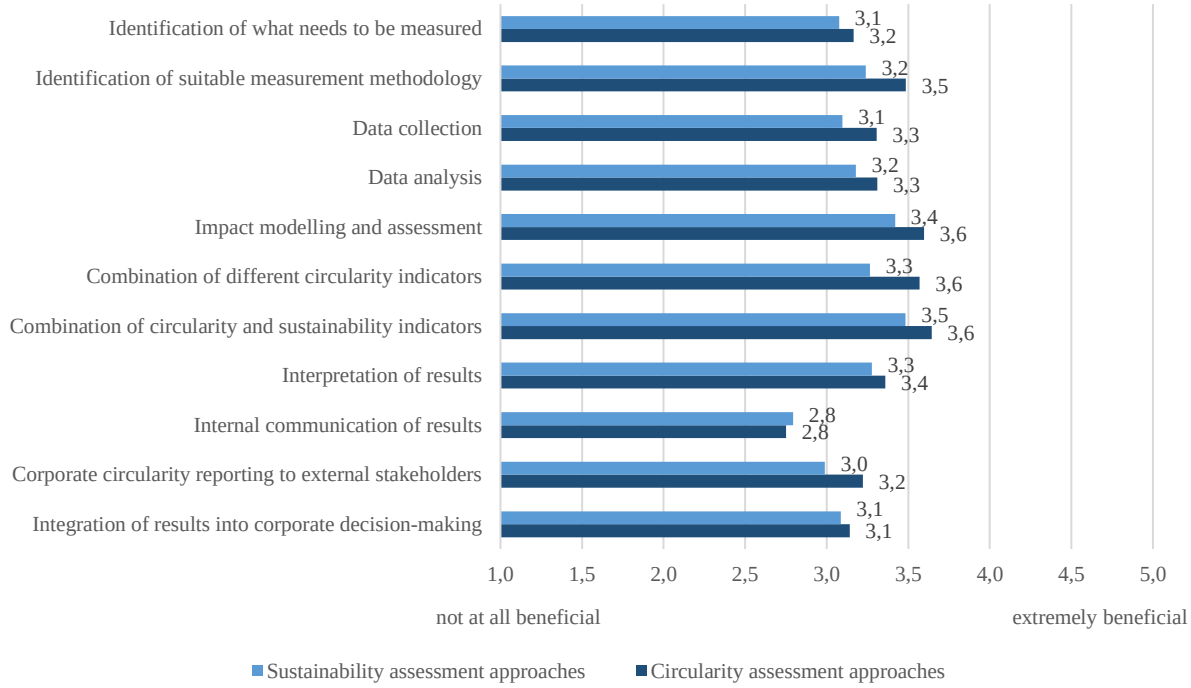

Figure 7. *Perceived benefit of external expert input for circularity and sustainability assessment processes.*

5. Discussion

The following discussion is structured into two parts. The first part discusses the results presented within this paper, whilst the second part points out directions for future analyses and additional data collection with semi-structured interviews.

5.1 Analysis of results

With respect to the main business activities of the surveyed companies, most results point to a waste management focus. The operations of surveyed companies are situated in all seven value chain positions, with *Recycling and Recovery* being the most present. This was reflected with the types of CE practices being implemented within the sample, with the most common practice being *'Recovery of products, materials or energy from waste'*, which occurs within the Recycling and Recovery value position. Similarly, as historically derived in literature (Cecchin et al., 2020), companies also indicated that the zero-waste characteristic is the most important one to describe a CE.

Given that the majority of respondents situate their business operations at several value chain positions and 71% of companies implement more than one CE practice, the results suggest that the companies within the sample are not specialised. This is interesting, as 49% of survey respondents can be classified as micro-companies, suggesting individual firms might have less resources to attribute for operations across the value chain. An explanation for this could be the presence of a high number of small, multi-disciplinary CE consulting firms within the sample. This was also noted as a potential reasoning for the large proportion (24%) of companies indicating they operate within the *'Other service activities*' sector and will be further investigated in future data analysis and interviews.

With respect to the maturity of CE implementation for each of the individual respondents, results showed within the sample that half of respondents (49%) have had a circular product or have implemented circular operational solutions for more than 2 years. This suggests that the CE networks included within this study consist of companies with relatively long-running CE practices, as well as companies which have only recently adopted or are still planning to implement CE practices within both their products and operational solutions. This result also reflects the steadily growing number of companies engaging with CE in recent years as discussed in literature (Kalmykova et al., 2018).

As members of CE networks were assumed to be familiar with the CE concept, it is not surprising that the surveyed companies consider all seven CE characteristics to be more than moderately important. The consistency between responses, indicated through a low standard deviation, also points towards a consensus of the CE concept amongst front-running companies. Surveyed companies also indicated they agree that CE contributes positively to sustainability impacts, albeit results show the lowest level of agreement concerning the economic benefits from implementing CE. The high level of agreement with most statements concerning the links between CE and sustainability, and particularly, with the statement suggesting CE is *one* of the main tools to achieve the SDGs supports this claim. The perceived positive correlation of CE and sustainability also potentially increases companies' motivations to implement CE practices and might be one of the drivers to join the selected CE networks. However, this needs to be confirmed through analysis of drivers for and goals of CE implementation in future research steps.

Concerning the number and types of assessment approaches applied, it was determined that companies within the sample were more likely to apply approaches on the company level rather than on the product level. For those applying an assessment approach on the company level (54%), firms were more likely to utilise some form of self-developed sustainability or circularity indicators (30.5%). This suggests that, despite the breadth of formal assessment approaches available, front-running CE companies are more likely to develop customised assessment approaches internally or with the help of external partners. Furthermore, the fact that most of the respondents represent small firms with limited funds might partially explain the prevalence of non-standardised assessment approaches on a company level. On a product level, a small majority of companies (53%) did not apply any assessment approaches. For companies which do, the most commonly applied approach was a life cycle thinking-based approach, specifically Environmental LCA, which has been predicted by literature (Corona et al., 2019; Moraga et al., 2019). However, as stated earlier, the majority of companies within the sample are micro-companies, who sometimes mentioned that they believe assessment approaches were of no benefit within the additional comments section.

Results suggest that the surveyed companies did not express a significant difference in identified needs for external expertise between sustainability or circularity assessment approaches. This suggests that companies within the CE networks do not differentiate between circularity or sustainability needs; the result could also reflect the companies' perceived existing competence with these processes. This is also supported by companies indicating *Internal communication of results* as the assessment phase which would have the lowest level of benefits for external expertise. This is potentially explained by the companies already being engaged in CE, however, and thus having enough expertise; future analysis will explore this aspect further.

5.2 Future analyses

Based on the findings in this paper, several directions for further analysis have emerged. In a next step, the authors plan to investigate the influence of specific firm characteristics on the outcomes of questions from the survey. A relevant research direction would be to explore whether companies of different sizes, operating in different sectors and countries, and at different positions in the value chain have a diverging understanding of the link between sustainability and CE. Focus will be given to the statements where the respondents' answers had a high standard deviation from the mean, indicating a range of different perspectives amongst the respondents. As pointed out in the results section, it is also important to see whether the lack of companies implementing CE practices of repair and/or a PSS in the sample could be linked to certain barriers for CE implementation indicated, e.g. regulatory barriers. Another promising link to analyse is the level of maturity of a company's CE practice implementation and the likelihood to apply assessment approaches at a company or product level. For example, the responses from companies who have had circular products on the market for more than two years can be compared with those who do not have circular products on the market yet. This comparison could then evaluate the hypothesis that companies with mature CE practices are more likely to implement an assessment approach than those which do not.

Based on the outcomes of this analysis, the authors plan to conduct interviews with respondents from the survey who indicated their willingness to participate. Triangulating deeper insights of semi-structured interviews with the identified data patterns

within the survey results is crucial, given the qualitative character of the survey (Jansen, 2010). Besides posing questions about trends established in the analysis of results, the interview guidelines will also integrate the comments made by respondents, where questions had a section for additional comments with an open text field. The authors will, for instance, take up remarks by respondents about the connection between sustainability and CE, particularly those concerning the somewhat contested social dimension, or comments suggesting the importance of the bioeconomy and sufficiency. Several respondents also highlighted the difficulty of assigning assessment approaches to either circularity or sustainability, with additional comments directly asking for clarification through interviews. Through conducting interviews and engaging further with the respondents, the final research outcomes can also help understand the underlying reasons why companies do or do not measure the performance or impact of their business activities.

6. Conclusions

This paper offered a contribution to the discussion of CE and sustainability practices at a company level. It presents an overview of how front-running companies understand the concept of CE and how they link it with the concept of sustainability. Furthermore, assessment approaches for circularity and sustainability are discussed and their application in the field documented.

The findings show that most front-running CE companies in the sample carry out some of their business activities in the 'Recycling and Recovery' stage of the value chain and conduct related CE practices. About half of the respondents have what can be considered mature circular products and operational solutions, demonstrating that the companies employing CE practices are advancing and CE networks accommodate both experienced and learning members. The companies in the sample have a similar understanding of the CE concept and its link to sustainability. The overall effect of CE on sustainability and the SDGs in particular is seen as positive, though this link is weaker for the economic dimension and issues of social equality. Despite the proliferation of sustainability and circularity assessment approaches in literature, only half of the respondents actually apply such measures. On the company level, self-developed indicators prevail, while on the product level LCA is most widespread. Companies seemed to be only moderately interested in receiving external expert input to further develop their circularity and sustainability assessment processes. A striking result, however, was that the surveyed companies indicated the same level of perceived benefits from external expert input across the assessment stages for both circularity and sustainability, pointing towards a similar operationalisation of the two concepts in terms of assessment.

Given that this paper has mostly focused on describing the immediate results of the questionnaire, the next step is to further analyse the patterns that emerged during this descriptive analysis. Propositions for further analyses include the connection of company characteristics with responses regarding the three overall research themes. The findings will subsequently be triangulated through semi-structured interviews with survey respondents with the aim to identify best practices for companies implementing CE practices. In order to overcome the limitation of covering merely two countries in the EU, the authors further plan to extend the survey to France and Portugal to carry out a cross-country comparative analysis.

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Indicators System of Intermunicipal Sustainability

A case study in rural areas, Beira Baixa, Portugal

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Abstract

It is essential and urgent to seek social cohesion and quality of life of citizens, namely quality public spaces, energy efficiency, employment, economy, integration and social inclusion, among others, through policies (global or local), while respecting the specificity of each region. Indeed, in order to change the municipalities' planning policy, it is essential to incorporate sustainability criteria and their measurement. In particular indicators are a useful tool for communication and to support decision. The intermunicipal communities, as a cluster of neighbour municipalities, have an essential role in the promotion of territorial policies as a key factor for European territorial cohesion. The case study presented is about the Beira Baixa region in the interior of Portugal. Its population represents 0.8% of the resident population of Portugal. This region holds the country's 3rd and 4th largest municipalities in terms of area (Castelo Branco and Idanha-a-Nova), but with the lowest populational densities (18 inhabitant/km2). The main objective of this study is to present the results of the themes and calculate an index to determinate the key areas of a questionnaire survey applied to a representative sample of the resident population of Beira Baixa, Portugal, over 18 years of age. The survey aims the support of the development of a participative Indicators System (IS) for Intermunicipal Sustainability assessment. The objectives of the questionnaire were to inquire the population's perceptions and awareness about sustainability concepts, main sustainability themes and self-assessment of the local sustainability. The data that resulted was analysed using adequate multivariate statistical techniques, in particular to merge the more relevant sustainability domains and respective themes. The results show a statistically significant association between "Have you heard of the term "Sustainable Development (SD)"?" and "municipality". Specifically, we can see that in the rural municipalities the percentage of the population that has never heard of SD is higher. Besides, there is an imbalance between the four dimensions associated with the concept of SD (environment, economy, social and governance/institutional), in the community as well as in each municipality. In the question that relates to the Themes of the IS the environmental and social ones were identified as the most relevant. The exploratory factorial analysis on the presented subjects revealed six "components": the first one is strongly related with the "Environmental", the second with the "Economical", the third with the "Social", the fourth with the "Rural", the fifth with the "Immaterial" and lastly the "External Aspects". The research revealed also the low involvement of the population in public decisions and in questions related to the environment. It is essential to involve the population in order to put pressure on the government and local authorities to diminish social inequalities and assume their responsibilities for commitments to society, namely regarding local sustainability.

Keywords: Sustainability Indicator Systems, Public Participation, Rural Municipalities, Beira Baixa

1. Introduction

Since the Local Agenda 21 (specially chapter 28), started by the Rio Conference (CNUAD, 1992) and the first European Conference on Sustainable Cities and Towns (1994), the monitorization of local sustainability has achieved high visibility and an ever increasing importance. This is true on a world, European and national scales, based on indicators or evaluation criteria, in order to support the processes of local decision. One of its most common applications in the comparison of municipalities (Gan et al., 2017; Guerra and Schmidt, 2009; Niemann et al., 2017; Seixas, 2008; Tanguay et al., 2010; Tran, 2016). In 2015, the adoption of the Sustainable Development Goals (SDG), more precisely SDG 11, has reinforced and placed municipalities at the top of the international agenda.

Recently, the development of Indicators Systems (IS) has become a central topic in small cities and rural areas, but research is still scarce (Mayer and Knox, 2010; Palmisano et al., 2016; Visvaldis et al., 2013). Regions that face serious challenges, for example, fragile life levels and conditions and weak economical basis (Ji et al., 2019; Yan et al., 2018). Even though there are many local experiences, important for the development of local sustainability systems, its promotion is still weak (Shen et al., 2011). And there is still some resistance in the incorporation of sustainability indicators into local policies, because of the fact

that it is hard to work with a large number of metrics and the fact that the indicators are too technical (Munier, 2011; Pupphachai and Zuidema, 2017).

An IS should not just combine many indicators. It is not just about finding reliable data and justifiable arguments, but also about including those that are fundamental and more prone to transmit the most precise information about the condition of the municipality or community. So, it should be adapted to each region, having in mind its characteristics and necessities (Batalhão et al., 2019; Mascarenhas et al., 2014; Ramos and Caeiro, 2017; Shen et al., 2011). That is, the choice of indicators should have in mind their availability, their scope and their precision, as well as the possibility of their comparison with other municipalities or communities.

Despite the efforts developed to standardize the indicators by the organizations and institutions, especially those in Europe, for the evaluation and monitorization of Sustainable Development (SD) (Moreno Pires et al., 2014), there are still problems with the use and application of local sustainability indicators, that result from the abstract definition of sustainability, the lack of consensus both in the methods and the universal and standardized approaches for the design of the IS, the problems in accessing data, that does not allow a correct qualification and quantification of the indicators, which results in the difficulty of choosing the number of indicators and in the lack of consensus regarding the IS steps (Fu and Zhang, 2017; Tanguay et al., 2010).

According to the United Nations (UN, 2007) the systems should provide critical information, cover the questions that are relevant to the SD and have data that are readily available or that could be made available in a reasonable timeframe and cost. It is important to stress that the evaluation of sustainability has its specificities when analysed with different scales (Smetana et al., 2015), where local scope policies may have a more effective impact than national policies, since they incorporate the specificities of the municipalities being studied.

The IS at a local level should allow a comparison both at a regional and national levels, based on a common indicators system (Mascarenhas et al., 2010). They are important parameters to evaluate local transformations and to quantify the sustainability (Feroni and Galvão, 2020). Sustainability Indicators Systems (SISs) should be a continually monitored process, that generates useful information to redefine policies and incorporates more sustainable practices (Batalhão et al., 2019).

Internationally, the UN, OECD and EU have developed many indicators, which have inspired many studies in many levels: national, regional and local (Eckerberg and Mineur, 2003). Many models and methodologies have been developed to evaluate sustainability, through indicators and indexes. Regarding cities some more known and applied examples stand out: Urban Sustainability Index (USI), Sustainability Index for Taipai, City Development Index (CDI), Compass Index of Sustainability, The Sustainability Cities Index, Urban Ecosystem Performance Index, Sustainability Seattle: developing Indicators of Sustainability Community, ISSI Index Italy, Green City Index (GCI), Reference Framework for European Sustainable Cities (RFSC), European Common Indicators for Urban environment, Complete Community Indicators for U.S. Towns and Cities, Sustainability A-Test, Sustainability Cities International (Huang et al., 2015; Mori and Christodoulou, 2012; Singh et al., 2012; Visvaldis et al., 2013).

The European Committee (Science for Environment Policy, 2015) has made available a detailed report on the best indicator tools for urban sustainability, mainly European and for big cities, with the goal of helping local government and key-players. Regarding European cities, Niemann et al. (2017) have highlighted four initiatives for Indicators Systems for sustainability at a local level: Local Sustainability Meter (LSM), Local Evaluation 21 (LE21), Baromètre du Développement Durable (BDD), and, Reference Framework for European Sustainable Cities (RFSC).

In 2010, the Red de Redes de Desarrollo Local Sostenible (Network of Local Sustainable Development Networks) (RdR/DLS, 2011), Spain, developed a Municipal Sustainability Indicators System for small and medium municipalities, with 4 basic criteria, made of 43 indicators belonging to 7 groups. In 2011, it was applied, for the first time, to four municipalities with a population size ranging between 3 697 and 80 610 people.

In a study conducted around urban indicators, by Huang et al. (2015), there were identified 411 indicators, of which 151 were social, 114 environmental, 93 economic and 53 institutional. But the large majority of the systems groups the indicators in three dimensions: environmental, economic, and social. However, Michael et al. (2014) points out that the urban indicators should incorporate the social, economic, ecological, environmental and institutional. Beyond the traditional themed indicators, Viégas et al. (2018) suggest the inclusion of immaterial themes in the indicators systems, which will allow an association between traditional indicators and the communities' visions, desires and perceptions.

In Portugal, many studies and projects of local SISs, are based on the indicators made available by the Sustainable Development Indicators System (SIDS, in Portuguese), Agência Portuguesa do Ambiente (Portuguese Environmental Agency, 2007) being a widely used tool (Ramos and Caeiro, 2017) that allows to evaluate and monitor the development of national sustainability, made up of 118 base-indicators, referring to the four dimensions: environmental (36), economic (36), social (36) and institutional (10). And many systems rely on the PSR models (Pressure-State-Response) or DPSIR (Driving forces-Pressures-State-Impact-Response) for dividing the indicators between the categories.

Even though there is an increase in recent years, the indicators systems are still in an early stage of development. The oldest one was developed in 2002 (Moreno Pires and Fidélis, 2015). There is still a scarce inclusion of sustainability criteria in the local policies, and Portugal is one of the European countries that took the longest to respond to the international community in terms of the Local Agenda 21 (Dias, 2015). The role of the indicators is limited probably because of a diminished concern about more inclusive and participated democratic processes or with a greater transparency around local policies (Moreno-Pires and Fidélis, 2012).

We point out the Regional Sustainability Indicators System, developed by Mascarenhas et al. (2014) in the quest for harmonizing data and information, standardized and universal approaches for the conception of IS, based in a participated process. In a recent study, applied to the Algarve region, Bienvenido-Huertas et al. (2020) have used the cluster analysis approach for the reduction of the number of indicators and to establish correct groups of the level of sustainability of the cities in the Algarve. At a municipal level, Moreno Pires et al. (2014) highlight the ECOXXI, innovative program in Portugal, that wants to contribute towards the use of indicators at a local level.

In the literature we see that the development of IS in small and/or rural municipalities, using methodologies or models developed by international or national institutions, but hard to duplicate in full due to the marked differences in the characteristic of the regions being studied.

In Portugal there are 308 municipalities, of which 185 have 20 000 people or less (Carvalho et al., 2016). This means that the weight of small municipalities is very high. A rural municipality is defined by four common principles: low population density; a prominence of farming, forest and pasture areas; a strong connection between the people and the surrounding environment; and, strong social relations among its inhabitants (Boggia et al., 2014; Comíns and Moreno, 2012; Palmisano et al., 2016; Quintá and Arce, 2017). The intermunicipal communities (CIM) were started towards the general goals among their municipalities, namely the promotion of the planning and management in the creation of new models of governance and transition towards sustainability.

The CIM of Beira Baixa (CIMBB) is composed of six municipalities (Castelo Branco, Idanha-a-Nova, Oleiros, Penamacor, Proença-a-Nova e Vila Velha de Rodão, Figure 1), it has an area of 4 614.64 square km, it contains the country's 3rd and 4th largest municipalities (Castelo Branco and Idanha-a-Nova respectively), their population (about 83 thousand people) represents about 0.8% of the national resident population, what translates in the lowest populational density (17.9 people per square km) in Portugal, where most areas are farms, forests and pastures.

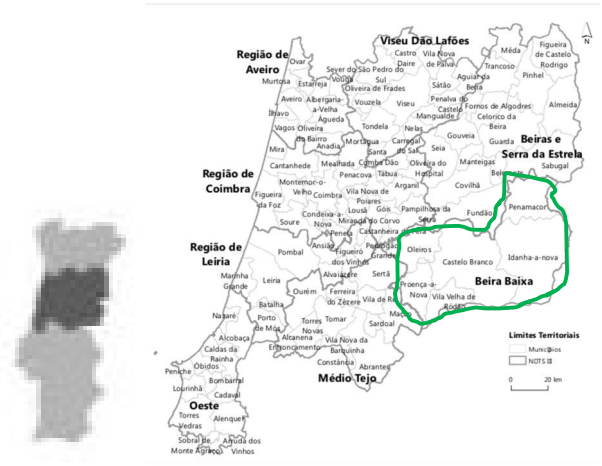

***Figure 1**. Region Centro of Portugal: Intermunicipal communities and municipalities. Source: INE (2017)*

According to CIMBB (2015) the municipality of Castelo Branco has development and social cohesion levels that go along with the national average, while the remaining municipalities of a rural profile (Idanha-a-Nova, Penamacor, Vila Velha de Ródão, Proença-a-Nova and Oleiros) have strong structural weaknesses, that are reflected in the demographic and socioeconomical indicators (aging index 279.5, total dependence index 67.7, illiteracy rate of 10.7%, activity rate of 59.6% and employment rate of 40.9%).

In the brief analysis of Integrated territorial development strategy (CIMBB, 2014), in what pertains to Local Sustainability (for example Local Agenda 21), we can indicate that this concept is still not well defined and clarified. So that, along with the population awareness, local leaders should also be made aware of it.

The main goal of this paper is to present the results of the themes and an index (to reduce the themes initially presented to the population) of the inquiry by questionnaire applied to the resident population, of legal age, of Beira Baixa, Portugal.

This questionnaire had as its goal to know the perceptions, the knowledge and attitudes of this population about SD and what areas there is a need to act for its implementation in the scope of the region where they reside. This questionnaire will be the basis for the development of a SIS, based in a process of involvement of the local population, to rural areas and intermunicipal communities and create an index for the various key areas of their region.

2. Methods

Initially we characterized CIMBB and its municipalities (Castelo Branco, Idanha-a-Nova, Penamacor, Oleiros, Proença-a-Nova and Vila Velha de Ródão) through bibliographic analysis, statistical data analysis (for example the Census information), spacial/geographical analysis (for example via Google Earth), among others. After that, we conducted a bibliographic analysis through local plans, programs and policies, with the goal of determining if CIMBB uses, effectively, local Sustainability Indicators and public participation (as indicated in the local Agenda 21) for decision making. To verify if people are sensible to the SD issues e how they consider it should be evaluated, for example through an IS, we used inquiry by questionnaire. Lastly, for the development of the SIS for the CIMBB based on a participation process, we made use of a bibliographic analysis, a questionnaire analysis, the conducting of interviews with key local players and "specialists" for the validation of the indicators and, finally, the collection of statistical data for the calculation of the indicators. At the same time, we intend to calculate an index (which allows the reduction of the themes initially presented to the population), to facilitate the understanding by the population for the key areas of their municipality.

So that the participation of the population could be identified and also their awareness of SD, an inquiry by questionnaire was applied (quantitative investigation) because it allows for a greater systematization, greater simplicity of analysis, and a faster

collection and treatment of the data (Carmo and Ferreira, 2015). Having in mind the size of the population, a sample by quota was defined (Coutinho, 2016) in the variables of municipality, gender and age group, to ensure the characteristics and the population's representability (for the different municipalities), with the goal of generalizing the results for the population being studied, its analysis will be quantitative.

In a brief way, the conception of the inquiry by questionnaire went through the following stages: a) bibliographic review; b) making of the first version; c) input by "specialists"; d) alteration of the first version after collection of input; e) pre-test; f) final version. The questionnaire is organized in five parts: SD Perception, SD Evaluation in municipality of residence, What is important to evaluate in the SD of your region in terms of the Goals for Sustainable Development (themes for the future IS for SD), Public participation and Characterization. It is made up of closed questions, most of them multiple choice and in the question about the themes for the IS a Likert scale was used (where 1 meant "not important" and 5 meant "very important").

The collection process went through some setbacks due to the characteristic of the population being studied, because it is an aged population (about one third), because of the size of the questionnaire and because of the goal of inquiring 1% of the population. The questionnaire was done between April and September 2018, in the municipalities that belong to the CIMBB.

A descriptive statistic, statistics tests relevant to the enquiry of relations between variables (e.g. Pearson's Chi-Square Test, Kruskal-Wallis test) and Exploratory Factor Analysis were conducted. Statistical analysis was performed using the SPSS 25.0 software.

3. Results and Discussion

The sample being studied is made up by 806 individuals, about 1% of the total resident population of legal age in the CIMBB, of which 504 (62.5%) reside in the municipality of Castelo Branco, 95 (11.8%) in Idanha-a-Nova, 49 (6.1%) in Penamacor, 76 (9.4%) in Proença-a-Nova, 52 (6.5%) in Oleiros and 30 (3.7%) in Vila Velha de Ródão. Over half of the respondents are female (52.4%), 35% is 65 or older and, opposite of this, almost 7% is in the 18 to 24 age bracket. Of the respondents, 99% is of Portuguese nationality and 82.9% was born in the district of Castelo Branco, being the district of Lisbon the second most indicated (3.8%). Almost one third of the respondents has a college degree, 46.2% works for another, mostly in the tertiary sector (69.5%), but the primary sector represents 14.5% of the respondents. Worthy of note is that 34.4% of the respondents is retired and almost 2% of the respondents "has no qualifications", of these Vila Velha de Ródão has the highest percentage (10%), followed by Penamacor (8.2%). About 93% resides in the CIMBB longer that 5 years. When we questioned about their subjective income, 52.4% the respondents rated their income as "reasonable" and almost 26% rated it "difficult".

Regarding SD Perception, Pearson's Chi-Square Test confirmed the existence of a statistically significant association between the variables "Have you heard of the term sustainable development?" and "municipality" ($p < 0.001$). It appears that in the municipality of Castelo Branco only 7.9% say they have never heard of SD while in the remaining municipalities that percentage is always equal to or higher than 13.2%. It should be noted that in the municipality of Vila Velha de Ródão the percentage of respondents who claim to have never heard of SD reaches 33.3%.

Respondents were asked to indicate the main themes associated with the SD. Figure 2 shows that the subjects of the economic and environmental scope are the most mentioned by the respondents, highlighting the items "Responsible consumption" and "Nature conservation".

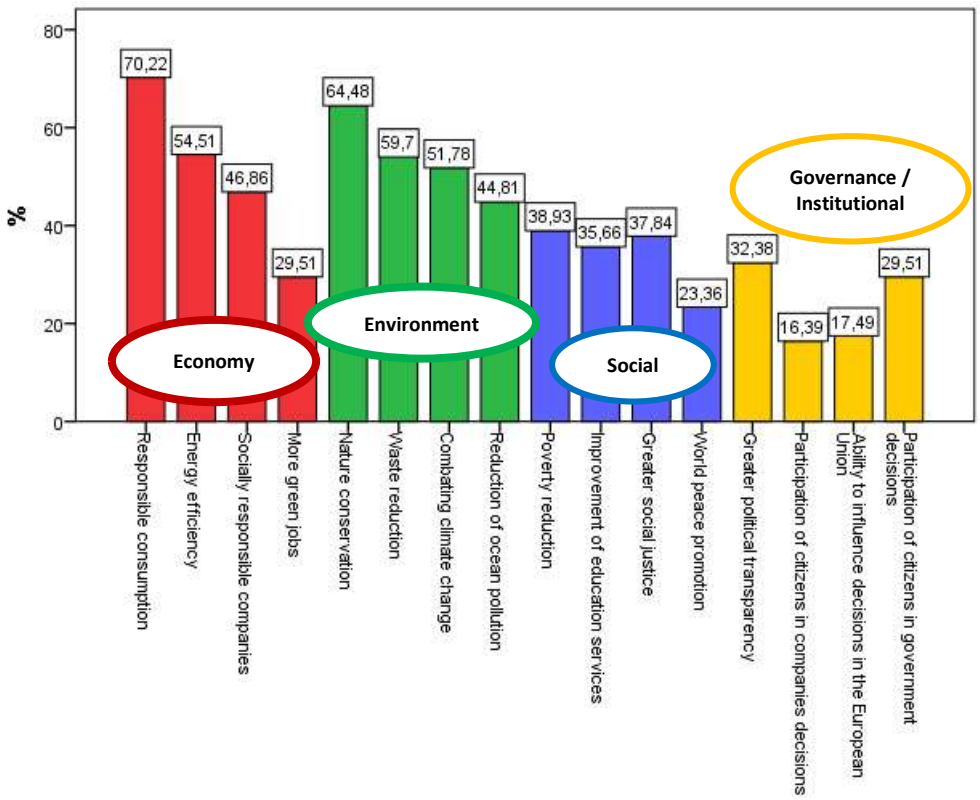

Figure 2. *In your view, what are the main themes associated with Sustainable Development*

An index was created that resulted from the sum of the scores obtained in the items that integrated each of the dimensions under analysis (economy, environment, social and governance/institutional), referring to the themes associated with the concept of SD and whose basic descriptive statistics are found in the Table 1. It is noteworthy that the environmental dimension is the most valued by respondents, followed by the economic dimension.

Table 1. *Basic Descriptive Statistics for the main themes associated with Sustainable Development - Environmental, Economic, Social and Governance/Institutional dimensions*

	N	Minimum	Maximum	Mean	Std. Deviation
Economy	**732**	**,00**	**4,00**	**2,0109**	**1,26724**
Environment	**732**	**,00**	**4,00**	**2,2077**	**1,46665**
Social	**732**	**,00**	**4,00**	**1,3579**	**1,41915**
Governance/Institutional	**732**	**,00**	**4,00**	**,9577**	**1,27465**
Valid N (listwise)	**732**				

In a subsequent phase, the existence of statistically significant differences between the scores obtained in the different dimensions for the municipalities under study was investigated (Figure 3). The Kruskal-Wallis test identified statistically significant differences for the Environmental (p=0.008) and Social (p=0.020) dimensions and the most evident differences are detected between the municipalities of Oleiros and Penamacor.

A possible reason for this situation, different visions of environmental dimension, is that in Oleiros, the business and transformation activity is strongly connected to forest exploration, and also the effort in the production of renewable energy (that can easily be seen in the wind power farms). On the opposite side, Penamacor has been concentrating in the tourism sector (landscapes, rurality and cultural heritage). Besides that, the Malcate Range Natural Reserve covers part of this municipality, and it is largely promoted as a protected habitat area for the Iberian lynx (CIMBB, 2015).

Regarding the social dimension, even though the rural municipalities have strong structural weaknesses, that are reflected in the demographic indicators, Penamacor has one of the highest values among the CIMBB (aging index 636.7, total dependence index 86.8 and illiteracy rate of 20.2%). Probably, and having in mind these indicators, the population considers that the social dimension should be one of the most valued, when associated with the SD concept (for example, education services and poverty reduction).

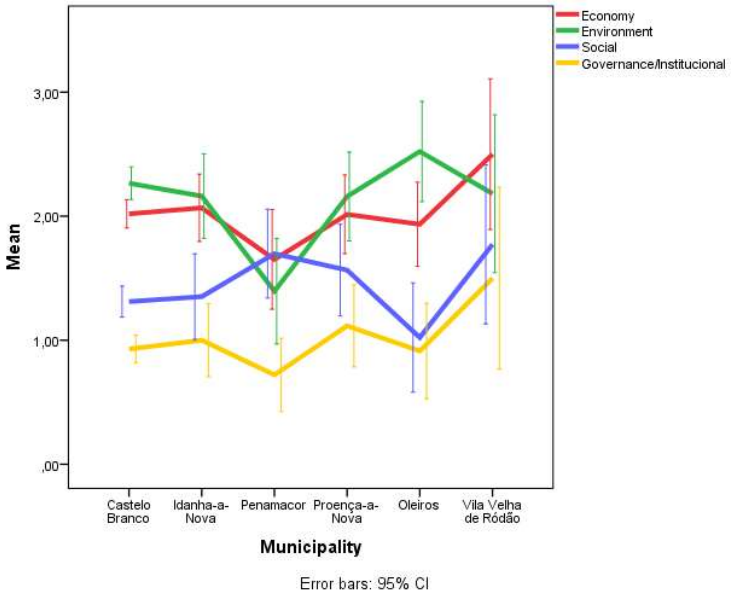

Figure 3. *Mean scores and error bars (95%) for the main themes associated with Sustainable Development - Environmental, Economic, Social and Governance/Institutional dimensions*

In the second part, Evaluation of the SD of the municipality of residence, we asked the residents about the public policies, associated with the SD, which they considered most important for their municipality with regard to the social, environmental, economic and governance/institutional areas (Figure 4). The items that stand out are “Improve public services” and “Ensure the good state of the environment” which are marked by 65.37% and 62.15% of respondents, respectively. On the opposite side, to “Increase public safety” (30.34%) is the least valued.

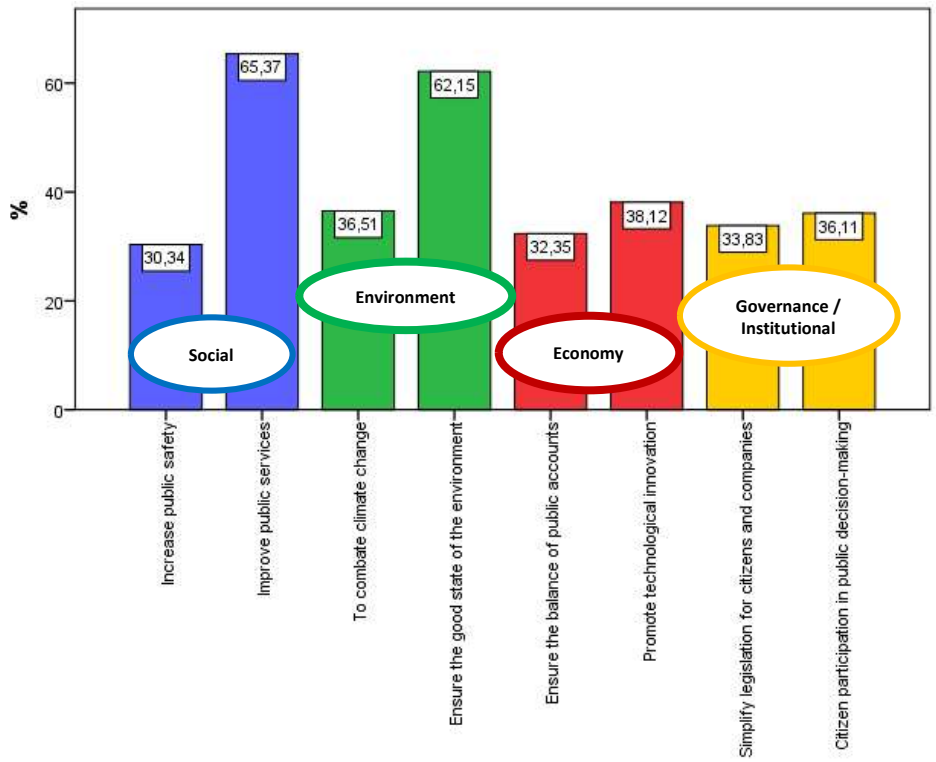

Figure 4. *In terms of public policies, what are the social, environmental, economic and governance areas associated with the SD that you consider most important in your municipality?*

An index was created that resulted from the sum of the scores obtained in the items that integrated each of the dimensions under analysis (economy, environment, social and governance/institutional), referring to the public policies that are considered most important in the municipality of the respondent and whose basic descriptive statistics are found in the Table 2. It is noteworthy that the environmental dimension is the most valued by respondents, followed by the social dimension. Again, coherently with previous results, the environmental dimension is an important one in CIMBB.

Table 2. *Basic Descriptive Statistics for the Environmental, Economic, Social and Governance/Institutional most important public policies*

	N	Minimum	Maximum	Mean	Std. Deviation
Social	745	,00	2,00	,9570	,71149
Environment	745	,00	2,00	,9866	,76012
Economy	745	,00	2,00	,7047	,70998
Governance/Institutional	745	,00	2,00	,6993	,74654
Valid N (listwise)	745				

These results are different when we compare with the First Major Inquiry on Sustainability in Portugal, and by dimensions, the social dimension, in its entirety, is the most represented area, the environmental and economic dimension seem relatively interconnected and with very similar results, the least valued is the governance/institutional dimension (Schmidt et al., 2016).

The existence of statistically significant differences between the scores obtained in the different dimensions for the municipalities under study was investigated (Figure 5). The Kruskal-Wallis test identified statistically significant differences for the Environmental ($p<0,001$) and Economy ($p = 0.032$).

Vila Velha de Ródão has in the paper industry its greatest anchor. This municipality has the Tagus river as its Southern border and the Northern border is one of the Tagus' affluents, the Ocreza river (CIMBB, 2015). In these last few years, there has been an increase in the pollution of the Tagus river and of its affluents, probably caused by this industry's expansion in 2011. To heighten this matter, the increase of the weather draught, in these last few years, has caused a lowering of the rivers' water

flow. The forest fires that happened in 2017, affected mostly the territories of Oleiros (it destroyed over 6 000 hectares) and Proença-a-Nova. It is normal to see a citizen concern with environmental preservation, in these municipalities, where the respondents valued more the public policies of the environmental area over the economic area.

Regarding the economic dimension, Idanha-a-Nova and Penamacor present marked weaknesses in the economic indicators (for example the lowest employment rate and highest unemployment rate) in the CIMBB. In general, the respondents tend to value the economic area compared to the rest of the rural municipalities.

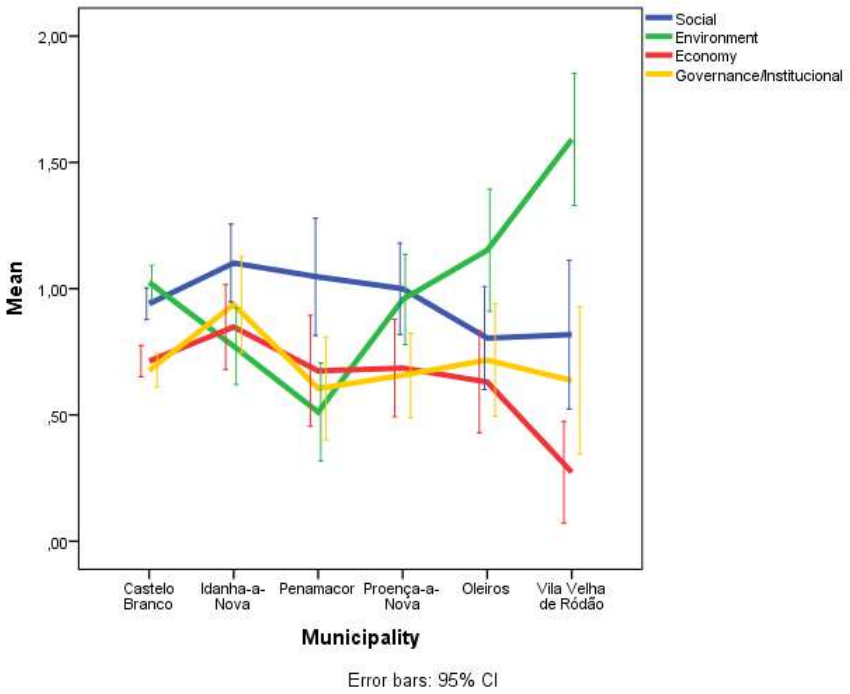

Figure 5. *Mean scores and error bars (95%) for the Environmental, Economic, Social and Governance/Institutional most important public policies*

When we asked about the sectors that should be invested in the municipality, Education and training (76%), Renewable energy (58%) and Environment (58%) constitute the major investment in the region according to the respondents. When we compare these results with the First Major Inquiry on Sustainability in Portugal (Schmidt et al., 2016), the appointed sectors by the residents of CIMBB differ substantially from the national average (Education 46%, Renewable Energy 37%). The Forests sector was chosen by 49% of the CIMBB residents while it was only 6% in the national inquiry. This might be due to the rural profile of the CIMBB and because it is a region in the interior of Portugal, with characteristics that are very distinct from the national average.

In the question related to the IS, when analysing the existence of an association between the question “Have you already heard of an IS, as an instrument to evaluate and report the SD” and the municipality of the respondents, we observe that, for all municipalities, the percentage of respondents who claim not to have heard of an IS is higher (56.8%). Although we did not detect a statistically significant association between these variables, it is observed that the percentage of respondents who are unaware of the IS is higher in Vila Velha de Ródão (76.9%) and lower in Idanha-a -Nova (52.3%) and Castelo Branco (54.9%).

Respondents were asked to indicate the reasons that justify the development of an IS in order to contribute to the improvement of the management of environmental, economic, social and institutional performance, and to make the processes of systematization and exchange of information more efficient on environment and SD. The reason most highlighted by respondents was “Disseminate information to the general public on SD”, as shown in Figure 6.

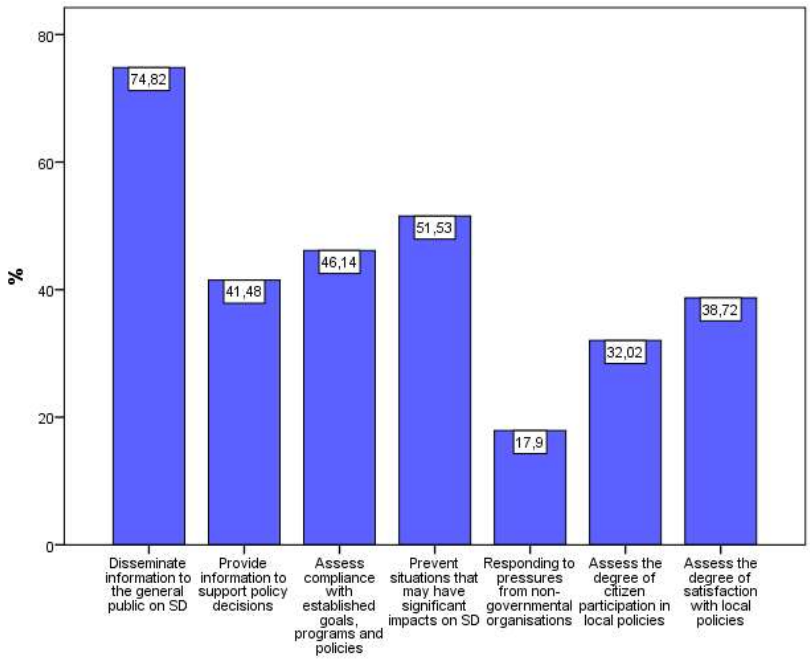

Figure 6. *Reasons for the development of an IS*

We asked if in the development/designing of a IS that allows the evaluation of the SD, the choice of the indicators should have in consideration the "opinion" of the citizens (for example, through public participation) and a large majority (74.2%) of the respondents considers that it should take into consideration the public participation, but about 21% refers that they "don't know". Besides public participation, we asked if they would like to directly participate in the discussion around the choosing of indicators (for example: unemployment rate, quality of life, number of tourists, greenhouse effect emissions, among others) to evaluate the improvement of their municipality's development and a little over half (55.3%) of the respondents would like to directly participate around the choosing of the indicators.

The challenge for local authorities is to mobilize the community in order to promote environmental citizenship (Mascarenhas et al., 2014), that allows the development of IS at a local level, still under development in Portugal (Moreno Pires and Fidélis, 2015), especially in this community of singular characteristics.

Respondents were also presented with a list of 40 themes that could be included in the SIS and asked to scale from 1 to 5 (where 1 is nothing important and 5 is very important) to assess the importance of each theme for their municipality. The most valued themes by respondents are Health, Education, Forests, Air quality and Employment. Note that these items tend to have lower standard deviations, reflecting agreement by the respondents. On the other hand, the least valued themes by respondents are "Marine and coastal environment" and "Fisheries" (furthermore, these themes showed the greatest standard deviations).

In a recent study by Mascarenhas et al. (2015), about the selection of sustainability indicators for territorial planning in the Algarve region, based in a participation process, the initial group of 49 indicators was reduced to 15, this reduction implies a loss of information that can be relevant for the territory. That is why other authors propose a selection of key-indicators that represent a larger group of indicators, to communicate with the leaders and community.

Regarding the communication of information on sustainability, despite the inherent dangers of the over simplification in complex areas, the use of the index (compound indicator) makes it easier to understand and interpret the indicators, namely for the population, as well as its usefulness in the gathering of regional data, making it easier to compare the different regions (Huang et al., 2015; Mascarenhas et al., 2015; Morse, 2016; Shields et al., 2002; Tanguay et al., 2010). Having in mind the unique characteristics of this region, we have chosen not to group the themes in the "traditional" dimensions (Environmental, Economic, Social and Governance/Institutional), since some of the themes can be included in more than one dimension.

In order to identify dimensions, these items were submitted to an Exploratory Factor Analysis. The factor analysis techniques were reapplied to the 40 items and obtained a value of 0.958 for the KMO and a value of p<0.001 correlated to the Bartlett Test, indicating that the applied analysis model is suitable for the sample under study. For the axes retained we resorted to the Analysis in Principal Components and for the determination of the number of axes to retain we used Cattell's Scree Plot. The six dimensions retained explain 68.7% of the total variance. After the Varimax rotation we obtained the distribution of the items among the factors shown in Table 3. In order to facilitate the analysis, the factors loading lower than 0.3 were retained.

The obtained factor structure evidences that Factor 1 comprises items related to **Social** dimension, Factor 2 regards **Immaterial** questions, Factor 3 focuses on the information regarding the **Environment**, Factor 4 focuses on the **Economy**, Factor 5 relates to **Rural** aspects and factor 6 to **External Aspects**.

Table 3 *Rotated Component Matrix after Varimax Rotation*

	Component					
	1	2	3	4	5	6
Health	,777					
Employment	,753					
Education	,742					
Housing	,709	,343				
Culture	,687			,329		
Justice	,638			,381		
Safety	,608	,330		,354		
Tourism	,523			,391		
Industry	,488			,377	,316	
Entrepreneurship	,476	,427		,456		
Transportation	,436			,335	,335	
Freedom	,312	,827				
Integrity		,813				
Happiness	,336	,782				
Solidarity	,409	,749				
Spirituality		,669		,312		
Receptivity to change		,600		,493		
Equality	,323	,477	,314	,447		
Climate change			,779			
Ozone layer			,749			
Air quality			,727			
Waste			,587		,354	
Soils			,549			,305
Environmental impact assessment			,538	,415		
Fresh water	,329		,529			
Noise			,515			,419
Natural and technological risks			,451		,424	
Investment and expenditure		,312		,703		
Socio-economic developments	,382			,662		
Public participation				,642		
Consumption Patterns			,404	,611		
Governance	,446			,586		
Research and development				,565	,347	
Population		,490		,525		
Agriculture					,675	
Forests	,318		,383		,605	
Nature and biodiversity	,381		,439		,542	
Energy			,422	,302	,519	
Fisheries						,821
Marine and coastal environment						,808

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 8 iterations.

As measure of internal consistency, we used Cronbach's Alpha (Table 4), obtaining good levels ranging from 0.754 (External Aspects) and 0.969 (Full Scale).

Table 4. *Cronbach Alpha in respect of all items in question and respective subscales*

Scale	No. (items)	Cronbach's Alpha
FULL SCALE	40	0,969
Social	11	0,932
Immaterial	7	0,919
Environmental	9	0,886
Economical	7	0,900
Rural	4	0,866
External Aspects	2	0,754

On an assessment of results obtained, we proceeded to the calculation of the scores observed for each of the dimensions. In order to make the results comparable, the scores were considered by the number of items that integrate each dimension, therefore assuming as a minimum value of 1 and a maximum value of 5. The missing data was substituted by the average of the corresponding dimension. Table 5 contains the basic descriptive statistics for each of the dimensions obtained.

Table 5. *Basic descriptive statistics for the scores obtained in the dimensions under analysis*

Dimension	N	Minimum	Maximum	Mean	Std. Deviation
Social	571	1,00	5,00	4,1364	,78911
Immaterial	550	1,00	5,00	3,9379	,87841
Environmental	540	1,00	5,00	4,0634	,75223
Economical	574	1,00	5,00	3,8661	,80551
Rural	611	1,00	5,00	4,2705	,80099
External Aspects	516	1,00	5,00	2,9138	1,34591
Valid N (listwise)	381				

It is observed that "Rural " and "Social" are the dimensions respondents value the most which means that having in mind the unique characteristics and specificities of this region, the importance of rurality, the population's concern about their demographic and socioeconomic fragilities are evidenced.

We wanted to know if there were differences in the scores obtained in the dimensions under analysis depending on the municipality of the respondents. (Figure 7). The Kruskal-Wallis test allowed the identification of statistically significant differences for the dimensions "Immaterial" ($p = 0.008$) and "External aspects" ($p = 0.019$). Interestingly, it is the respondents from the municipality of Penamacor who tend to attribute higher scores to the "Immaterial" dimension and lower to the "External Aspects" dimension.

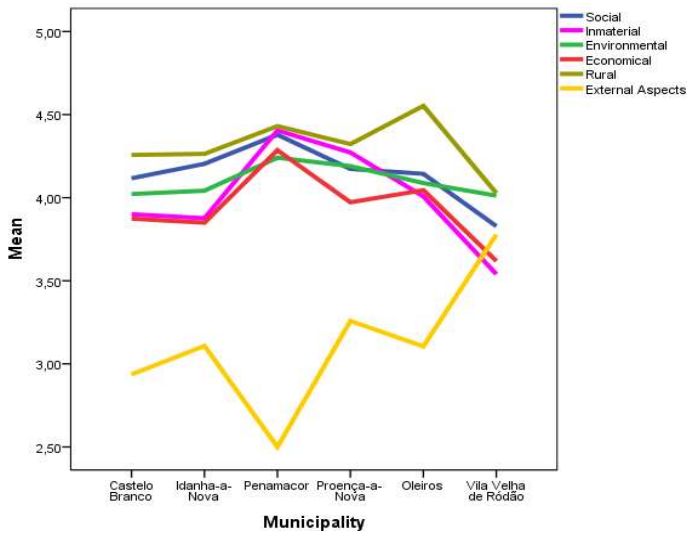

Figure 7. *Mean scores for the dimensions under analysis according to the respondent's municipality*

The media (55.9%), the official municipality Newsletter (34.9%) and the information that is posted in public places (32.4%) were the main ways in which the population indicated that they would like to have access to the SD indicators of their municipality. Again, the media has an important place in the communication of the indicator results. It is necessary to broadcast the use of sustainability indicators to the population, the media, to do that the use of online tools created for that purpose, can be a solution, among others, and that way, the information exchange will increase the awareness both of the global and of the local dimensions (Mascarenhas et al., 2014; Morse, 2015; Selsky and Parker, 2005).

There are many platforms that make available online information, but only some allow access to their members. And the majority of the platforms do not have the population as their target audience (do not have a teaching nature), which makes the understanding and interpretation of the results of their municipality's local sustainability harder.

Beyond accessibility and communication, through the media and online platforms, it is crucial that the results are understandable to the community, especially in the rural areas, with an aged population, which has as a characteristic a strong asymmetry with the coastal area of the country.

In order to increase sensitivity towards the importance of the transition to sustainability, so that the municipalities and intermunicipal communities can incorporate and strengthen the implementation of indicators in their policies, in an effort to make those municipalities more sustainable for the current and future generations (Michael et al., 2014; Pupphachai and Zuidema, 2017).

4. Conclusions

The main goal of this paper was to develop an index to facilitate the understanding by the population for the key areas for a intermunicipal community and their municipalities, composed of small municipalities and rural areas, based in public participation. These are very import regions for Europe, with singular characteristics, because this is where you find the majority of the resources and natural areas.

From the research conducted, it was possible to observe that the practice of local sustainability is already well promoted as well as its progress. Many of the systems are developed by scientists or researchers and made available to the municipalities in platforms. However, the large majority of the indicators systems, are created for large cities, which can hardly be duplicated in rural municipalities because of their specificities, very different from large cities. As a major obstacle to the mentioned systems, it is impossible to predict all the characteristics of the municipalities, the systems are created in a generic fashion, where public participation is null or non-existent, which makes it harder for the population to get involved in matters of local sustainability.

Results showed most of the respondents had already heard of SD. However, there is a statistically significant difference between the environmental and social dimensions, in the themes associated with SD and between environmental and economical dimensions, in Public policies. The most chosen themes by the population of the CIMBB are associated with the environmental and social themes (e.g. Forests, Air quality, Nature and biodiversity, Agriculture, Education and Health). The Exploratory Factor Analysis has shown an important component for this region, the "Rural" component. Beyond the traditional themes/indicators, these results show the importance of incorporating "Immaterial" themes to the IS. Specially, in these rural areas, where values and traditions are still very much a part of the community.

It is essential that each region develops its own SIS, based in a participation process and having in mind its specificities. But this system should allow a comparison both at a regional and a national level, for example through the definition of key-indicators. It is, also, essential its broadcasting via the media and online platforms with the goal being the clarification of the SD and it is paramount to communicate the results, in an accessible and understandable way.

As a future development, this proposal will be presented to the local CIMBB leaders and to specialists of this area, through interviews and focus groups. And, lastly, given the received input, we will improve the Sustainability Indicator System and to

convince the local CIMBB leaders that it is important incorporate and strengthen the implementation of the indicators in their policies.

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Strengthening early stage decision-making by process-integrated sustainability assessment in local infrastructure transitions

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Abstract

Urban infrastructures are vital for the distribution and the exchange of energy, matters and information as a basis for the well-being of societies. How infrastructures are designed and managed has strong impacts on their sustainability, including performance, resilience, social justice, economic viability, resource consumption and climate mitigation. Existing infrastructures are deeply embedded in socio-technical regimes. Currently, modernisation needs, sustainability concerns and climate change as well as technological advances especially in ICT drive a transformation of such socio-technical infrastructure systems. This could open up space for improving infrastructures' sustainability and contributing to sustainability transitions, e.g. by introducing coupled socio-technical infrastructure systems.

However, such transformation does not necessarily lead to more sustainability: While sustainability gains importance in infrastructure planning, there is little empirical information on sustainability effects of coupled systems. Navigating sustainability transitions requires continuous social learning about intended actions and their effects, taking systemic synergies and trade-offs as well as diverse actors' perspectives and needs into account. Tools for a collaborative and systematic consideration of sustainability effects in early planning phases are hardly applied or discussed. Against this background, we have developed and tested a tool for in-process assessment to support sustainability-oriented decisions in early planning stages where there is still a great deal of scope for decision making. The tool is based on a sustainability concept developed for coupled infrastructure solutions and includes 26 indicators related to a) performance and resilience, b) social justice and economic viability, c) resource consumption and emissions. To verify the relevance and applicability of our assessment approach we applied and tested the tool in (i) a Delphi-based online survey and (ii) action-oriented research in local case studies, both embedded in the German context.

Our general findings show that coupled infrastructures can deliver services in a more sustainable and resilient way, e.g. by reducing or substituting primary energy demand and greenhouse gas emissions. However, not all novel solutions necessarily improve sustainability. Therefore, adapted regulations and targeted local process management that fosters collaboration with diverse actors are required to guide the ongoing transformation towards more sustainability. In real-world case applications our approach has proved to be a flexible tool to reflect on and integrate different sustainability aspects and perspectives considering short-term and long-term effects as well as the identification of critical aspects.

Hence, the proposed sustainability check can contribute to ongoing planning and discussion processes by helping local actors to elicit potentially benign and disadvantageous effects. We draw conclusions regarding the application of process-integrated sustainability assessment for informed decision making in the field of infrastructure planning and management. As such, our sustainability check provides a new process tool to facilitate collaborative and systemic reflexivity and assessment.

Keywords: informed decision making, coupled infrastructures, sustainability assessment, sustainability transition, transformation, action research

1. Introduction: Why assessing sustainability performance of local infrastructure transformations?

Infrastructure systems fulfil essential functions and services of great public interest, e.g. providing energy, water, mobility and communication as well as managing waste and wastewater. Currently, digitisation, urbanisation, demographic change as well as climate mitigation, climate adaptation and energy transition including nuclear and coal phase-out put infrastructure under great pressure and require fundamental changes – for example from centralised to decentralised or from passive to smart infrastructure (Loorbach, 2010; Malekpour et al., 2015; Markard, 2011). New technical possibilities of information and communication technologies (ICT) and their proliferation accelerate the dynamic of change as they make existing services more user-convenient or even completely new services available. In all these changes, infrastructures and their services need to ensure efficiency, supply security and social justice.

In this context, the transformation of existing infrastructure systems offers great potential to contribute to sustainability transitions (Frantzeskaki and Loorbach, 2010; Hölscher et al., 2020). Infrastructures are part of socio-technical systems, which next to the physical artefacts and technologies also include societal expectations and behaviours, market patterns and institutional norms and rules (Frantzeskaki and Loorbach, 2010; Moss, 2014) and are above this connected to the environment as a resource or as a sink. This is why infrastructures are also referred to a socio-eco-technical systems (Grabowski et al., 2017). The transformation of infrastructure systems means to create radically new socio-technical systems through the co-construction of social and technological changes, including policy ambitions, social practices, institutional arrangements, knowledge and values (Monstadt and Coutard, 2019). Innovative infrastructure solutions can contribute to such transformation by leading to new market structures, new demands, social innovations or new forms of interaction between interest groups (e.g. ‘prosumers’) (Frantzeskaki and Loorbach, 2010). This could open up space for contributing to sustainability transitions.

Great hopes are placed specifically on coupled infrastructure solutions as a way to achieve more sustainability in the delivery of infrastructure services. In policy-oriented debates on resource efficiency, resilience and ‘smart’ development, coupled infrastructures are put forth as a way to leverage previously unexploited synergy potentials interacting resource flows, technological interconnections, institutional interactions and financial interdependencies between different infrastructure domains (Monstadt and Coutard, 2019). They have thus the potential to generate ecological, social and economic benefits such as resource efficiency, maximising returns on investment and more citizen-focused approach to service provision (Anderies et al., 2016; van Broekhoven and Vernay, 2018).

However, the transformation of infrastructure systems is complex and contested. Once in place, infrastructures are hard to change due to sunk costs, vested interests, societal expectations and existing regulatory frameworks (Frantzeskaki and Loorbach, 2010; Schiller, 2010). Especially the coupling of different sectors counters existing regulatory frameworks and implies the involvement of a larger number of actors and interests (Monstadt and Coutard, 2019). Overturning existing regimes will inevitably cause conflict, resistance and chaos, and some innovations might imply controversial social and economic consequences (e.g. geographical shifting of industries and jobs, further concentration of wealth) (Bulkeley et al., 2014). In addition, such transformation does not necessarily lead to more sustainability. While sustainability gains importance in infrastructure planning, there is little empirical information on sustainability effects of coupled systems. Given the complexity of socio-technical infrastructure change, questions also concern the implications for planning, management, financing and using coupled infrastructures for sustainability. The transformation of infrastructure systems for sustainability transitions thus requires continuous social learning about intended actions and their effects, taking systemic synergies and trade-offs as well as diverse actors’ perspectives and needs into account.

2. New opportunities and challenges for sustainability transitions through coupled infrastructures

When it comes to the discussion of novel interconnections of different kinds of infrastructures, often the term sector coupling is applied. The term is widely used to describe novel and innovative interconnections of the energy sector with other sectors – mainly for the purpose of improving energy efficiency (Robinius et al., 2017). We apply a more general and broader understanding of coupled infrastructures: infrastructures are coupled or interconnected generally when an exchange

relationship is established between any infrastructure sectors or their sub-systems: e.g. when excess wind power is being used to produce synthetic hydrogen, when a waste water treatment plant provides energy in Demand-Side Management settings to help stabilising the power grid (see below case “Rödental”) or when digital, app-based solutions enable the intermodality between different means of transportation such as busses, carsharing, ridesharing and rental bikes (see below case “Augsburg”). This relationship can include the exchange of energy, maters or information, needed to provide infrastructure services. According to our understanding, no real unilateral or mutual dependency (cf. Rinaldi et al., 2001) is required to speak of coupled infrastructures.

Coupled infrastructures challenge and change existing socio-technical infrastructure systems in various ways. Technical solutions, the management and the way infrastructure services are provided and used can be changing fundamentally when two previously independent systems are functionally coupled. Systems become technically more complex and new organisational challenges have to be solved. New actors enter the scene, new hierarchies emerge, responsibilities have to be redefined and redistributed, new job profiles have to be created. Even the traditional separation of suppliers and users is no longer obvious and may not always be possible in the future as homeowners become electricity suppliers or platforms such as Airbnb or Drivy turn the provision and use of private apartments or vehicles into virtual infrastructures accessible to all.

Coupled infrastructures are not a new phenomenon. The goals pursued and the design of the interconnections are usually related to social priorities and the technical possibilities of the respective time. About 100 years ago, the transportation of people was revolutionised by the introduction of electrically powered trams, which introduced a new means of road transport. Today, saving energy, reducing greenhouse gas emissions or stabilizing power grids are important goals that trigger new types of connections between infrastructures. What is certainly new, however, is the great dynamic of change.

Most of the new coupled infrastructures are aimed at optimising parts of existing systems. Often, this optimisation is not carried out within the established system but is accompanied by a system change implying technical innovation, new organisational structures and consequences for the user of the services provided. This sort of radical change we address with the term of transformation, which refers to the changes embodied for possibly achieving sustainability transitions (Frantzeskaki and Loorbach, 2010; Hölscher et al., 2018). This transformation requires guidance on the path of transition to sustainability. Informed decisions need knowledge about different sustainability effects and tools to make them visible.

The sustainability of infrastructure is thus a key challenge. It is no longer sufficient for infrastructures to provide their services in satisfactory quality and stable conditions. Health, social participation, nature and environmental protection, climate protection and resource conservation have become increasingly important. For infrastructures, this means that they have to meet multiple requirements – their services should be provided in the most resource-saving manner possible and with the least possible side effects, while at the same time remaining affordable and guaranteeing security of supply.

These changes bring with them numerous new opportunities but also challenges. Infrastructures that are built or adapted today are important and persistent components in a long process of societal change. They must therefore be critically scrutinized to determine whether and to what extent they contribute to societal goals and particularly to sustainability in the long term. The planning, implementation and operation of infrastructures must be constantly measured against the fulfilment of sustainability goals. Local politics and infrastructure operators are called upon to actively shape the change. This is the only way to harness the potential of the new opportunities and manage the uncertainties and risks associated with infrastructure coupling to help the sustainability transition.

But the literature hardly provides any information about sustainability effects of coupled infrastructures, i.e. whether such systems are also economically efficient, socially just and resilient. The lack of easily accessible tools to assess potential sustainability effects of coupled infrastructures further complicates early planning and decision-making phases for infrastructure innovation. The danger is that, especially as coupled infrastructures are prevalent in policy discourses, there are unintended side-effects and coupled infrastructures miss opportunities for contributing to sustainability transitions. What is especially needed is a practical tool that allows practitioners to collaboratively and systemically reflect about and assess the sustainability of coupled infrastructures.

This article deals with this gap. We present results from ongoing work that developed and tested an easily accessible tool for the screening of sustainability effects of coupled infrastructure solutions. This tool provides guidance on assessing sustainability effects of coupled infrastructures through 26 different sustainability indicators. We tested this tool through (i) a Delphi-survey based sustainability assessment of 14 hypothetical cases by over 100 experts and (ii) transformative research in two real case applications of the assessment tool. Based on these findings, we draw conclusions for the ongoing work directed towards the further development of the tool particularly for the application in real world planning situations.

The contents of this article are based on work carried out in two projects under the headline "Transformation towards sustainable, coupled infrastructures" funded by the German federal Environment Agency (Umweltbundesamt FKZ 3715 48 102 0 and FKZ 3719 15 103 0). Detailed results are available as reports in the Publication series “UBA Texte” (Hirschnitz-Garbers et al., 2020a, 2020b; Hölscher et al., 2020; Olfert et al., 2020). An additional guideline for municipal actors will be available by summer 2020 (Olfert et al., coming in 2020).

3. Methods: developing and testing sustainability check for planned infrastructure solutions

Developing the sustainability check

Information about the sustainability effects of planned infrastructure development is an important basis for informed decision-making in the development of sustainable infrastructure solutions. The aim should be to generate relevant and actionable knowledge for decision-making or implementation processes at an early stage – if possible before "preferred options" have created the first path dependency without being tested. For this purpose, we propose a sustainability check that maps a broad spectrum of sustainability impacts of coupled infrastructures and shows where the possibilities and necessities for steering interventions by local politics, planning and operators are. The check was developed specifically for coupled infrastructure solutions. It is aimed at municipalities and infrastructure operators. We tested the sustainability check in a Delphi-based assessment with over 100 experts in 14 exemplary hypothetical cases and two real world cases of ongoing infrastructural change in Germany.

The sustainability check comprises 26 sustainability indicators along four major topics. These indicators are partially applied looking separately at the coupled sub-systems, thus differentiating effects for involved sub-system A and B (marked A/B):

"Performance": influence of the coupling on the performance and operation of the infrastructure. It includes three indicators: (1 A/B) performance in the sense of *productivity*, (2 A/B) *technical complexity* in the coupled technical system and (3 A/B) *organisational complexity* which in the assessment are applied separately for the subsystems involved.

"Resilience and security of supply": reliability of performance and supply security in the context of external stressors, including climatic extremes. Eight indicators address aspects of engineering resilience in particular: (4 A/B) *susceptibility* to external stressors, (5 A/B) *dependencies* between sub-systems coupled, (6) *redundancy* (e.g. with regard to raw materials and plants), (7) *modularity* of the infrastructure system (in the sense of local/regional options for solving faults), (8) *buffering capacity* to compensate for faults, (9) *adaptability/reversibility* of the coupled infrastructure system, as well as (10) *time* and (11) *costs for restoring functionality* after faults.

"Social justice and economic viability": influence of coupled infrastructures on the price and costs of providing and using infrastructure services- Four indicators describe the selected effects: (12) *quality and quantity* of the infrastructure service, (13) *user side investment needs* describing technical accessibility and possibly required follow-up investments, (14) *user fees* for the infrastructure services as well as (15) *economic viability* for operators.

"Resource efficiency and conservation": effects of coupled infrastructure solutions on natural resource use and environmental impacts. Eleven indicators describe a wide array of potentially relevant resource use and impact categories: (16) *primary energy demand* excluding renewable energy, (17) *total energy demand*, (18) *raw material demand*, (19) *demand for critical raw materials*, (20) *land consumption*, (21) *water consumption*, (22) *greenhouse gas emissions*, (23) *emission of other hazardous substances* relevant for human health and the environment, (24) *noise generation*, (25) *waste generation*, (26) extent of *harmful soil changes*.

We operationalised the indicators by translating each criterion into case specific questions and providing a qualitative scale providing trend-information from “not suitable” (-2) to “very well suited” (+2) (Table 1, Olfert et al., in review). This work was accomplished in an intensive iterative process involving test persons selected from science and infrastructure management in several stages.

Table 1. *Five-stage assessment scale.*

Rating		Context-related examples
strongly negative	(–2)	not suitable – e.g. significant increase in costs, significant increase in raw material demand, etc.
slightly negative	(–1)	fairly unsuitable – e.g. slight increase in costs, rising demand for raw materials, etc.
neutral	(0)	no change compared to traditional, non-coupled systems
slightly positive	(+1)	fairly well suited – e.g. slight cost reduction, tendency to decrease raw material demand, etc.
strongly positive	(+2)	very well suited – e.g. significant cost reduction, significant decrease in raw material demand, etc.

Applying the sustainability check with hypothetical cases

We then tested the sustainability check via a Delphi-survey based assessment involving more than 100 Experts with 14 hypothetic cases of innovatively coupled infrastructures from the sectors water, sewage, energy, transport, waste and ICT (see Table 2) organised in seven groups (two cases each group).

Table 2. *14 hypothetical cases of coupled infrastructures.*

Nr.	**Case name**
Cases panel 1 (Heat from waste water)	
1.1	Central heat and waste heat recovery from waste water
1.2	Decentralised heat generation in wastewater networks
Cases panel 2 (Waste heat/solar heat)	
2.1	Feed-in of (industrial) waste heat in heat networks
2.2	Feed-in of solar thermal energy into heating networks
Cases panel 3 (Control of energy networks)	
3.1	Control of hybrid energy networks on a local/regional scale
3.2	Virtual power plants - Swarm-controlled operation of generation plants for power load regulation
Cases panel 4 (Power grid stabilization)	
4.1	Power grid stabilisation through integration of accumulator-based electric vehicles
4.2	Induction-based charging of vehicles in areas of flowing traffic (e.g. road junctions)
Cases panel 5 (PtH / PtL)	
5.1	Power to heat (PtH) - storage of excess electricity in heating networks
5.2	Power to Liquid (PtL) - electrolysis of renewable electricity into hydrogen

Cases panel 6 (Fleet management)	
6.1	App-supported management of virtual vehicle fleets (merging private vehicles in a car sharing model)
6.2	App-supported fleet management in free-floating car sharing
Cases panel 7 (Sewer network management)	
7.1	Intelligent rainwater management
7.2	Controlled sewer congestion - management of congestion situations in the sewer network in combination with multifunctional open spaces in urban areas

Involved experts where thoroughly selected to ensure best quality of assessment and considering the perspectives of infrastructure operation, infrastructure planning, related public administration and infrastructure research. Survey participants from these fields where involved to avoid professional bias in the assessment. The Delphi-survey was implemented in two rounds with provision of anonymised interim analysis after Round 1 (Figure 1).

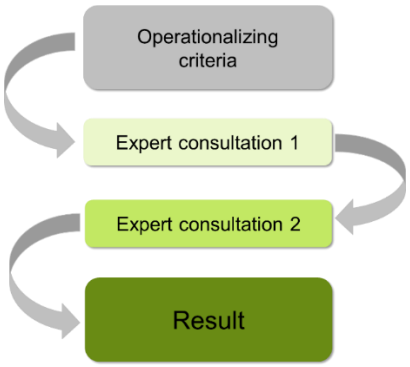

***Figure 1**. Schematic process of a Delphi-based consultation.*

Applying the sustainability check for infrastructure planning in real-world cases

Based on the experience of applying the sustainability check with synthetic cases, the approach was also tested with two real-world cases as part of transformative case study research (see Hirschnitz-Garbers et al., 2020b): Case study "Rödental" – Demand-Side-Management in the municipal sewage plant; case "Augsburg" – Mobility-App linking the city of Augsburg's multiple transport services and improving their accessibility (see Table 3 below).

***Table 3.** Two real-world cases of coupled infrastructure development.*

Case "Rödental"	Case "Augsburg"
Case description: Applying demand-side management measures to help stabilizing the grid by a bundle of measures including a) switching off micro-gas-turbines, b) starting the heat pump or c) operating a P2H system as a heat source, and provision of positive control power by sustaining micro-gas-turbines for on-site power generation. The sustainability check was carried out in November 2017 involving the management, the technical management of the wastewater treatment plant and the wastewater treatment master. The aim of the sustainability check was to assess in particular the economic, technical and ecological potentials as well as the manageability of a demand side management in the Rödental wastewater treatment plant.	Case description: Interconnecting mobility offers of the city of Augsburg transport services and improving their accessibility by introducing a mobility app. The sustainability check was applied in the Augsburg case study in February 2019 with one deeply involved expert from the city of Augsburg municipal utilities. The aim of the sustainability check was to assess in particular the economic, technical and ecological potentials as well as the manageability of a Mobility app in Augsburg.

In order to apply the sustainability check to the two cases, we first adapted the questions asked to local infrastructure experts (from utilities) to assess the sustainability of the planned infrastructure couplings to the case study contexts. Based on an in-depth understanding of the respective cases, informed by literature review and interviews with the utilities we selected the relevant indicators and reframed, where needed, the questions contained in the sustainability check. This ensured that the experts involved were not confronted with questions that had no recognizable connection to the case (e.g. questions about water consumption or noise emissions looking at virtual services in the transport sector) and hence could discourage participation and reduce practice-relevance of the sustainability check.

In both cases employees from different departments or levels of the municipal utilities took part in the sustainability check. In the case "Augsburg", only one expert could participate, whereas in the case "Rödental" the technical manager and two employees participated. The rules of the procedure were then detailed to the participants. The transformative research approach chosen in our work helped ensure that actors from the municipal utilities agreed to take part in this joint and participatory sustainability assessment (see Hölscher et al., in revision). In particular, long-standing exchange between researchers and practice actors with multiple personal meetings and an agenda oriented towards practice relevant support provided by the research team helped building trust and positioning our work as relevant for utilities. This allowed creating the environments, in which utilities agreed to experiment with such participatory sustainability assessment.

4. Findings from testing the sustainability check

Sustainability effects of coupled infrastructures – findings from the Delphi-survey

The results of the evaluation show strengths and weaknesses of selected coupled infrastructure solutions. For many indicators trends can be derived from the assessments (see Figure 2). A trend can express positive or negative effects or, as frequently encountered, neutrality of effects. In some cases, a wide range of ratings can be observed indicating uncertainty or even polarisation of estimations. The effects are usually specific for the subsystems involved in a coupling. In summary, the following trends are observed:

Performance: The examined interconnections usually have the potential to deliver the expected performance and, by leveraging previously unexploited synergies, can in some cases have higher performance potential than conventional non-coupled systems. However, the relation of coupled sub-systems is often asymmetric where only one sub-system gains and the other provides – even though usually without losses Interconnection usually also goes along with a partly significant increase in technical and organisational complexity.

Resilience and security of supply: Corresponding with the stated performance potentials, coupled infrastructures can locally or regionally strengthen security of supply by improving the redundancy, modularity and buffer capacity of involved infrastructure systems. However, new interconnections often also create new susceptibilities to faults and dependencies between the coupled systems. Where dependencies between the subsystems are observed, these are usually unilateral. However, real dependencies exist, particularly where IT is a central part of the technological solution.

Social justice and economic viability: The studied interconnections generally seem not to cause losses in the quality and quantity of service. However, economic consequences are expected for many of the novel solution including higher operation costs for the provider and higher end user prises for the user of the innovative infrastructure services. This usually does not call into question the economic viability of coupled infrastructures. The use of infrastructure services often requires noticeable investments on the part of the users, e.g. to enable the use of mobile online services or where buildings need to be adapted to reduce temperatures in the heating system if regenerative or alternative heat sources are integrated.

Resource efficiency and resource conservation: The effect of coupled infrastructures on most of the resource indicators is usually rated neutrally or often slightly positively – which both is interpreted positively in the context of possible performance improvements described above. Especially for primary energy demand, final energy demand and greenhouse gas emissions mainly positive effects are expected. The assessments regarding the demand for land, raw materials and

critical raw materials vary from case to case. The space requirements of coupled solutions are usually higher. However, comfortable new services can be more resource consumptive or impede other societal goals.

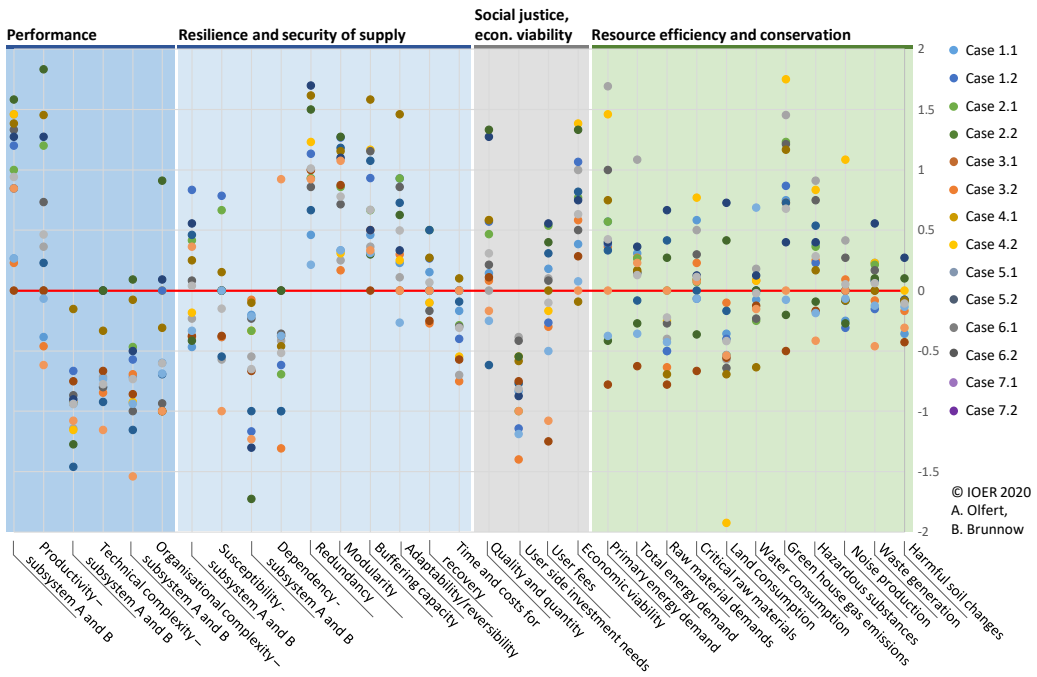

Figure 2. Result overview for 14 hypothetical cases (adapted from Olfert et al., 2020).

After carrying out the survey with more than 100 experts, we conclude that the sustainability check is well suited as an instrument to enable a fast and simple evaluation of uncertain questions related to sustainability effects of new infrastructure solutions. Overall, the check was well accepted by a large number of professionals from various fields of expertise. Of the experts who had signaled a basic willingness to participate, about two thirds actually took part in the survey and provided fully applicable results. The latter we also take as evidence that the case-specific operationalization of the set of indicators was appropriate to ensure the accessibility of the wide range of questions to the different professional backgrounds involved. However, we must also note that the participation on a voluntary basis also led to some fatigue or overburdening. Thus, some of the experts only provided surveys for one of the two cases offered. At the same time, no fundamental "failures" on the side of single indicators where found – meaning indicators regularly neglected. The answer option "no answer" was used rather little over the whole survey. The topic of social and economic compatibility shows the largest, but still relatively low proportion of non-responses, at 12.2% "no response"-answers. We also interpret the fact that most of the experts made intensive use of the optional open questions to communicate more detailed considerations as an indication of the general acceptance and relevance of the sustainability check.

Sustainability effects of coupled infrastructures – findings from the real-world applications

The results of the sustainability check for case "Rödental" and case "Augsburg" are summarized in Figure 3 and Figure 4. For Rödental, the participating experts see

- both positive and negative effects on ‘performance’ because the planned coupling will increase both the technical and the organizational complexity, because new signal transmission will need to be established and integrated into daily routines. Experts saw a very positive effect of the coupling on local and regional energy grid stabilization;

- both positive and negative effects on ‘social justice and economic viability’ because local and regional supply of energy will be strengthened due to grid stabilization effects. Connection to a virtual power plant needs additional digital and physical infrastructures (e.g. optical fiber cables) and thus require additional investments;
- positive effects on ‘resilience and security of supply’ because decentralized energy generation enhances the robustness of service provision and eases replacement of local grid hubs.

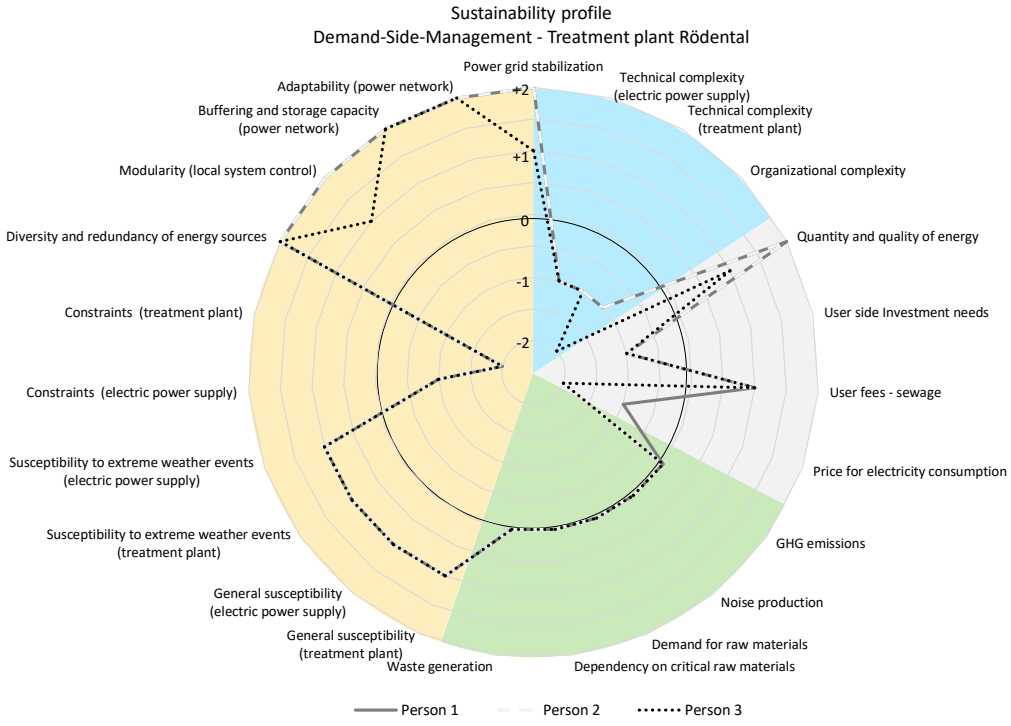

Figure 3*. Sustainability check for demand side management options in the real-world case “Rödental” (Hirschnitz-Garbers et al., 2020 adapted)*

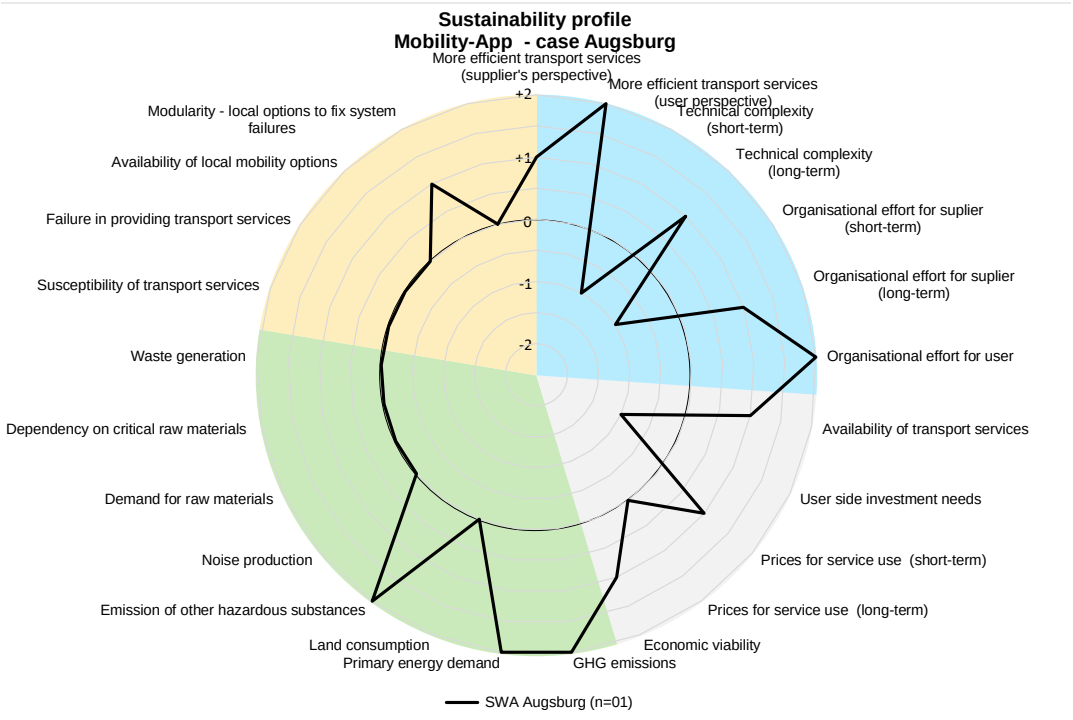

***Figure 4**. Sustainability check of introducing the mobility app in case "Augsburg" (Hirschnitz-Garbers et al., 2020 adapted)*

For Augsburg, the participating experts see

- short-term negative, but long-term positive effects on 'performance' because technical and organizational complexity will increase in the short-term due to the app and associated coordination requirements within the institutions, but reduced complexity in the long-term once digital and organizational links are established;
- slightly positive effects on 'social justice and economic viability' because available mobility offers become easier to know and access and use more cost-effectively (through the app's best-price automation);
- positive effects on 'resource efficiency and conservation' due to the mobility app hopefully leading more citizens to use public transportation instead of own cars, thus reducing fossil fuel needs and GHG generation;
- slightly positive effects on 'resilience and security of supply' in relation to the availability of local mobility offers because the existing offers become more easily visible and greater use might trigger an expansion of public mobility services thus increasing their supply security.

Unlike in the Delphi-based application, real cases can be evaluated concretely against the background of known socio-technical contexts. The non-anonymized process also enabled and partly promoted an exchange between the experts from different professional backgrounds involved in a case. The results of the testing on real cases lead to findings that were partly not expected – e.g. the moderating function the sustainability check can evolve. These findings are suitable for extending the areas of application of the sustainability check, which is being done in work currently underway. The results presented and discussed here are therefore to be understood as work in progress.

The sustainability check is applicable with real cases. The suitability of the evaluation concept and the individual indicators has been fully confirmed. In total, the assessments confirm the impression gained in the Delphi-based survey that the set of indicators also in real world applications is appropriate to depict impact potentials of infrastructure solutions in a differentiated manner. The personally involved experts have fully accepted the sustainability concept in its thematic scope and have used it for a reflected assessment. The case-specific operationalization of the indicators has proved to be particularly important in order to facilitate the experts' access to the indicators. In both cases, the evaluation could be carried out in the planned time-frame of less than 30 minutes. However, obtained results, mainly in terms of how the assessment framework was applied by the expert suggest a further consideration in our work of further developing the sustainability check.

5. Discussion: applicability of the sustainability check for early stage planning and decision-making for infrastructure coupling

Results from the real cases confirm the Delphi-based obtained opportunities and challenges. While the effects on potential performance and resource consumption (e.g. energy demand) are assessed mainly positive, the challenges lie in ensuring the security of supply of the systems as well as in the area of technical and organizational complexity. Apparently, the assessments of the three experts involved in the "Rödental" case are not only relatively close, but also agree on the trend for each indicator. However, the assessment process has raised additional questions at those points where the performance of the intended solution appears insufficient. Case "Augsburg" shows that the increase in technical and organizational complexity in particular could be a temporary phenomenon which, once the novel solution has been established, tends to turn out rather positive and is assessed as a relief. In both cases, the options pursued could lead to a slight increase in end consumer prices and thus social aspects require increased attention as well as careful planning and design.

The sustainability check offers the users great flexibility for case-specific adaptation and handling. The application of the sustainability check with real cases has shown that practitioners handle the set of indicators flexibly in order to take a closer look at specific aspects of their solutions. In the case "Augsburg", the questions of technical complexity,

organizational effort and effects on end-consumer prices were modified in particular in order to be able to map short- and long-term effects. This distinction appeared to be of particular importance in view of the planned mobility apps. For purposes of change management, it can be useful to distinguish between the fact that a planned solution can increase complexity and effort in the short term, but in the long term it may lead to significantly lower complexity and effort if once established. In the further development of the sustainability check, it should therefore be considered to generally integrate this temporal element. In this way, expected changes in impacts over time can be taken into account in the decision-making processes. In case "Rödental", the experts spontaneously used the sustainability check to discuss changes to the assessed combination of measures. While the advantages of the evaluated solution were basically not in question, the focus was on identifying possible critical moments of different measures. One such critical moment was identified, for example, with regard to ensuring the purification performance of the wastewater treatment plant. As a result, the combination of measures was reduced in such a way that both the objectives of providing control energy to the electricity grid and the safe operation of the wastewater treatment plant are guaranteed.

The sustainability check can be used to mediate between different professional perspectives. When applying the sustainability check with real cases, it has been shown that a value-free coexistence of different dimensions and indicators can promote the exchange between actors with different perspectives. Particularly case “Rödental” showed that the tool offered by the sustainability check was accepted by the persons involved as a means of mediating between the different and sometimes conflicting perspectives of the parties involved. As a surprise, the sustainability check thus became an instrument that facilitates communication and promotes mutual understanding in the planning process. In particular, it has helped to neutralize hierarchies between the participants and the dominance of certain perspectives. This has created a solid basis for a factual discussion. Even though an unintended effect, it seems worthwhile to further develop this function in the further development of the sustainability check.

Therefore, our findings show that the sustainability check provides a valuable and practical tool that supports the sustainability assessment and planning of coupled infrastructure solutions on the local and regional level. In particular, the sustainability check can support strategic planning and decision-making when introduced at an early stage and undertaken in a participatory manner. Then practical application fostered collaborative and systemic reflection and learning on planned infrastructure decision and helped to reveal opportunities, trade-offs and challenges, as well as implications for planning, management and use. In this way, the sustainability check can become a practical tool to support the transformation of infrastructure systems for contributing to sustainability transitions.

6. Conclusions

Sustainability is an important challenge for infrastructure development. In addition to resource efficiency novel infrastructure solutions will also need to deliver on resilience, economic and social factors. Potential sustainability effects of innovative infrastructure interconnections are often specific to the different solutions. However, some general conclusions can be drawn from the hypothetical cases.

There is a trend towards more decentralised and redundant services and more complex solutions. One of the greatest strengths is the usually constant to slightly improved performance of coupled systems. Many solutions can reduce primary energy demand and greenhouse gas emissions. Raw material requirements are often neutral to uncertain. The need for space is increasing, in some cases significantly. Interconnections create new dependencies especially where IT is involved as a central technological solution. System resilience is improved by redundancy of plant components and energy sources, buffer capacity and modularity. Many novel solutions require additional investments on the user side. This poses socio-political challenges. Comfortable new services can be more resource consumptive or impede other societal goals. Adapted regulations and targeted local process management are required to guide the ongoing transformation towards more sustainability.

Operators, municipalities and regions are faced with the task of supporting the sustainability transition of infrastructures through the targeted management of change processes. Informed decisions are a key challenge that can be solved by a

systematic and differentiated consideration of sustainability impacts. These can help to draw attention upon the strengths and weaknesses of options in early phases of change processes and to develop sustainable options addressing the new challenges they present.

As we could show, the application is flexible: the assessment can compare one or more variants, consider different time horizons or consider several scenarios; it can be adapted to coupled and uncoupled infrastructures solutions and can also address more than two coupled subsystems. On this basis, preliminary decisions can be made as to which simulations and analyses may be needed for feasibility studies or more concrete implementation planning. The evaluation is qualitative and thus particularly suitable for structuring a differentiated consideration of different perspectives of actors involved. Applications in real world cases showed an unexpected moderating function of the sustainability check which is to be reinforced in the scope of the further refinement of the sustainability check.

The easily accessible assessment concept proposed with the sustainability check enables researchers and managers to map different aspects of sustainability on the basis of locally available expert knowledge and with limited effort and repeatedly. The strength of the proposed concept lies in its ability to generate indications for effects that require particular attention by actors involved in planning and management. Such knowledge can be used as valuable input beginning in very early stages of land-use planning by municipals administration or even more for the layout and the design of innovative infrastructure solutions by infrastructure operators and specialist planners. This bears particular opportunities as in early planning phases restrictions are low while the scope of possibilities openly addresses issues of sustainability are widest while searching for appropriate solutions. In the asset of infrastructures, the responsibility for transformation lies mainly with the operators of the systems. Opportunities to use the knowledge provided by the sustainability check arise to a small extent directly in the operation of the facilities. However, there is even greater potential for technical adjustments at the end of the life cycle of components when they need to be replaced and systems can be converted. It is in these early phases, where municipal actors in charge of infrastructure development can take trend-setting decisions and shape local framework conditions for the

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Assessing Sustainability - Part 2

Emergy accounting in sustainability assessment

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Abstract
Emergy accounting (EmA) is a method in the "sustainability assessment toolbox", that has gained increasing interest due to several reasons: 1) it includes naturally economic flows alongside with energy and material flows (also other information flows than money can in theory be included but has yet not been done so to any larger extent); 2) EmA has interesting alternative solutions to problematic areas where the popular Ecological footprint method has gained criticism from the scientific community; 3) EmA as a complement to LCA may make it possible to develop the LCA method to assess also larger systems as cities, regions, and countries, which is not currently possible. There is currently no standard how EmA should be used in sustainability assessments. Preliminary features of a framework were presented at ISDRS 2016, and in this paper this framework is further developed and compared with ten recent emergy papers addressing sustainability. The ISDRS 2016 preliminary framework included 1) the Emergy Sustainability Index (ESI); 2) the normalizing mechanism in EmA; and 3) emergy as a network measure; in this paper is also included 4) pulsing sustainability. The results showed that all ten papers used the normalizing feature of energy, material and money. Eight of them included the possibility to capture network properties of the system investigated with indices and systems diagrams. Seven of them used the, to some extent disputed, Emergy Sustainability Index (ESI). None of the ten papers addressed the pulsing aspect of sustainability.

Keywords: network, systems, pulsing, sustainable development

1. Introduction

Emergy accounting is one of the methods in the sustainability assessment toolbox. In its use of stocks and flows of energy and matter it is similar to Life Cycle Assessment (LCA), Material Flow Analysis (MFA) and Substance Flow Analysis (SFA). However, Emergy accounting also includes stocks and flows of money and information. In its mechanism of relating to a global baseline of renewable flows Emergy accounting is similar to Ecological footprints in that it is not just revealing which of two alternatives is using more or less of different stocks or flows but also comparing the use to available renewable flows on a global annual basis. The latest global emergy baseline was calculated to 12.1 x 1024 sej/year (Brown and Ulgiati, 2016).

Grönlund and Fröling (2016) at the ISDRS conference in Portugal 2016, presented a preliminary framework of how different aspects in Emergy accounting (also labelled Emergy Analysis or Emergy Synthesis) captures sustainability.

This paper expands this framework and then apply it on ten recent emergy papers addressing sustainability.

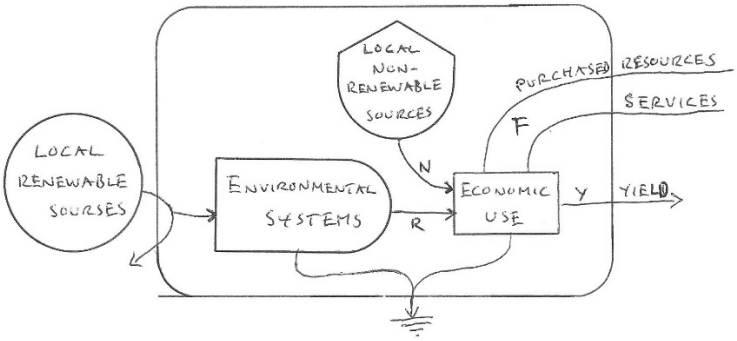
2. Methods

The ten articles were selected by a search in the database ScienceDirect at 3rd April 2020, using the terms EMERGY and SUSTAINABILITY. From the list produced by the database the first 11 articles were included in the investigations. This since two of the papers were published as a pair from the same research group, and therefore treated as one paper in this investigation.

3. Emergy and the Energy Hierarchy Principle

Emergy is a measure appearing when applying the energy hierarchy principle to natural (e.g. forests and lakes) or human (e.g. cities and countries) systems. The principle postulates that energies in any system will self-organize in hierarchical patterns given time to do so (Odum, 1994, 2007). Emergy is expressed in relation to one type of energy occurring in the hierarchy, almost always solar emergy joules, sej. In the context of economy, emergy values can alternatively be expressed in a currency related unit, for example Em€ or Em$ (proportional to values in sej). The significance is that Em€ or Em$ measures the contribution different items gives to the whole system, rather than how individuals value different items on the market; a donor value approach rather than a receiver (market) value approach (Grönlund et al. 2015). Emergy accounting use many different indices (Brown and Ulgiati 2004) based on stocks and flows of renewables (R), non-renewables (N), feedback from other systems higher up in the energy hierarchy (F), and the yield or contribution from the system evaluated (Y), see Figure 1.

Examples of other indices than those presented in Figure 1 are percent renewable (%Ren) and Emergy Investment Ratio (EIR=F/(R+N)).



Emergy Yield Ratio : EYR = Y/F = (R+N+F)/F
Environmental Loading Ratio: ELR = (F+N)/R
Emergy Sustainability Index: ESI = EYR / ELR

***Figure 1**. The Emergy Sustainability Index, ESI (after Brown and Ulgiati 2004).*

4. Sustainability aspects in Emergy accounting

Grönlund and Fröling (2016) presented three types of sustainability aspects relevant for Emergy accounting: 1) the Emergy Sustainability Index (ESI); 2) the normalizing mechanism in EmA; and 3) emergy as a network measure. Below they are presented together with the fourth dimension of "Pulsing" added to the framework by Grönlund (2020), and originally by Odum et al. (1995), and Odum (1996, 2007).

a. ESI, Emergy Sustainability Index

The ESI was introduced by Brown and Ulgiati (1997) and Ulgiati and Brown (1998) as "…an aggregate measure of economic (large yield) and environmental (low stress) compatibility." It is defined as the Emergy Yield Ratio divided by the Environmental Load Ratio (Figure 1). It captures, on the yield side, the contribution of an activity (e.g. forestry or fish farms) to the larger system (e.g. society), and on the stress side the increasing load on the local system (which original state is measured by R) from released local non-renewable recourses (N) and purchased recourses introduced to the local system (F). The ESI measure has been frequently used by many authors, often interpreted in a far more general way than originally suggested by Brown and Ulgiati (1997). An interesting discussion regarding the ESI was published as Letters to the editor in the journal Ecological Modelling during 2011 and 2012 (Harizaj, 2011; Brown and Ulgiati, 2011; Giannetti, 2012). The focus of the discussion was what factors would maximize the ESI. Of course high yield (EYR) and low load (ELR) will do it, but in which constellations of R, N and F? The outcome of the discussion was that it was clear that the ESI still needs refining and that it "…does not capture the complexity of the sustainability concept" (Brown and Ulgiati, 2011).

b. Emergy as a normalizing measure

The probably most attracting feature of emergy accounting is its mechanism of normalizing flows not only between energy and matter, but also between energy and money (Odum 1996); this is almost unique among environmental assessment methods. Thus, when drawing an emergy diagram (according to Odum 1996 and Brown and Ulgiati 2004), it is not only possible to

illustrate flows of energy, matter, information, and money within the same diagram, it is also possible to put values on all of the flows with the same unit: sej (solar emergy joules). From a sustainability point of view it is also interesting that when using the energy hierarchy diagrams of emergy accounting, the domains of the traditional triple-bottom-line approach in the sustainability debate comes out naturally (Grönlund et al. 2008; Grönlund 2016), see Figure 2. In each of the three domains it is possible to use the normalized quantitative numbers of emergy regardless of the original units of the flows, be it joules, kg, bits or Euros (at least in theory, the social sustainability parts are still problematic in the collection of raw data).

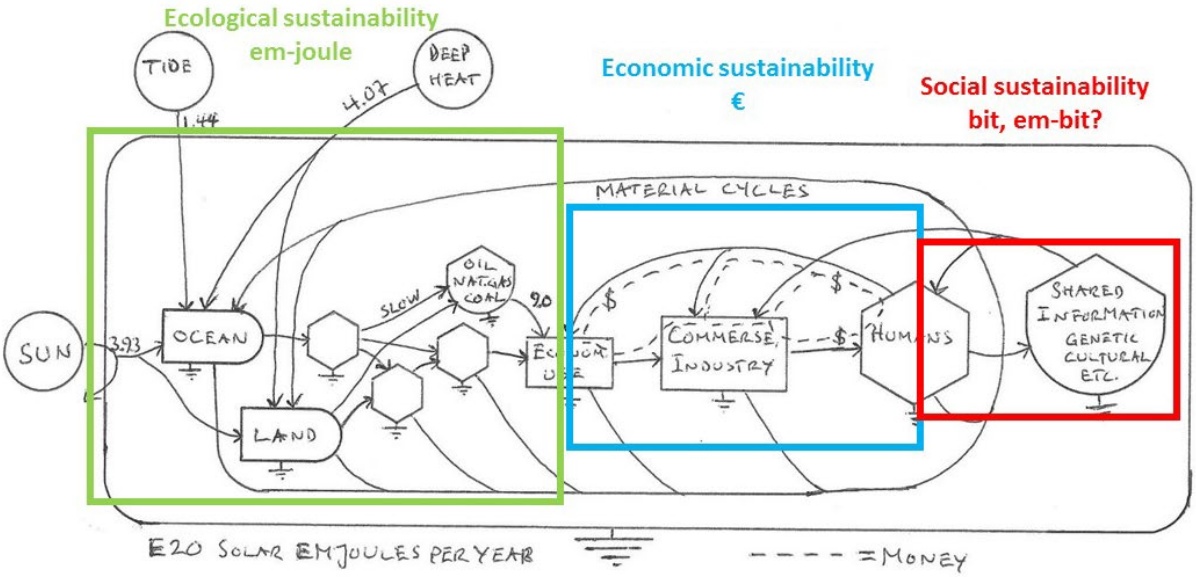


***Figure 2**. The triple-bottom-line domains in the energy hierarchy (modified from Odum 1996, Figure 3.1, by Grönlund et al. 2008; Grönlund 2016).*

c. Emergy as a network measure

An aspect of the emergy accounting approach that has not been explicitly discussed in the sustainability literature so far is the feature of emergy as a network measure rather than a "state variable" measure. The energy hierarchy has been suggested as a new thermodynamic (TD) law since it claims to describe distribution and dynamics of energy in universal terms (Odum 1994). Grönlund (2009) and Grönlund and Brandén Klang (2009) suggested that a problem for this suggestion to have a breakthrough as an accepted TD law is due to the fact that it expands the classical TD (heat TD, Figure 3). This expansion is not performed by those who work with the classical TD (i.e. heat engine and chemical engineers) but by other research groups who are not used to view their work as TD (Figure 4). These groups are for example business modellers, computer scientists, and meteorology modellers working with theories of networks, systems, and complexity (Figure 4). The expansion also includes the new systems ecology measures with a network focus, as Environs (Patten 1992), Ascendancy (Ulanowicz 1997) and Emergy (Odum 1994) (Figure 4). A special case is the measure Eco-exergy (Jørgensen 2006) which takes its fundaments much more explicit in the old classical TD but address the new quality aspects. Grönlund and Brandén Klang (2009) suggested that also the Extended Exergy concept (Sciubba 2003) is taking this step by adding money to the classical TD.

The network aspect can be captured in indices to some extent, but also in the systems diagrams often connected to the emergy accounting tables.

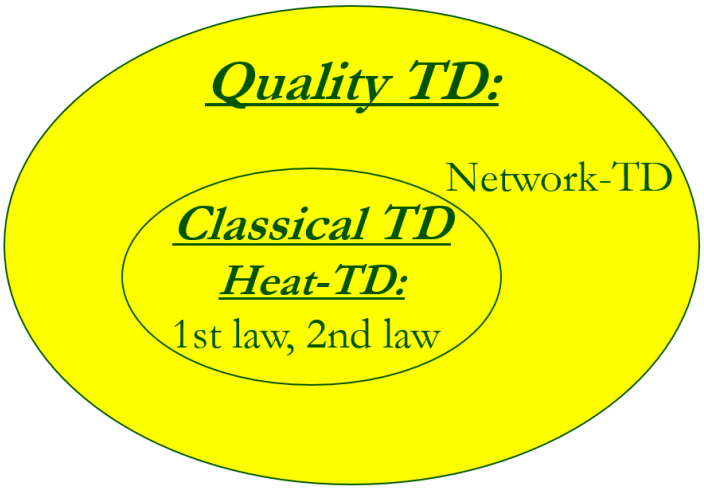


***Figure 3**. A view of the expansion of the field of thermodynamic (TD) from the classical heat TD to quality TD including network TD (from Grönlund and Brandén Klang 2009; Grönlund 2016).*

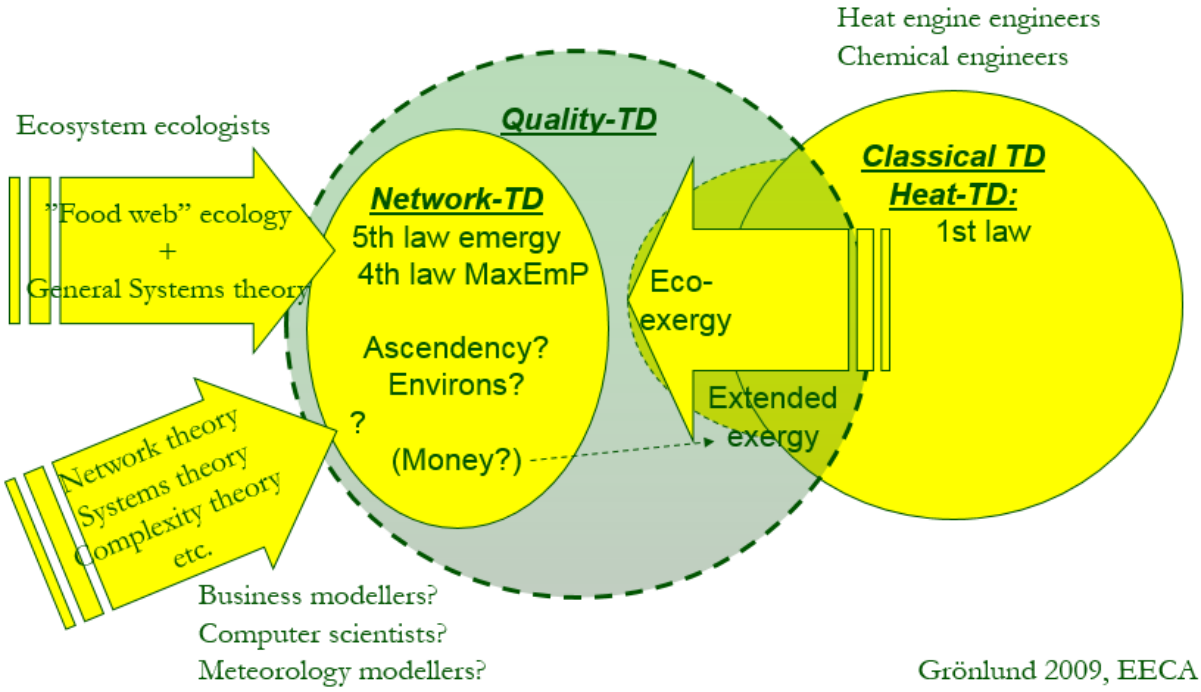


***Figure 4**. A suggested thermodynamic classification of the new ecosystem theories emerging (from Grönlund and Brandén Klang 2009; Grönlund 2016).*

d. Pulsing sustainability

A wanted stable steady state is often intrinsic in definitions of sustainability. However, for example Odum et al. (1995) argue that pulsing is the normal state for systems: the pulsing paradigm. If pulsing is a general systems pattern, sustainability is likely to have different features in different stages of the pulsing cycle. Odum et al. (1995) divide the pulsing pattern into four stages: (I) growth, (II) stagnation, (III) decline, and (IV) slow regeneration (Figure 5). Odum and Odum (2001) gave different suggestions and strategies for sustainability in the different stages. In the pulsing context, during phase I it is observed a wanted outcome of continuous growth. This growth may be considered sustainable if it is part of a pulsing pattern that is sustainable as a whole, over time.

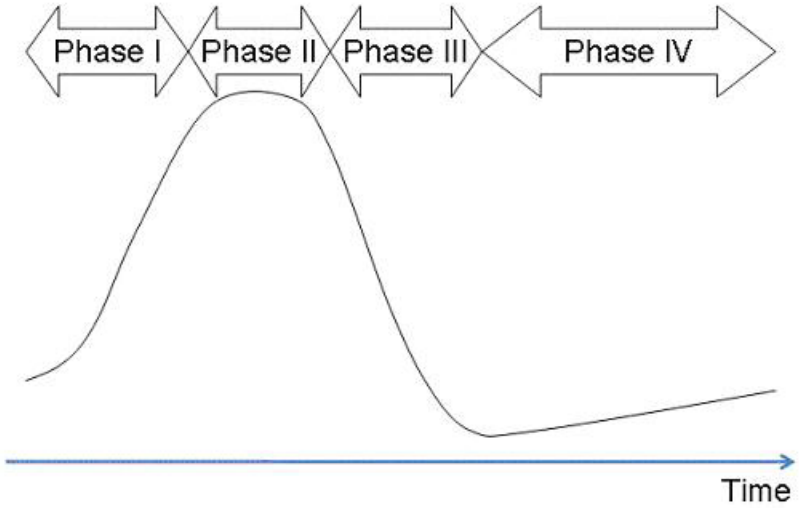


***Figure 5**. The four pulsing stages (after Odum et al., 1995).*

5. Results

Below are shortly presented the ten different articles included in the application. Five of the emergy indices is below called "standard indices", since they have been used for more than 20 year. They are: EYR, ELR, EIR, %renewable, see Figure 1. The sustainability aspects are summarized in Table 1.

a. Alizade et al. (2000), J. Cleaner Production

The aim of the study by Alizade et al. (2000) was to evaluate the sustainability of two existing wastewater treatment plants in the city of Mashhad in Iran, using eco-efficiency index based on emergy and life cycle analysis. The emergy approach was choose because it was indicating the sustainability regarding ecosystem services. Potential for sustainability improvement was analyzed by some scenarios of agricultural compost from sludge, 10% reduction of energy consumption, and 10% reduction of chlorine consumption. The eco-efficiency index based on emergy analysis as well as emergy sustainability index introduce Al-Teymour treatment plant with installation of a composting unit as the most sustainable option. The other method approach, ecoefficiency index based on life cycle analysis, came up with a different answer with 10% reduction of energy consumption at the KhinArab plant as sustainable alternative. Alizade et al. (2000) used the standard indices, and added net emergy to their analysis.

b. Amiri et al. (2020), J. Cleaner Production

Amiri et al. (2020) studied sustainability of mechanized and traditional rapeseed production systems in Lorestan, Iran. They used emergy accounting to complement an econometric model using so called production factors. This since it was considered important to include the free environmental inputs in the production function. The free energy of solar radiation and the amount

of soil organic matter and minerals were considered as economic inputs affecting sustainability. Their findings were that application "of policies to 1) integrate small land holdings into the total production function for rapeseed, 2) increase the knowledge and skills of the workforce in the agricultural sector, and 3) implement conservation measures to prevent soil organic matter reduction and erosion are practical approaches are suggested to improve the productivity and sustainability of these agricultural systems". Amiri et al. (2020) did not use the standard indices.

c. Asgharipour et al. (2020), Ecological Modelling

Asgharipour et al. (2020) used emergy to evaluate the sustainability of greenhouse systems, with the aim to find management recommendations that increase the sustainability of these systems. Four greenhouse systems for cucumber, tomato, bell pepper, and eggplant production, located in Jiroft city, Iran, were evaluated with the following standard emergy sustainability indices: renewability in % (%Ren), EYR, ELR, ESI, EIR, and added a modified ESI, and a new Emergy index of sustainable development (EISD). The results showed that the sustainability of the cucumber production system was greater than that of the other three systems. "The calculated unit emergy values for economic yield (UEVE) generally indicated that greenhouse systems were at least 100 times more sustainable than open farm systems for the production of different products, primarily because of drastically reduced soil erosion." It was concluded that "…selection of a plant with more potential to use free local environmental energy, higher yield, and more efficient use of labor will lead to greater sustainability of greenhouse vegetable production systems."

d. Buonocore et al. (2020a, 2020b), Ecological Modelling

Buonocore et al. (2020a, 2020b) investigated coastal and marine natural capital stocks in Marine Protected Areas (MPAs), and their provision of ecosystem services with focus on their protection and sustainable management. The total biophysical value of natural capital stocks related to the total area of the Gulf of Naples and Campania Region was calculated in emergy units (sej) and compared with an assessed economic value. A map also showed the spatial distribution of the emergy per square meter value. Buonocore et al. (2020a, 2020b) did not use the standard indices.

e. Chen et al. (2020), J. Cleaner Production

Chen et al. (2020) did an evaluation of Chinese chemical fertilizer consumption in the Jiangxi Province, applying both emergy evaluation and economic analysis. They used what they call an improved emergy analysis method. Four kinds of fertilizers were investigated in the study. Chen et al. (2020) did not use the standard indices but what they call improved versions of them: IEYR, IELR, IESI.

f. de Souza Junior et al. (2020), Science of the Total Environment

de Souza Junior et al. (2020) investigated the transition from a linear to a circular economy, and used emergy and LCA measures for this. The case used was a manufacturing of baseboards made of recycled Expanded Polystyrene (EPS), obtained from an extensive reverse logistics system composed of different recycling processes. They found that the emergy values were in favour of the circular alternative compared to the linear, while the LCA indicators gave a more complicated view. They only used total emergy in the analysis, and did not include any other emergy indicators.

g. Huang and Chiu (2020), Landscape and Urban Planning

Huang and Chiu (2020) investigated peri-urbanization, land teleconnections, and the equality of ecological exchange with emergy analysis. Urbanization not only change the land use locally, but also implies land use changes in places far away and affects the socio-ecological systems there. In the study they used urban land teleconnections (ULT) as a framework to link urbanization and land use changes. The unequal exchange between the urban area and the remote area were assessed in emergy terms. The results showed that remote areas tended to deliver agricultural products or cement with low emergy exchange ratios when sold to urban markets. This low emergy exchange ratio caused land conversion in the remote area. Huang and Chiu

(2020) used standard emergy indices, but complemented them with new indices as "fraction of purchased emergy used" and "density of purchased emergy used" in their sustainability assessment.

h. Jing et al. (2020), J. Environmental Sciences

Jing et al. (2020) did an assessment of greenhouse gas emissions from internal combustion engine automobiles and electric automobiles in the United States. They applied a life-cycle approach based on emergy accounting. They concluded that the electric alternative had a higher ESI than the internal combustion engine automobiles, and that the integration of emergy and GHG emissions analysis could provide a wider perspective on industrial sustainability of automobile production.

Table 1. *An overview of what identified sustainability aspects that were included in the different papers of this study.*

Article	ESI	Normalizing	Network	Pulsing
Alizade et al. (200). J.Cl.Pr.	Yes	Yes Explicitly	Yes, diagram Indices: EYR, ELR, ESI, Net emergy	No
Amiri et al. (2020). J.Cl.Pr	No	Yes Explicitly	Yes, Diagram Indices: No standard emergy indices, but using emergy numbers in another econometric method (agricultural production factors)	No
Asgharipour et al. (2020). EM	Yes, plus IESI.	Yes	Yes, Diagram, Indices: %Ren, EYR, ELR, ESI, EIR, Modified ESI, Emergy index of sustainable development (EISD)	No
Buonocore et al. (2020a, 2020b), EM	No	Yes	No, No diagram No indices, only emergy total values and emergy density (sej/m2).	No
Chen et al. (2020)	Yes, plus IESI	Yes	Yes, many diagrams. Indices: IEYR, IELR, IESI	No
de Souza Junior et al. (2020)	No	Yes	Yes, diagram. But no indices, just total emergy use.	No
Huang and Chiu (2020)	Yes	Yes	Yes, diagram, Indices: EYR, ELR, ESI, EIR, Fraction of purchased emergy used, density of purchased emergy used	No
Jing et al. (2020)	Yes	Yes	Yes, diagram, Indices: EYR, ELR, ESI,	No
Liu and Yang (2020)	No	Yes	No, No diagram No indices. Emergy-ecological footprint in hectare.	No
Lu et al. (2020)	Yes	Yes	Yes, diagram. %Ren, EYR, ELR, ESI, EIR	No

i. Liu and Yang (2020), J. Cleaner Production

Liu and Yang (2020) investigated the dynamic changes in ecological sustainability and the relationship with urbanization in the coastal city of Xiamen in China. They used a modified ecological footprint approach based on emergy calculations together with a set of ecological sustainability indicators, and a dataset of 17 years, from 2000 to 2017. The results showed a breaking point in 2008-2009 when the city changed from an ecological surplus to an ecological deficit. Liu and Yang (2020) did not use any of the standard indices, not even a systems diagram for their evaluation.

j. Lu et al. (2020), J. Cleaner Production

Lu et al. (2020) investigated integrating industrial symbiosis and urban symbiosis with a case study of the Chinese city Yongcheng. The results indicated that twenty-nine in-use and ten potential symbiosis activities showed big potential for saving regarding material, CO2 emissions and in emergy terms. Examples were slag substitution for feedstock mix in cement clinker production, coal use, and municipal solid waste reduction. Lu et al. (2020) used the standard indices.

6. Discussion

The Emergy Sustainability Index (ESI) was used in seven of the ten papers included in the investigation. Despite the discussion about its usefulness (section 4.a) it was used in a mostly uncritical way. Two of the papers, though, presented a developed version of the ESI: the “Improved ESI”, IESI. Time will show if this new sustainability index will have a more widespread use.

The normalizing feature of the emergy concept was, as expected, used in all of the ten papers. Since weighing approaches between numbers in energy units (J, kWh, BTU, etc.) and different types of material types (in kg) are often challenging, it is not surprising that the normalizing feature is attractive in emergy accounting. That the normalization feature also includes monetary values seems to be extremely rare. Probably extended exergy analysis (Sciubba 2003) is the only other method that includes this feature.

Capturing networks was pointed out by Grönlund and Fröling (2016) as an obvious sustainability feature in emergy accounting. Eight of the ten papers explicitly use this approach with both diagram and indices. Five of them use, what can be called “standard indices”, since they have been used for more than 20 years: the EYR, ELR, EIR, %renewable. Only one of the eight papers does not use the standard indices, but an own ecocentric method. Another one of them use, what they call improved versions of the standard indices: IEYR, IELR (Chen et al. 2020). Most revealing regarding the network is, however, the systems diagrams that forms that basis for the emergy accounting tables. To draw these diagrams the authors are forces to reveal their opinion of how things are connected in the network. Only using indices does not reveal this.

Pulsing was the main feature in the discussion about sustainability in the Odum publications from 1996 to 2007, see Grönlund (2020). None of the ten papers included in this investigation address the pulsing feature in any result section. This is interesting, since H.T. Odum publications are presented as key literature in all of the ten paper, including the 1996 textbook Environmental Accounting, where Odum clearly underlines the pulsing feature in connections to sustainability.

7. Conclusions

Ten recent papers, randomly selected, was evaluated in their approach to assess sustainability in the context of emergy accounting. All ten papers used the normalizing feature of energy, material and money. Eight of them included the possibility to capture network properties of the system investigated with indices and systems diagrams. Seven of them used the, to some extent disputed, Emergy Sustainability Index (ESI). None of the ten papers addressed the pulsing aspect of sustainability.

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Sustainable Building without Certification

An Exploration of Implications and Trends

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Abstract

Sustainable and resilient infrastructure plays a pivotal role in meeting the United Nations Sustainable Development Goals (UN SDGs). Current information from the U.S. Environmental Protection Agency (EPA) and other credible sources indicate that buildings account for approximately 40% of total energy consumption worldwide, which leads to about 48% of greenhouse gas emissions from the building sector alone. To combat this problem, the current trend is to design sustainably, and one of the leading determinants of the metrics by which these buildings are measured is the Leadership in Energy and Environmental Design (LEED) rating system administered by the United States Green Building Council (USGBC). However, the LEED certification criteria and process have been seen by many as either cumbersome or sometimes too expensive. As a result, buildings are being constructed following LEED or other sustainable building guidelines, but without necessarily pursuing external certification. This paper takes a critical look at LEED implementation without certification through the lens of sustainable development and societal transformation and addresses three (3) questions: 1. What is the rationale behind not pursuing LEED certification? 2. When certification is not part of the objective, how are particular sustainability criteria selected? 3. With regards to criteria selection and performance evaluation, to what extent do LEED building projects that undergo certification differ from those that do not, and what are the potential implications for building performance? The results provide insights on the implications of assessment-related decisions in building design and construction as we look to transform our societies into more sustainable, healthier, and livable places, and support global goals for sustainable development.

Keywords: Sustainable Building Rating Systems, LEED, Certification, Decision-making, Sustainable Development

1. Introduction

Approximately two-thirds of the global population is expected to reside in urban areas by the year 2050, according to the United Nations Department of Economic and Social Affairs (2018), and there is mounting pressure to establish healthy and livable urban environments that meet the needs of increasingly populous communities and mitigate the effects of climate change. As we look to transform societies sustainably, the cumulative decisions for each building project become much more critical and require justification. Yet some organizations are deciding to implement sustainable building standards like Leadership in Energy and Environmental Design (LEED), and are forgoing the typical third-party certification process.

The built environment comprises the totality of man-made construction projects to sustain our way of life, and the process has significantly contributed to the depletion of natural resources, environmental decline, and climate change (Chen et al., 2015). To mitigate these issues, various industries related to the built environment have initiated sustainable practices to be more mindful of their impact on the environment. The U.S. Green Building Council (USGBC) was founded in 1993 to address the contributions of the building and construction industry and its impact on the built environment (USGBC, 2009). The building sector has been identified as being responsible for about 40% of worldwide energy consumption and 48% of greenhouse gas emissions, and the objective of the LEED rating system is to develop a set of practices that would seek to mitigate these negative impacts from the building sector (Jeong et al., 2016). By bringing together non-profit organizations, government agencies, architects, engineers, developers, builders, product manufacturers, and other industry leaders, LEED formed a committee under the guidance of the United States Green Building Council (USGBC) to develop a set of sustainable building standards for new construction (CBRE, 2018). The new comprehensive system took into account interrelated standards that

cover all aspects of the building process, from design through construction and the operation and maintenance of buildings (Chen et al., 2015).

Over the years, LEED has evolved to be the standard-bearer in the United States with regards to sustainable building practices and has resulted in a surge in construction of sustainable buildings (CBRE, 2018). In 2006, the United States saw 26 new buildings pursue and receive LEED certification. That number had grown to 67,200 in 2018, showing the increase in demand and revealing the green building market as one of the fastest-growing industries (CBRE, 2018). A study conducted by researchers at Maastricht University looked at the 30 largest metro areas in the United States and found that green-certified office spaces comprised 41% of market totals in 2018. In the same study, the city of Chicago led the way with almost 70% of its office buildings certified as green, followed by San Francisco at 64%. The researchers noted that building certification had become a more recognized and essential aspect of a building's profile (CBRE, 2018).

Amidst the growth of building rating systems such as LEED, there have been concerns regarding the certification process, including the expense associated with certification, the justification for some of the criteria, and the rationale of the rating systems. As a result, some project teams are deciding to forego sustainable building certification while attempting to transform societies to be more sustainable. This paper examines these concerns and takes a critical look at LEED implementation without certification through the lens of sustainable development and societal transformation and addresses three (3) questions: 1. What is the rationale behind not pursuing LEED certification? 2. When certification is not part of the objectives, how are particular sustainable criteria selected? 3. With regards to criteria selection and performance evaluation, to what extent do LEED building projects that undergo certification differ from those that do not, and what are the potential implications for building performance? The study draws from and analyzes a survey of relevant decision-makers in building design and construction projects, including developers, architects, construction managers, and facilities managers. The results suggest that cost is a critical factor in the pursuit of sustainable building certification. On criteria such as brand reputation, credibility, and marketability, certified buildings are perceived to be better than non-certified buildings. Also, the building owner is a major driving force in the decision to pursue sustainable building certifications.

Background

1.1 Sustainable Building Rating Systems

There are numerous sustainable building rating systems in operation around the world that, regardless of any differences, share the overarching goal to reduce the ecological footprint of buildings through sustainable practices. In addition to LEED, popular schemes include Passive House (Passivhaus), a voluntary standard for energy-efficient buildings adopted predominantly in colder climates (Passive House Institute, 2019); Green Globes, a green rating assessment, guidance, and certification program administered by the Green Building Initiative used primarily in Canada and the United States (Green Globes, 2019); Green Building Index (GBI) and Green Star, national rating certificates adopted by Malaysia and Australia, respectively (Jeong et al., 2016); and Building Research Establishment Environmental Assessment Method (BREEAM), the world's longest established method of assessing, rating, and certifying building sustainability (BREEAM, 2020). Many of these systems share similar categories and certification levels, and comparisons between the various systems have been the focus of other studies. The focus of this study is rather on the use of such rating systems as benchmarks for the construction and operation of sustainable buildings without the pursuit of certification.

1.2 LEED Standards

The USGBC defines LEED as "the most widely used green building rating system in the world. Available for virtually all building project types, from new construction to interior fit-outs and operation and maintenance, LEED provides a framework that project teams can apply to create healthy, highly efficient, and cost-saving green buildings (USGBC, 2020)." LEED certification is a globally recognized symbol of sustainable achievement (USGBC, 2009).

While the original version of LEED (version 1.0) was developed as a rating system for new construction, the system has been updated with the latest version being released in 2018 (version 4.1) to include additional certification types. The five main certification types are LEED Building Design and Construction, LEED Interior Design and Construction, LEED Neighbourhood Development, LEED Building Operations and Maintenance, and LEED for Homes. The certification level depends on points allocated on the basis of how well a building meets criteria in the different assessment categories for each certification type, which includes the following levels: Certified (40-49 points), Silver (50-59 points), Gold (60-79 points), and Platinum (80+ points). There are six assessment categories: Sustainable Sites (SS), Energy and Atmosphere (EA), Water Efficiency (WE), Indoor Environmental Quality (IEQ), Materials and Resources (MR), and Innovation (INNO) (USGBC, 2020).

1.3 Certification Schemes

Certification schemes codify a set of standard practices and provide a means for organizations to provide information on and authenticate their adoption of these practices (Aravind and Christman, 2008; King et al., 2005). An organization seeking recognition of its sustainable building design and construction can choose to undergo verification of their implementation of LEED or other green building standards through third-party assessment and certification. Certification does not fully ensure optimal or sustainable performance, but the objectivity and expertise of the assessor combined with the rigor of the assessment provide external credibility for the organization's claims (Arnold and Whitford, 2006) and provide customers and investors with assurance about the organization's practices (King et al., 2005). The 2018 World Green Building Trends report indicated that the main driver for green building in the U.S. was client demands (Jones and Laquidara-Carr, 2018).

The LEED certification process has been criticized as being costly, inequitable, and inadequate as an indicator of sustainable performance. Boschmann and Gabriel (2013) maintain that the LEED system is backward and counterproductive to sustainability. It rewards technology-focused efforts more so than projects that employ an adaptive approach with a focus on local natural systems and does not encourage life cycle thinking. Chen et al. (2015) note that limited credits are available for passive design approaches, while energy and atmosphere carry extensive weight. Studies on certification in a variety of domains suggest that the driving force for achieving it may be the desire to present a particular outward image or pressure from customers, rather than a genuine desire to improve (Yusof and Aspinwall, 2000). While LEED certification can offer minimum assurances associated with sustainable development and discourages greenwashing, it offers no guarantee of exemplary or transformational behaviour.

LEED construction can be expensive, adding an estimated 10-30 percent to the total project cost, and certification fees can account for an estimated 5-15 percent of these expenses (Vamosi, 2011). According to the USGBC (2020) fee schedule for LEED building design and construction, the per-building registration and pre-certification fees are approximately $6,500, and certification fees are a factor of building gross floor area, with a minimum of $3,400 for buildings under 250,000 square feet, and a minimum of $33,000 for those between 500,000 and 800,000 square feet. Fees and rates for larger buildings are not indicated in the schedule and require an individual quote. Added cost may also be attributed to higher rates for green design from architecture and engineering firms, and the cost of expertise from LEED-accredited professionals and consultants (Vamosi, 2011). A 2018 study of green building trends based on a survey of building design and construction professionals indicated initial cost and affordability concerns as the top barriers for green building. The authors noted a significant increase, compared to an earlier study in 2015, in the number of respondents who eschew third-party rating systems due to cost, along with an increasing share of projects forgoing certification (Jones and Laquidara-Carr, 2018).

Going forward, firms may become less dependent on certification as a means to demonstrate sustainable development. LEED provides an "organized, consensus benchmark," developed by a vast network of industry professionals (USGBC, 2009), that can be directly applied by architects, builders, and building managers in the design and construction process to improve energy and environmental management. If the primary goal of the organization is to improve its performance in support of sustainable development, the standard can potentially be implemented just as effectively without certification, providing that facilities

managers possess or can acquire the necessary competence for implementation. Some organizations may thus consider the additional steps and costs associated with certification to be superfluous.

2. Methods

In efforts to address the research objectives, a survey was conducted with professionals that have worked with or managed green buildings. A purposive convenience sample was used in the selection of potential participants in the survey for this study, based on the authors' professional networks in sustainable construction, architecture, and environmental management. This ensured access to participants with the necessary background or experience in sustainable buildings (Orcher, 2005). A literature review was utilized to identify related studies and the gaps and to identify criteria to inform the development of the survey instrument. Institutional Review Board (IRB) approval was obtained from the Human Subjects Research Office (HSRO) at the authors' institution. The questionnaire was administered through the Qualtrics survey development platform and contained sixteen (16) research questions and six (6) background and demographic questions. The research questions branched out such that the maximum number of questions a participant encountered through the longest route was eleven (11). The instrument included primarily closed-ended questions with pre-determined response choices stemming from the literature review, to increase response consistency and enable quantitative analysis; however, some were formulated to allow participants to provide additional comments if they wanted to explain their responses. Open-ended questions were also included to allow participants to provide more depth in their response in relation to the rationale for certification decisions, and the selection of criteria, metrics, and performance indicators for their projects. The questionnaire was pilot-tested by a selection of five professionals that have worked with sustainable buildings after several rounds of testing by the research team for content validity, and final adjustments were incorporated into the instrument based on their comments.

Professionals working with sustainable buildings selected from industry and academia were invited to participate in the survey. Of the thirty (30) responses collected, there were twenty-one (21) complete responses to the survey, and nine (9) incomplete responses. The incomplete responses were not included in the analysis since the main research questions were not answered. The background of the respondents is presented in the results section.

Descriptive statistics were computed to analyze the data. Qualitative data was analyzed with NVivo software, and quantitative responses to the survey were analyzed using Microsoft Excel due to the relatively small dataset. The results are not generalizable but suggest potential trends in the industry. A Chi-squared test was performed to evaluate the relationship between respondents' perception of certified and non-certified buildings and twelve selected criteria.

The hypotheses are:

- H_0: There is no association between perceived building certification status and the selected criteria.
- H_a: There is some association between perceived building certification status and the selected criteria.

The results gathered from the analysis and the research are presented in the following section.

3. Results and Discussion

Background information was collected from the respondents, including information about the organization they work for (Figure 1), their current role (Figure 2), their years of experience in their role (Figure 3), and the number of LEED projects they have worked on (Figure 4). Participants represented organizations in architecture, construction, engineering consultancies, and college/university campuses (Figure 1). Of the twenty-one (21) respondents, 52% have a sustainable building credential. Seventy-six percent (76%) of all the respondents have designed, constructed, or managed at least one LEED project.

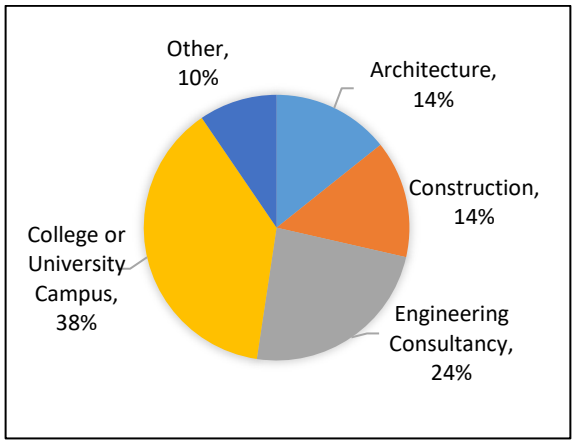

Figure 1. *Organization type of respondents*

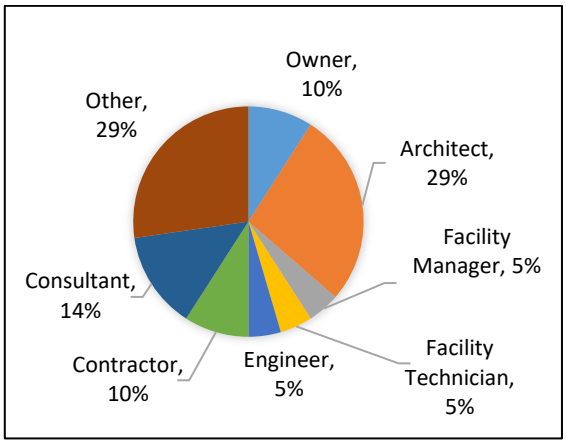

Figure 2. *Current role of respondents*

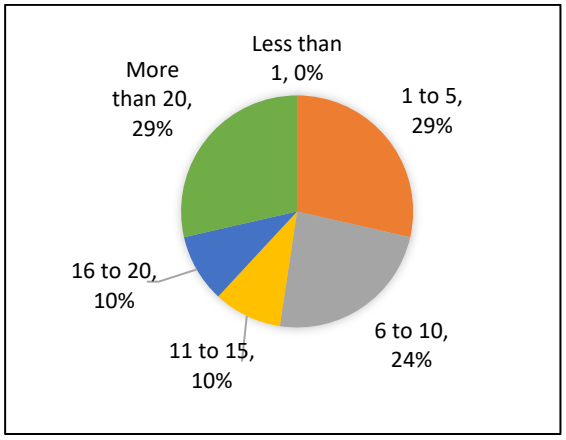

Figure 3. *Respondents years on the role*

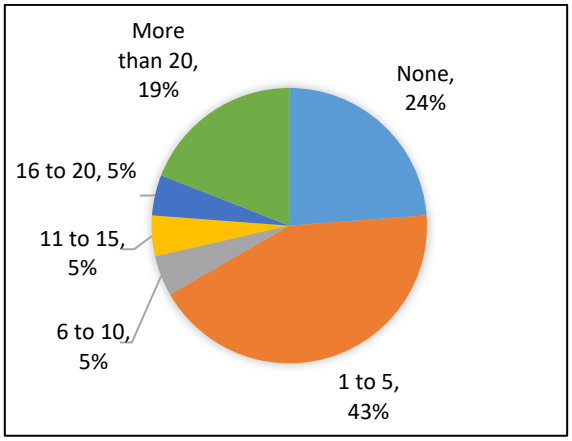

Figure 4. *Number of LEED projects worked on*

The Chi-squared test performed to evaluate the relationship between respondents' perception of certified and non-certified buildings and the twelve criteria in Figure 5 yielded a p-value of 3e-11, which is smaller than the significance level (0.05).

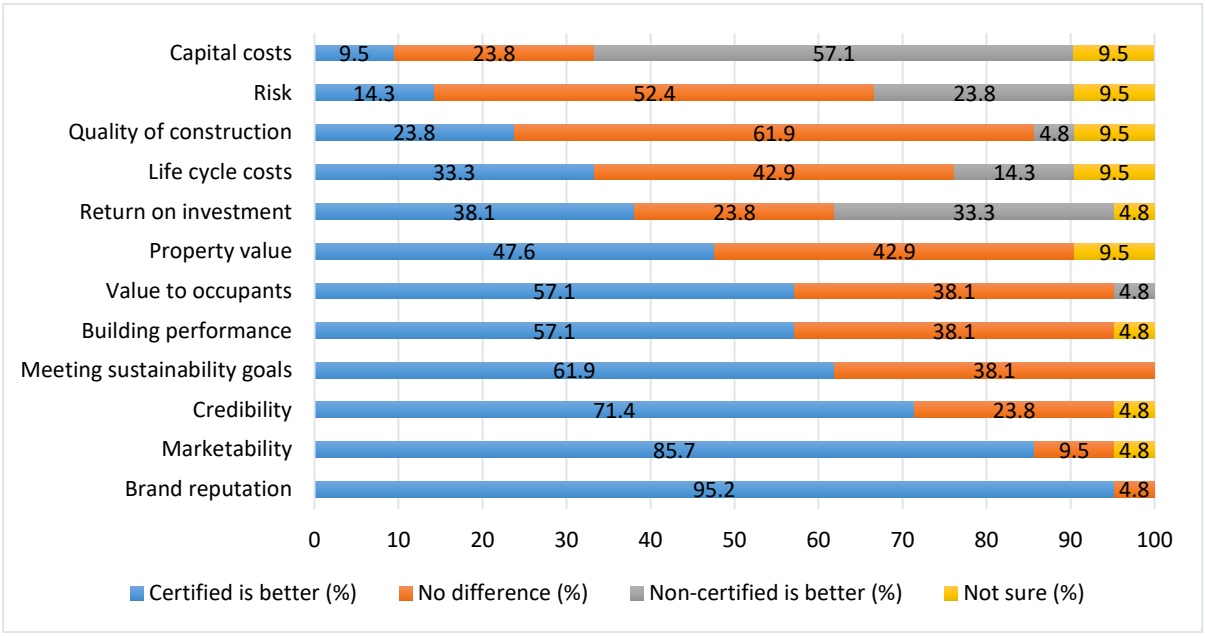

Figure 5: *Perceptions on the Value of Certified Buildings*

We conclude that there is enough evidence from the data to reject the null hypothesis, supporting that there is some association between perceived building certification status and the criteria. The criteria were then analyzed based on the responses of the twenty-one (21) participants for whether they perceived that certified buildings were better, there was no difference, non-certified is better, or they were unsure. The breakdown of their responses is presented in Figure 5. In terms of capital costs, 57.1% felt that the costs for non-certified buildings are better than for certified buildings. Certified buildings were considered to be better than non-certified buildings in relation to five criteria, including brand reputation, credibility, marketability, building performance, and meeting sustainability goals. For three criteria, the majority of respondents indicated no difference between certified and non-certified buildings. When considering the quality of construction, 61.9% felt that there was no difference, 52.4% felt that there was no difference in terms of risk, and 42.9% felt there was no difference in terms of life cycle costs. While 47.6% felt certified buildings are better in terms of property value, 42.9% felt there was no difference between certified and non-certified buildings.

A variety of sustainable building certifications that were pursued in the past and are currently pursued are presented in Figure 6. Nineteen (19) of the respondents' organizations had pursued a sustainable building certification in the past, and two (2) had never pursued a sustainable building certification. The most common certification pursued in the past and presently is LEED. The "Other" category included certifications such as Enterprise Green Communities, Passive House, Austin Energy Green Building (AEGB), Fitwel, WELL, Building Owners and Managers Association (BOMA) International. Based on the data collected, those that indicated that their organizations had pursued LEED or any sustainable building certification in the past were asked if they were currently pursuing certification. In total, nineteen (19) reported that their organization had pursued certification in the past, while fifteen (15) indicated that their organization was currently pursuing certification. The breakdown of the types of certification pursued is presented in Figure 6.

To determine the factors that were responsible for the decision to pursue (15 respondents) or not pursue (4 respondents) a sustainable building certification, the most common reason was leadership decision to pursue, and some respondents specifically mentioned the owner's decision was the driving force to pursue certification (Figure 7). Financial benefits were the most common factor in the decision not to pursue certification. Responses indicated that most projects in this category were deterred by the financial constraints of sustainable building certification. For those that were pursuing certification, other factors that were mentioned included owner/client requirement, when the building typology lends itself to sustainable learning opportunities (e.g., university science buildings), environmental responsibility, meeting requirements, providing a LEED laboratory for certification of buildings and experience for students, and operational benefits.

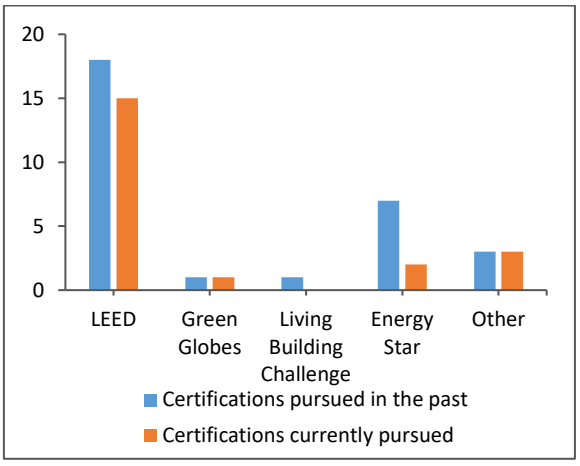

Figure 6. *Certifications pursued for building projects*

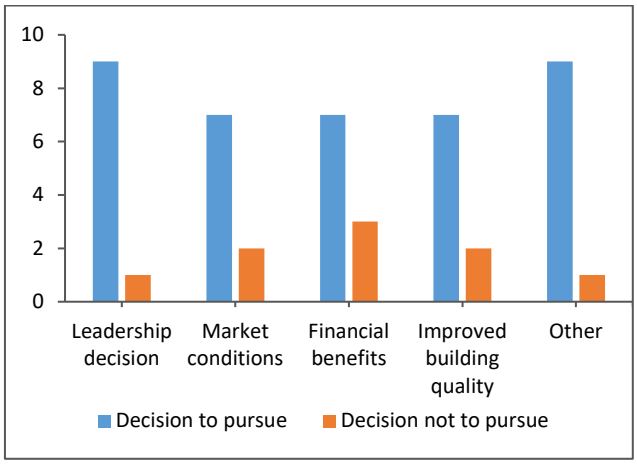

Figure 7. *Factors that informed the decision for sustainable building certifications*

Concerning the parties involved in the decision making to pursue certification, thirteen (13) of the respondents indicated that the building owner is mostly involved, followed by the architect and facilities management team (Figure 8). Other individuals

that were identified are the sustainable design consultant, LEED-certified designer, sustainability director, and the sustainability team.

The key party involved in the decision-making process to pursue or not to pursue certification is the building owner. Depending on the type of facility, the building owner is sometimes part of the leadership team (i.e., a university building). The project architect is involved at an early stage of the design process and plays an important role in determining if the building pursues certification or not. The involvement of the facilities management team is determined by the owner. In campus settings, the facilities manager may be involved early on in the design process to provide input on the design. For newer facilities, the facilities manager may not have been selected during the design phase, but may be involved during the commissioning phase of the building. Studies have indicated that early stage decisions for sustainable buildings can provide the most significant benefits and improve project success (Bragança et al., 2014). Early involvement of key parties can also increase project success.

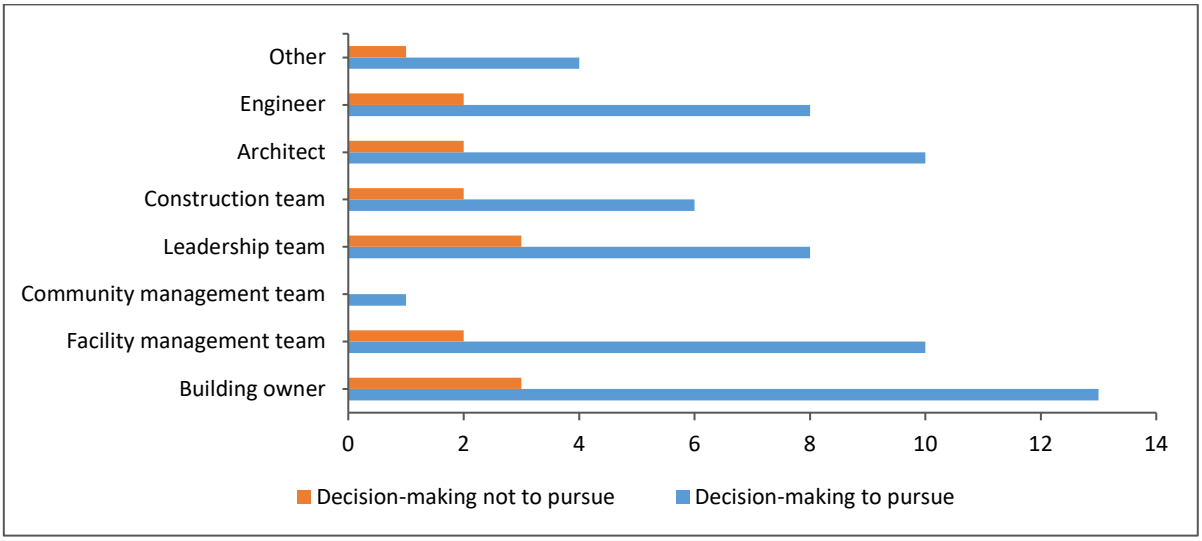

Figure 8. *Parties involved in the decision-making for sustainable building certifications*

Ten (10) of the respondents monitor or track several parameters relating to sustainable building performance goals, namely, post-occupancy evaluations to monitor occupant satisfaction, energy use, water use, building commissioning, operational care performance, indoor air quality, rainwater capture, sustainable landscapes, daylight, views, district energy usage and efficiency, interior materials, access to transit, renewables (on-site and off), innovation, waste management and landfill diversion, data sharing and access, access relating to the Americans with Disabilities Act (ADA), acoustics, thermal comfort and ventilation, green vehicle, and space utilization. Tracking these helps with managing the buildings, monitoring costs, and is beneficial for decision making for future projects. In contrast, eleven (11) respondents indicated that they do not specifically measure anything in relation to sustainability for buildings that are sustainable but not certified.

The most common standards or guidelines that are followed by respondents who measure or track building performance parameters to indicate a measure of success are LEED, ENERGY STAR, American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards, and others including Stars, 2030 Challenge, carbon measures (operational & embodied), sustainability Key Performance Indicators (KPIs), and Guiding Principles for Sustainable Federal Buildings.

The respondents explained that sustainable but not certified buildings were viewed with some scepticism since there is no evidence of sustainability, except when some metrics are deliberately tracked. Also, certification provides some accountability that would otherwise be difficult to implement. While some owners are committed to sustainability and are persuaded about the benefits of certification, the costs involved are usually a turnoff. The perceived value of certified buildings is also a subject that is up for discussion, and the true value of certification to the building owner should be further explored.

4. Conclusions

This paper has looked at perspectives on sustainable building certification and the implications for different stakeholders. The article discussed the emerging challenges of certification for building construction and management and the decisions to certify or not to certify. The building owner is a major driving force in the decision to pursue sustainable building certification, and this is consistent with the literature in the sense that certification is market-driven, and building owners take into account customer expectations. The project architect is involved at an early stage of the design and plays a vital role in determining if the building pursues certification or not.

Based on the responses collected, cost is a crucial factor in the pursuit of sustainable building certification. Results suggest that third-party certification may offer notable advantages in relation to brand reputation, credibility, marketability, building performance, and sustainability goals, but not necessarily in relation to risk, capital cost, life cycle cost, return on investment, and quality of construction.

The response rate of the initial survey is low, and facility-based personnel represented only 20% of the responses. Future work involving broader dissemination of the survey questionnaire, broader participation from facility-based personnel, and participant interviews will provide further insights into the factors that affect the decisions on sustainable building certification, as well as selection and monitoring of performance criteria, including implications and trends.

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The effects of environmental performance on competitiveness: A stochastic frontier approach

Environmental performance and competitiveness

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Abstract

The main inputs to economy are the environment and natural resources especially in biodiversity countries. Because of this, they are associated to the competitiveness and efficiency taking into account that natural resources are a factor for production affecting productivity and growth. Moreover, if natural resources will become scarcer, which require to anticipate this change to prevent a decrease on competitiveness. In this context, the analysis of competitiveness and its relationship with environmental performance is an important topic, especially in emerging economies with high biodiversity as a strategy to promote and prevent environmental damage and to improve competitiveness. This study evaluates the effects of environmental performance on competitiveness using a stochastic frontier approach in Colombian regions using the competitiveness index based on methodology proposed by world economy forum for global competitiveness index and different environmental variables, which allows us to understand how environmental performance plays an important role in the results of competitiveness in Colombian regions that evidence economic and social disparities. The results of this study suggest the importance of environmental performance for the increase competitiveness. Increased environmental performance should lead to an increase in competitiveness. It is important to close regional gaps through political instruments that promote adequate environmental measures that consider competitiveness and innovation to promote sustainable development and the responsible use of natural resources. The findings of this study are important to design adequate instruments that include environmental performance and competitiveness as key elements to promote sustainability, growth and welfare in Colombian regions.

Keywords: Competitiveness, environmental performance, sustainability, empirical analysis, political instruments, Colombian regions

1. Introduction

In recent years, the concept of sustainable competitiveness has emerged as the set of institutions, policies and factors that make a country productive over the longer term while warranting social and environmental sustainability. This definition implies high-quality growth, natural resource management, social equality, human development and well-being, which should be the ultimate objectives of companies, businesses, society and national development (Corrigan et al., 2014) where it is important to determine the effects of environmental performance on competitiveness.

Achieving competitiveness requires having access to certain resources and skills. Such factors can be divided based on two perspectives. The first (Huggins and Izushi, 2015) focuses on basic (natural resources, climate, unskilled and semi-skilled labour and debt capital) and advanced factors (information and communications infrastructure, highly educated labour such as engineers and computer scientists and university research institutes in sophisticated disciplines). According to the second perspective (WEF, 2016 and 2019), basic factors of competitiveness include education, health, infrastructure well-functioning markets and a fourth industrial revolution in terms of business sophistication, innovation and research and development; these factors are considered fundamental to achieving development, growth and competitiveness. According to these perspectives, environmental management and performance are central in that competitive economies are better positioned to adopt greener technologies and processes and transition to a low carbon or “de-carbonized” economy. For this reason, it is important to analyse how different environmental variables may affect competitiveness, especially in countries with higher levels of biodiversity and natural resources.

The purpose of this paper is determine the relationship between environmental performance and competitiveness for Colombian regions. Colombia is studied due to its biodiversity and natural resource wealth and thus relevance to an analysis of the above relationships to formulate adequate policies and guarantee sustainable development. Overall, this study makes important contributions to the current debate on sustainable development and competitiveness. This paper is structured as follows. Section 2 describes our methods and data. Section 3 presents our results and a discussion. Conclusions are drawn in Section 4.

2. Methods

We use the stochastic frontier model and its various techniques to estimate levels of economic efficiency for different Colombian departments, using the production levels of Colombian departments as an analysis unit and proxy. Stochastic frontier techniques have been widely used to measure efficiency levels of different production units and economic sectors (Agovino, et al., 2020, Benedetti et al.,2019), allowing for the estimation of how different variables affect competitiveness and inefficiency (Parmeter and Kumbhakar, 2014).

Given that we use departments as production units in our empirical analysis, we use Cobb-Douglas technology in a translogarithmic manner to make estimates. In the Colombian case, there have been no studies on the efficiency of departments using stochastic frontier techniques, which is the main contribution of the present work. It should be noted that efficiency is a relative concept and that its determination involves the comparison of different available alternatives obtained from diverse combinations of productive resources.

In this paper, we model the effects of environmental performance on competitiveness using the Cobb-Douglas production function where the competitiveness of departments (IDC) is influenced by factors such as: the coverage of aqueducts (CA), coverage of natural gas (CGN), coverage of electric energy (CEE), and cost of electric energy (CoEE). We also include expenditures on research and development (R&D) as a percentage of gross domestic product together with the technological progress denoted by A, which represents total factor productivity (TFP). The main data sources are the following: the Private Competitiveness Council and University of El Rosario (2019), the Superintendent of Public Services, Colombian Office of Statistics (DANE), the Mines and Energy Ministry, the Colombian Electric Information System and Energy Mining Planning Unit, the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM), among other.

3. Results and Discussion

In this section, the trends and analysis of the flow of materials in different periods of time in the city of Bogotá are presented, taking into account the main inputs and outputs at a general level and by components where dynamics of growth and decrease are observed according to different pressures or actions on the environment or the greater awareness of the inhabitants of the city.

To analyse the effects of environmental performance on competitiveness, one model was developed using the stochastic frontier approach to reinforce systematic statistical evidence for the proposed relationships. In this section, we present and discuss the main results of the model (see table 1).

Competitiveness is the result of adequate resource and risk management where a robust control system and management can achieve competitive improvements and respond more efficiently to the requirements of a complex world (Saedi et al., 2019, Tekathen and Dechow, 2013). The proposed model analyses the number of ISO 14001-certified companies, the municipal risk management index and the adequate disposal of solid waste in identifying positive relationships between these variables and competitiveness. Therefore, improvements in risk and environmental management and the adequate disposal of solid waste can improve competitiveness index values among Colombian departments.

These results show that environmental and risk management are closely connected to strategies and competitiveness due to affect costs, differentiation, cost savings, reductions in resources and energy, the anticipation of events and future trends of

innovation, social aspects and potential risks, making it important to proactively and responsibly manage environments, risk and competitiveness (Lopez-Gamero and Molina and Azorin, 2016, Hadj, 2020).

Table 1. Results of model used to analyse relationships between competitiveness and sustainability

	Environmental and risk management	
	[1]	
	Stochastic frontier	**(Std. Err)**
Constant	1.702[a]	(0.047)
Total factor productivity (TFP)	0.182[a]	(0.037)
ISO14001-certified companies	0.017[b]	(0.010)
Municipal risk management index	0.017[b]	(0.007)
Adequate disposal of solid waste	0.003	(0.003)
σ2	0.153	(0.115)
γ	0.997	(0.001)
σ_u2	0.152	(0.115)
σ_v2	0.000	(0.000)
Log likelihood	80.042	
Wald test	89.89	
Number of groups	33	

Figures shown in parentheses are standard errors. [a] Significance at the 1% level, [b] Significance at the 5% level, [c] Significance at the 10% level.
**If Prob>chi2 is < 0.05, random effects are rejected.*

4. Conclusions

The study shows that environmental performance has a positive effect on competitiveness in Colombian departments. This is turn highlights the importance of protecting the environment and biodiversity, which can in turn encourage development, social inclusion and growth in Colombian regions.

The findings of this study can help policy- and decision-makers enhance competitiveness based on environmental performance, which can in turn limit the depletion of natural resources and alleviate the effects of pollution and climate change, social issues and low productivity while improving efficiency levels, encouraging more effective use of forests, natural landscapes and ecosystems, and facilitating the development of cleaner technologies and entrepreneurial endeavours. Such factors can in turn encourage progress through sustainable development.

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Provision, quality of and access to education

Assessing Education from Space: Using satellite Earth Observation to assess pupil density in primary schools in rural areas of Nigeria

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Abstract

Nigeria is a country with a rapidly growing youthful population and the availability of good quality education for all has long been a key priority for the country. An important element of this is the improvement of access to high-quality primary education in rural areas. A key indicator for achieving this is the provision of adequate classroom space for more than 20 million learners in Nigerian public schools as overpopulated classrooms are known to have a strong negative impact on the performance of both pupils and their teachers. However, it can be challenging to assess this indicator for over 60 thousand primary schools, especially in rural areas.

In this research, we evaluated the pupil density of schools in Nigeria using satellite Earth Observation (EO) data to determine the size of available teaching spaces coupled with a governmental database of school-provided data on the number of enrolled pupils between 2011 and 2014. From these data, we evaluated the area per pupil of 1900 randomly selected public primary schools in rural areas across 19 Nigerian states, spanning all regions of the country. In order to identify overcrowded schools, we used the minimum standard threshold defined by the Federal Government of Nigeria which states that schools should provide at least 1.2 m^2 of classroom space per pupil. Our analysis shows that, by this definition, 71 % of the schools examined were overcrowded. Such overcrowding can be expected to have a negative impact on educational performance, achieving universal basic education and on meeting the UN Sustainable Development Goal 4 - Quality Education.

While measuring floor area can readily be performed manually *in situ*, collecting and reporting such data for the number of rural primary schools in a large and populous country such as Nigeria is a substantial, time-consuming administrative task with considerable potential for errors and data gaps. Satellite EO data are readily available, provide accessibility in remote areas, are reproducible and is easy to update over time. This paper provides a proof-of-concept example of how such EO data can contribute to addressing socio-economic dimensions of the UN's Sustainable Development Goals framework.

Keywords: Earth Observation, UN Sustainable Development Goals, education, socio-economic, pupil density schools

Introduction

Nigeria is the most populated country in Africa, and the seventh in the world. It also has one of the largest populations of youth in the world. From an estimated 42.5 million people at the time of independence in 1960, Nigeria's population has grown to around 195 million in 2018 (http://data.un.org/en/iso/ng.html). Although in 2014 Nigeria became the largest economy on the African continent (Friedman, 2014), the country still faces many serious issues such as violent rebellion and terrorism, endemic corruption, low life expectancy, inadequacies in public health systems, income inequalities, and high illiteracy rates (Ajiye, 2014; UNDP, 2018).

Policies aimed at providing free universal primary education for all children pre-dates Nigerian independence in 1960. In the 1950s, the colonial government recognised that secondary and tertiary education should be prioritised in order to provide the required number of teachers to achieve universal primary education (UPE). The attainment of UPE gathered pace during the 1960s but was piecemeal as separate states implemented their own policies (Oni, 2008). However, in 1976 the military government, in power at the time, launched a major effort to implement free UPE across the entire country and this was based on a significant school building programme as well as the recruitment and training of teachers (Oni, 2008). Despite the prioritisation of UPE by successive governments, both civilian and military, the realisation of UPE remains a challenge and, since 1976, there have been many initiatives designed to address bottlenecks and constraints within the system. Since the 1970s the UPE programme has morphed into 'Universal Basic Education' (UBE), and at the time of writing, UBE covers six years of primary school and three years of junior secondary education. This can be followed by optional three years of senior secondary education and four years of tertiary education.

Primary education is the only level of education that is available in urban and rural areas throughout the developed and developing world, is the largest subsector of any education system and offers a unique opportunity to contribute to the transformation of societies. In Nigeria, responsibility for educational institutions is shared between different bodies at the federal, state and local government levels, and a suite of indicators have been developed to help assess attainment and the quality of UBE that is received by pupils. Various standards for basic education were urged by the Universal Basic Education Commission (UBEC) (2000) in order to attain the Millennium Development Goal (MDG) 2 (Achieve universal primary education).

Nigeria's education system struggles with the challenge of an ongoing lack of adequate facilities. In particular, there is evidence that UBE faces multiple issues such as insufficient classroom space to accommodate the high pupil enrolment, inadequate furniture and no functional chalkboards, lack of maintenance of the building infrastructure and the lack of teachers. All these lead to overcrowded classrooms and this greatly limits the quality of the education that can be attained (Chege et al., 2008; Okojie, 2012; Dunne et al. 2013; Humphreys and Crawfurd, 2014). UBEC's (2010) report does not specify a legal minimum space requirement for classroom dimensions. However, it does provide provisions and guidance on space norms and these include a minimum standard for learning space at 1.2 m^2/ pupil in rural primary schools (1.4 m^2/pupil for semi-urban and urban primary schools) (UBEC, 2010).

Currently, among the suite of standards listed in UBEC (2010), the key indicator that the Nigerian government uses for measuring quality education and equity is the Pupil- Teacher Ratio (PTR) (http://uis.unesco.org/node/334770), with an ideal value set at 35:1 for primary schools. Values higher than this equate to overcrowding in schools. As reported in a research survey by Ayara et al., (2013), much higher PTRs do occur, such as 49:1 in primary and 62:1 at the junior secondary level in Cross River state schools. A remarkable example of high PTR linked with overcrowding is noted in the following report by Sherry in 2008: *"all the schools I have seen are hugely overcrowded. In one record case, in a rural school, I saw a class of over 200 pupils of ages ranging from 11 to 21 with only one teacher to attend to them"* (Sherry, 2008, p. 39–40). In particular, a five year study of the Nigerian education system and its ability to support equitable access to and improve the learning outcomes from basic education systems called 'Education Data, Research and Evaluation in Nigeria (EDOREN)', funded by the UK Department for International Development and delivered by Oxford Policy Management, found that: "*consideration needs to be given to alternative ways of assessing classroom overcrowding, to complement pupil–teacher ratio rates, as the latter does not necessarily give an accurate indication of the numbers on the ground and can give the impression that classes are of manageable size when in reality they are not."* (Humphreys and Crawfurd, 2014). Overcrowded classroom are well-known to be detrimental to educational outcomes (Opanuga et al., 2019) and have also been reported in many studies as having a negative impact on adult literacy (Fowler and Walberg, 1991) as well as on youth literacy (Domike and Odey, 2014). Respondents of surveys in Nigeria have often noted how a shortage of building infrastructure can result in overcrowded classrooms (Ijaiya, 1999; Olaleye et al., 2017) and Ikoya and Onoyase (2008), in a comprehensive national survey of primary school infrastructure, found that 53 % of schools surveyed lacked fundamental structures.

Likewise, a major barrier to improving access to education also includes the prevalence of poverty (Amzat, 2010), gender biases (Salami, et al., 2020), and the poor state of public primary school infrastructure (Hardman et al., 2008; Ikoya, 2008; Sherry, 2008; Olaleye et al., 2017). In addition, the Education Sector Support Programme in Nigeria (ESSPIN) assessment of basic education facilities in Kano, Jigawa and Kaduna states concluded that around 75 % of school infrastructure was "'*very poor*"' (ESSPIN, 2009), while the 2009/10 school census in Adamawa State deemed 67 % of public primary school classrooms to be in '*poor condition*' (Dunne et al., 2013). The prevalence of poverty (Amzat, 2010), gender biases (Salami et al., 2020) etc play a role in educational attainment and that poverty is a common determinant of the level of educational attainment in Nigeria (Bruns et al., 2003; Federal Ministry of Education, 2005; Amzat, 2010; Ehigiamusoe, 2013). For example, the wealth of an area can influences the resources allocated to education but also, of course, limited availability and quality of education can itself result in people having less opportunity and thus increases their likelihood of being in poverty.

It will be clear from the above that overcrowding in classrooms is recognised as an important factor relevant to educational attainment in Nigeria and is often inferred from the PTR metric. Here we propose a direct determination of space allocated to pupils using satellite Earth Observation (EO) to measure classroom size. While classroom areas could be readily assessed by school staff, EO provides an opportunity for an independent, and, through image recognition machine learning algorithms, rapid assessment of teaching spaces for the whole country. Because many Nigerian rural primary schools are built to a common pattern, they are easy to spot from satellite imagery. Each school is located near a road, with a playing field in front and a line of rectangular buildings (classrooms) behind and typically running parallel with the road. Thus, unlike surveys and measurements *in situ*, EO satellite data provide the potential for a rapid, inexpensive and accurate assessment (Harrington et al., 2017).

In this study, we provide a first proof-of-concept assessment of the use of EO data for measuring school building footprints (area m^2) that could help governments and non-governmental organisations (NGOs) to quickly identify schools with overcrowded classrooms. We have measured classroom areas (m^2) for 1900 rural primary schools across 19 Nigerian states, and combined this with available enrolment data to estimate the area per pupil for each school. Primary schools in rural areas were chosen for the research because i) rural primary schools are an important component of delivering Nigeria's UBE ambitions and ii) most rural primary schools are single- storey buildings facilitating accurate measurements from satellite imagery.

Given the lack of published and official data on the area (m^2)/ pupil or pupil density in primary schools in Nigeria, the authors needed to find a way of testing the validity of their values for the indicator. One way of doing this would have been to measure the actual floor space of classrooms *in situ* for a small sample of schools, and then compared that to the EO measurements estimates, and arrangements have been made to perform these studies after the COVID-19 outbreak. As an alternative, to test the accuracy of the approach it was to correlate the EO-derived area per pupil with a number of other indices, notably poverty and literacy rate, to check whether it has validity. It was assumed that a relationship between the EO-derived area/pupil and indicators such as poverty and literacy rate should be seen. If no such relationship was observed, then this would cast some doubt on the validity of the EO-derived area/pupil index.

1. Materials and Methods

1.1. Study area

Nigeria has 36 federal states plus the Federal Capital Territory of Abuja, divided into 6 geopolitical zones. Within the states, there are 744 local governments in total. For this study, we selected 19 states (Fig. 1) spanning all six geopolitical regions of the country, aiming to cover a wide diversity of political and religious beliefs.

1. North Central- Kogi, Benue, Kwara, Nasarawa
2. North eastern- Bauchi, Taraba, Gombe
3. North Western- Sokoto, Kaduna, Zamfira
4. South- Edo, Delta, Cross River
5. South- Eastern- Enugu, Abia, Anambra
6. South Western- Ondo, Oyo, Osun

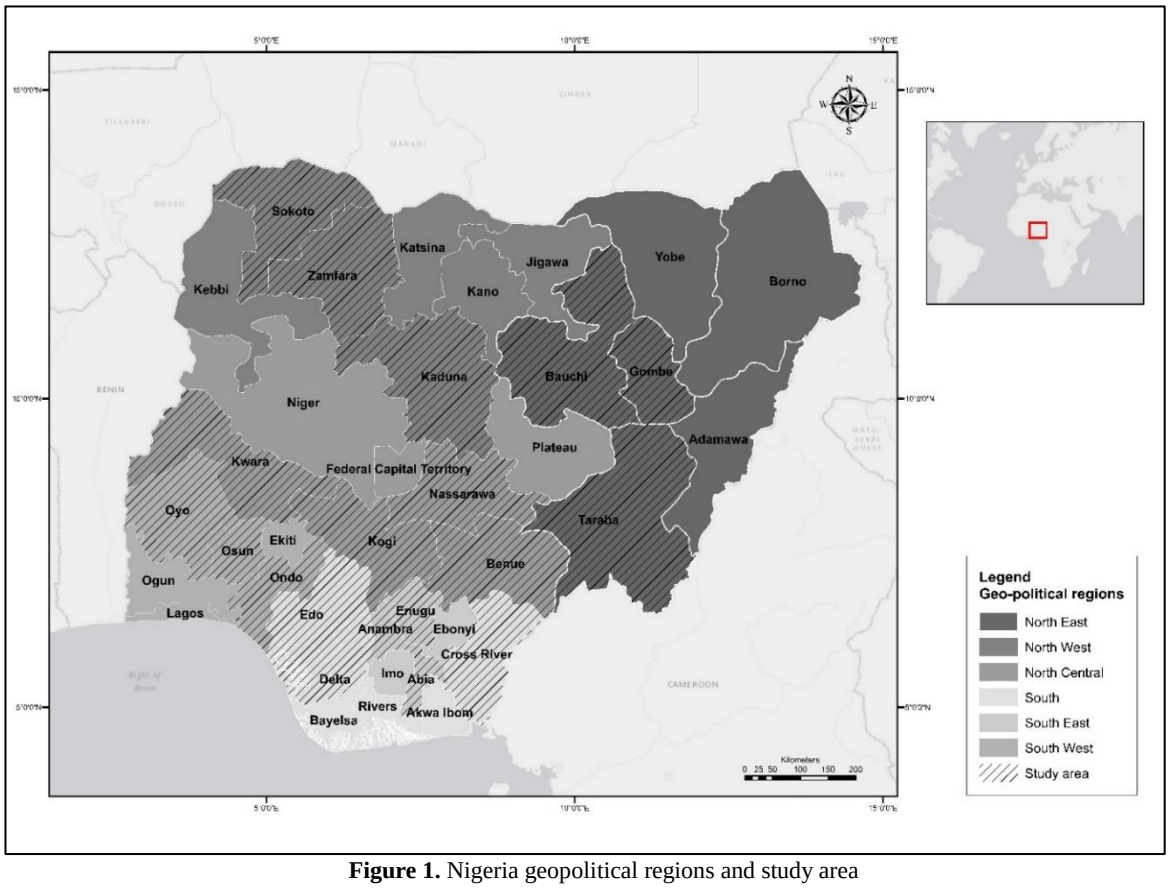


Figure 1. Nigeria geopolitical regions and study area

1.2. Data Sources

Nigerian governmental data resources for rural primary schools and satellite imageries from Google Earth Pro were used as the main data sources. Firstly, the location of all schools was obtained via the Education Facilities in Nigeria (EFN) database which includes school location (latitude and longitude), school type, school name, number of children, number of toilets, date of survey (survey period between 2009 and 2014), and number of teachers. The database comprises 98,667 schools across Nigeria. The goal of this dataset was to build Nigeria's first nation-wide inventory of education facility, to make the data collected available to planners, government officials, and the public, to be used to make strategic decisions for planning relevant interventions and to help achieve the MDGs.

The Google Earth Pro platform uses historical satellite and aerial images that collect each image at a specific date and time. However, for this study, only satellite imageries were available, and they were mostly provided by Maxar Technology (Digital Globe) and CNES/ Airbus. Therefore, we used very high spatial resolution satellite imagery (> 1 m) to measure the buildings. In addition, for the best results of measurements, we used a top-down view of the image as it is recommended (https://support.google.com/earth/answer/9010337?co=GENIE.Platform%3DDesktop&hl=en).

In order to complement the EO-derived indicator (area (m^2)/ pupil), we used a series of statistical analyses based on literacy data and poverty indices. We extracted the youth literacy percentage (children age 5-16 able to read) by State from the Nigeria Education Data Survey (NPC, 2010) for the 19 states (fig.1). This survey was designed to provide information about literacy and numeracy of adults and children, and other aspects of educational attainment, based on a sample of 30,000 households.

The poverty indices used in this paper were from the www.worldpop.org models (https://www.worldpop.org/focus_areas#case5). This dataset is based on geolocated household survey data, Demographic and Health Surveys (DHS) program, Living Standards Measurement Study (LSMS) program, either $1.25 and $2 a day consumption-based poverty metrics and Multidimensional Poverty Index (MPI). The data was available at the local government area (LGA) level. Likewise, we used relative poverty rates (%) per State obtained from Nigeria Poverty Profile (National Bureau of Statistics, 2010). Relative poverty measurement is defined by the living standards of the majority and separates the poor from the non-poor. The threshold at which relative poverty is defined varies from one country to another, thus households with expenditure in Nigeria greater than two-thirds of the total household per capita expenditure are considered non- poor whereas those below it are poor.

1.3. Determination of the area (m^2) per pupil

Certain features e.g. school geolocation, pupil numbers (see Fig. 2) were extracted from the EFN database. Then, from the 60,000 public primary schools across the country, we randomly selected 1900, with at least 2 km between schools, spanning all the regions of the study areas. Thus, having the coordinates of the school location, these data were coupled with manual measurement of the footprint area of the school buildings using the satellite imagery to obtain the area (m^2) per pupil (see eq. 1) for the time of the EFN survey (2011-2014). As Google Earth Pro provides historical images, most of the measurements were undertaken at the same or close to the EFN survey year.

$$\textbf{Area } (\mathbf{m}^2) \textbf{ per pupil} = \frac{\textit{total school size}(\mathbf{m}^2)}{\textit{total number of pupils}} \quad (1)$$

To identify overcrowded schools, we used the minimum standard threshold definition of UBEC (2010) of at least 1.2 m^2 per pupil.

In terms of the identification and validation of school location, we observed that most sample schools followed a common pattern as expected from the rapid school building programme that took place during the 1970s. Fig. 3 shows four examples of school configurations and locations which present characteristic patterns and a typical morphology, such as a schoolyard with bare soil or mowed grass, rectangular-shaped buildings, having up to 5 building units in a row, L or U building layout, and being in a peripheral location in the village with the main road passing by.
In addition, *in situ* measurements are currently underway in Nigeria aiming to validate (ground truthing) EO teaching areas estimates. The results to date suggest that the figures are in alignment.

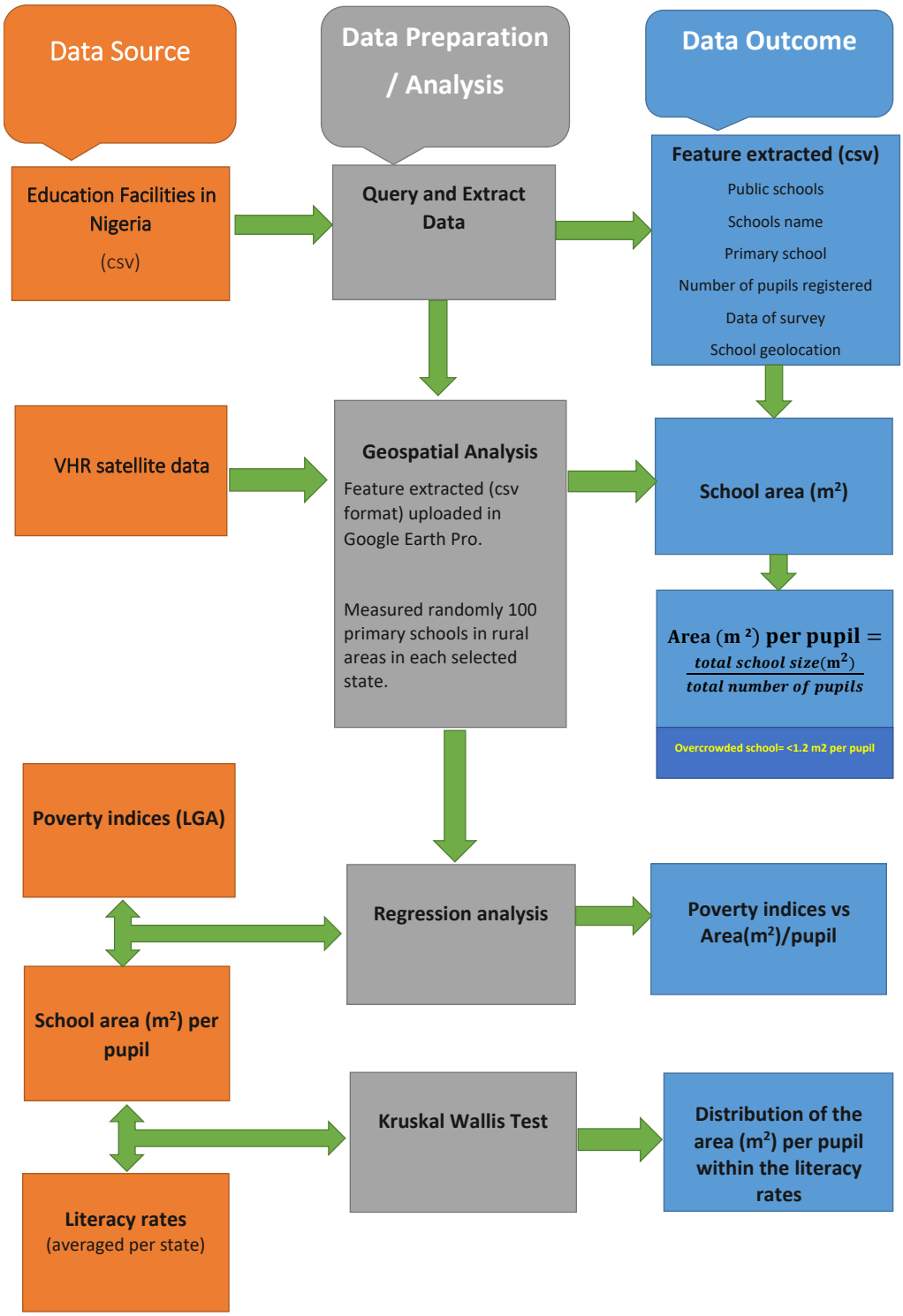
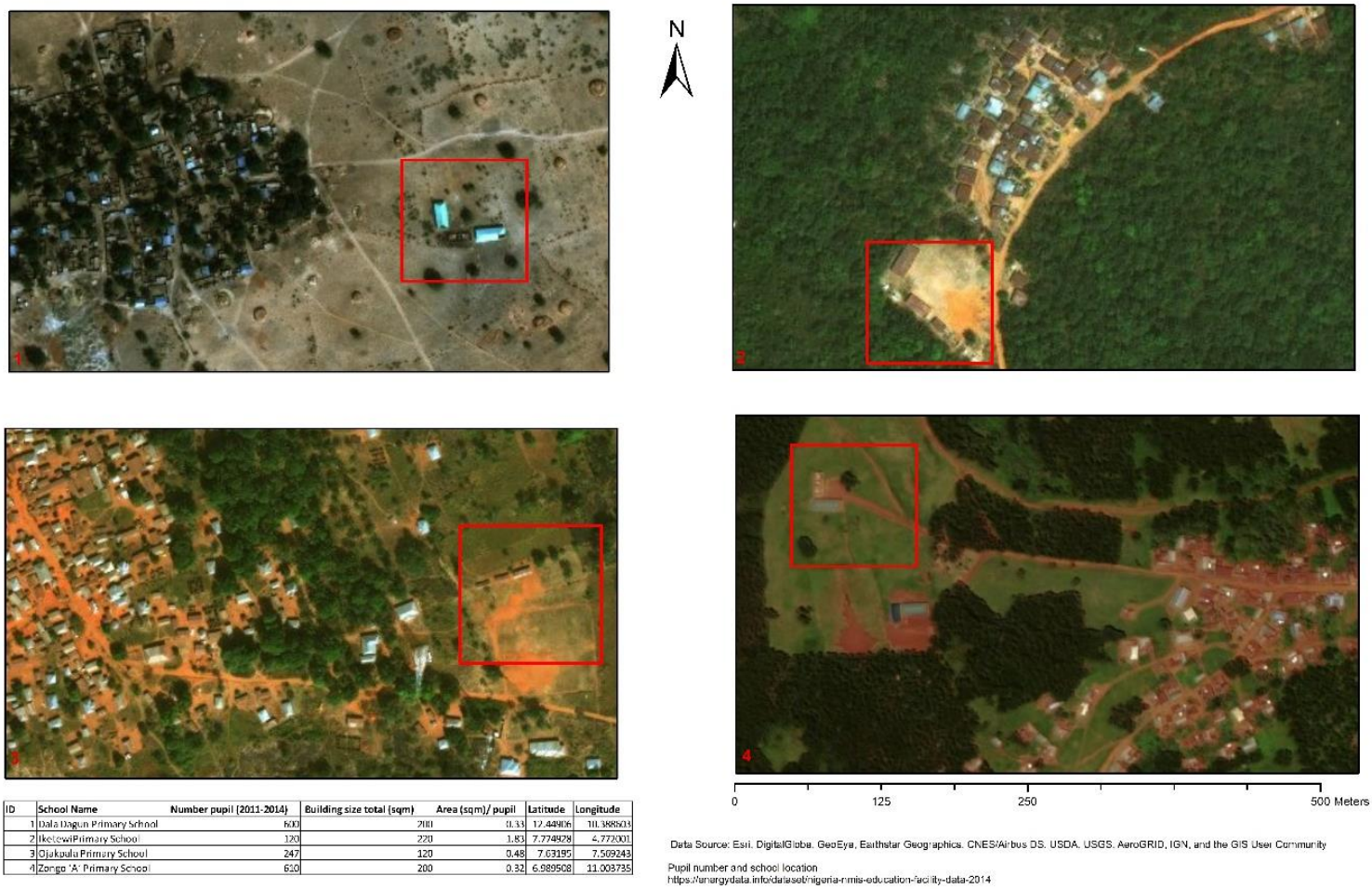


Figure 2. Workflow for the derivation of overcrowded rural primary schools in Nigeria and its relationship with poverty indices and literacy rates.



ID	School Name	Number pupil (2011-2014)	Building size total (sqm)	Area (sqm)/ pupil	Latitude	Longitude
1	Dala Dagun Primary School	600	2181	0.33	12.44906	10.388504
2	IkeCewiPrimary School	120	220	1.83	7.774928	4.772001
3	Ojukpula Primary School	247	120	0.48	7.63195	7.509243
4	Zonga 'A' Primary School	610	200	0.32	6.989508	11.003735

Figure 3. Examples of the characteristic spatial patterns and locations of Nigerian rural primary schools.

1.4. Data analysis

In order to understand the relationship between overcrowding and poverty, a regression analysis was used to relate area (m^2) per pupil with poverty indices given at the LGA level for 380 schools (20 for each state). An empirical relationship was determined, using the regression model of the form (2):

$$\ln(y) = \ln(a) + b\ln(x) \qquad (2)$$

where:
y= area (m^2)/ number of pupils registered;
a and b are regression coefficients
x is the poverty index (described by a value from 0 (low poverty) to 1 (high poverty))
ln = natural logarithm

Additionally, we wanted to test the validity of the values obtained from equation (1) and evaluate the relationship between overcrowding schools and literacy. As the literacy data (% of children 5-16 able to read) obtained were averages for states, the data were related to area (m^2)/ pupil using the Kruskal-Wallis test. The Kruskal Wallis test is the non-parametric equivalent of the analysis of variance (ANOVA). The literacy rate groups were as follows: Group 1- 0-25 %; Group 2- 25- 50 %; Group 3- 50- 65 %; Group 4- 65- 80 %; Group 5- 80-100 % (Table 1). Furthermore, we ranked all the area (m^2)/ pupil score in all 1900 observations, where we assigned the lowest rank to the lowest area (m^2) per pupil. If two or more scores were the same, then they were "tied". "Tied" scores get the average of the ranks that they would have obtained, had they not been tied. After the data were ranked, we could sort them into the literacy groups (Table 1). As a last step, the Kruskal-Wallis formula was applied in order to test the hypothesis. Note that the Kruskal-Wallis test merely identifies that the 5 groups differ in some ways, inspection of the group means, and medians are used to evaluate the extent of the differences.

Table 1. Groups by Youth Literacy rates (%)

Youth Literacy (%)	**Group 1**	**Group 2**	**Group 3**	**Group 4**	**Group 5**
	0- 25 %	25- 50 %	50- 65 %	65- 80 %	80-100 %
Study States	Bauchi	Benue	Kogi	Edo	Abia
	Taraba	Nasarawa	Kwara	Delta	Anambra
	Sokoto	Gombe	Cross River	Ondo	Osun
	Zamfara	Kaduna	Enugu	Oyo	

2. Results

A high proportion (71 %) of the rural primary schools evaluated were found to have less space per pupil than the UBEC's minimum space requirement of 1.2 m^2/pupil, with only 29 % of the schools provided at least the minimum space.

Figure 4 shows the distribution of space per pupil across the 1900 schools studied. The red vertical line represents the desired 1.2 m^2/pupil. Thus, schools on the left of that line are overcrowded and schools on the right meet or exceed the minimum space requirements. More than 700 schools have extremely low space per pupil (0.2 - 0.7 m^2/pupil) and around 350 schools provide an area per pupil between 0.7- 1.2 m^2.

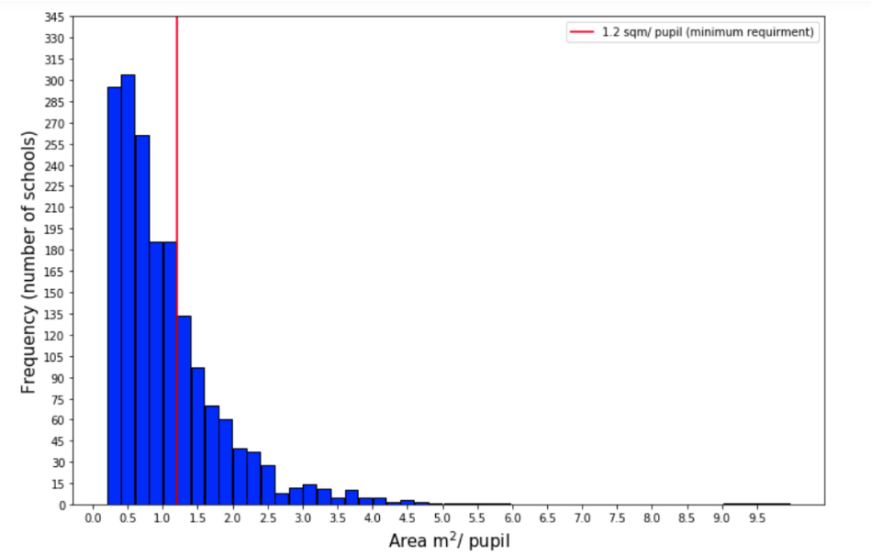


Figure 4. Distribution of area (m^2) per pupil in schools

Figure 5 presents the number of overcrowded schools for the 100 randomly- selected, rural primary schools at the individual State level. It is noticeable that the proportion of overcrowded schools varies by State with a higher proportion of overcrowding occurring in the north and northern central states, whilst in half of the southern region states have more than 50 % or more of their rural primary schools with at least the minimum space for learning.

Likewise, figure 5 illustrates the relative poverty rates (%) by State, data extracted from Nigeria Poverty Profile 2010 (National Bureau of Statistics, 2010). States such as Bauchi, Kwara, Gombe, Nasarawa, Taraba, Sokoto, and Zamfara, where over 90 % of schools per state are overcrowded, have poverty rates over 70 %. In the states Benue, Delta, Edo, Enugu, and Kogi, 50 % - 90 % of schools are overcrowded and these schools have lower poverty rate (60 % - 69 %). The states Abia, Cross River, Ondo, Osun, and Oyo have the lowest percentage (20 % - 60 %) of overcrowded schools and these States also have the lowest poverty rate (30 % - 59 %).

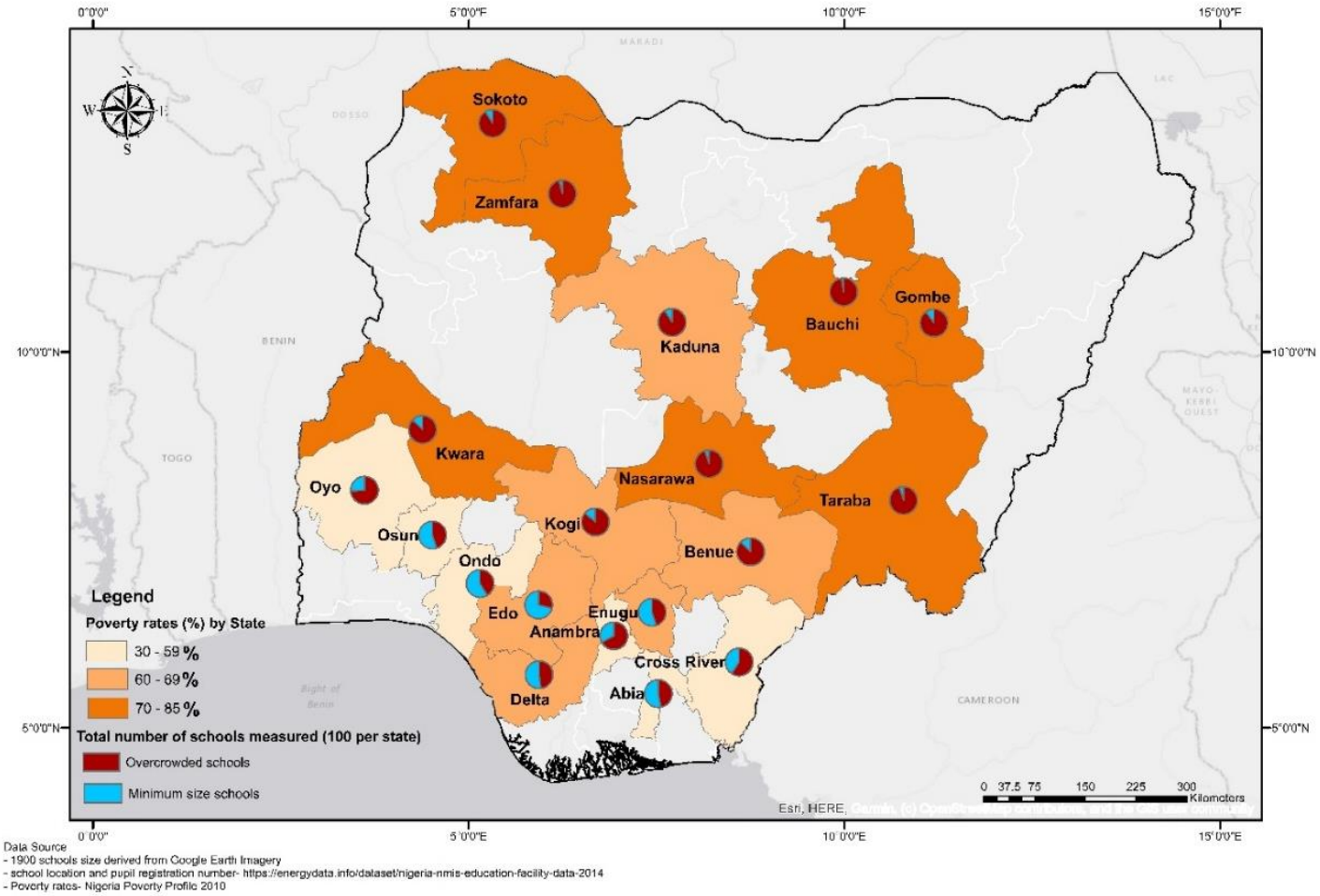


Figure 5. Primary school conditions in Nigeria (rural areas) (2011-2014)

Figure 6 shows the relationship between the poverty index (values from 0 to 1; higher values represent poorer regions) (*x*-independent variable) and area m^2/pupil (*y*- dependent variable) in 380 measured schools. Empirically, we chose the best-fit model, a power regression, to these results. We can also see in fig. 5 when *x* values increased *y* values decreased, indicating a moderate relationship between the prevalence of poverty and school space per pupil (poorer the population of LGA is less area for a pupil in school is available). Overcrowded schools (<1.2 m^2/pupil) fall below the red horizontal line and those above provide at least the minimum space per pupil.

Table 2 presents the statistical significance of the coefficients ln(*a)* and *b* alongside with the standard error (SE), whereas the R^2 denotes the percentage of the variation that the independent variable affects the dependent variable. The chosen fitted model is statistically significant at P<0.001.

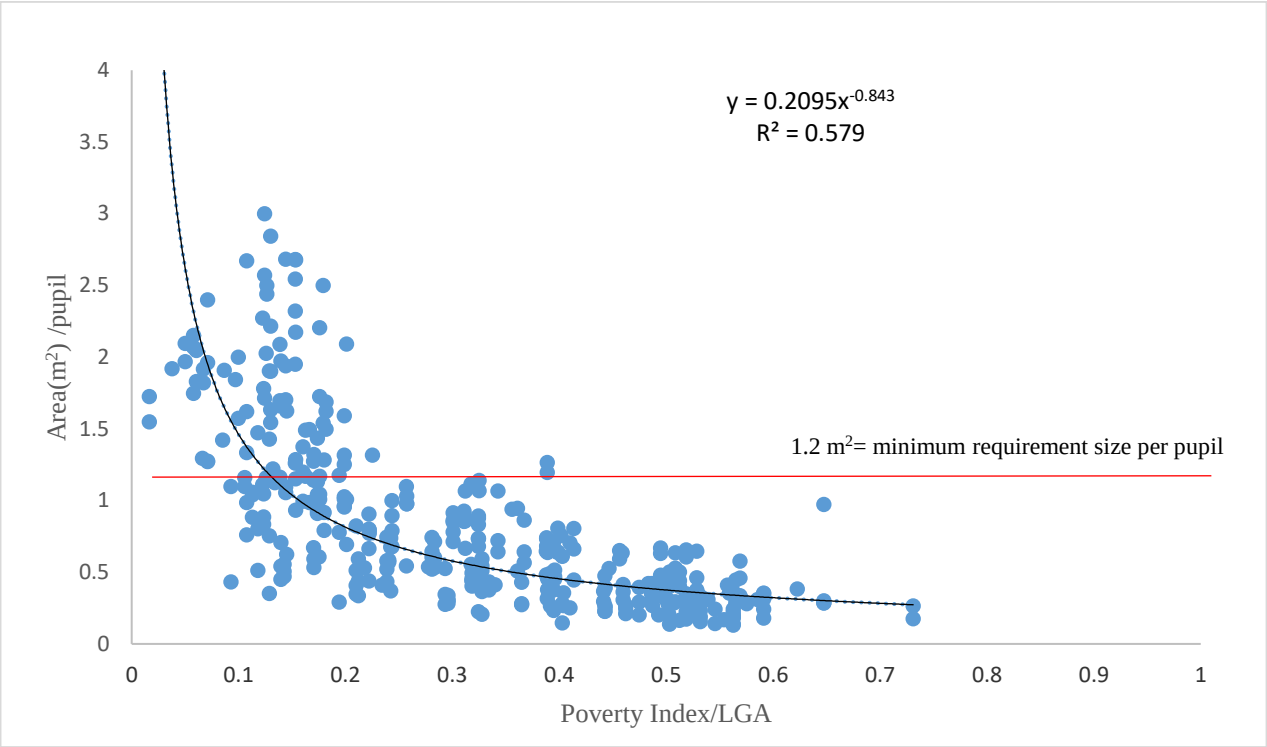


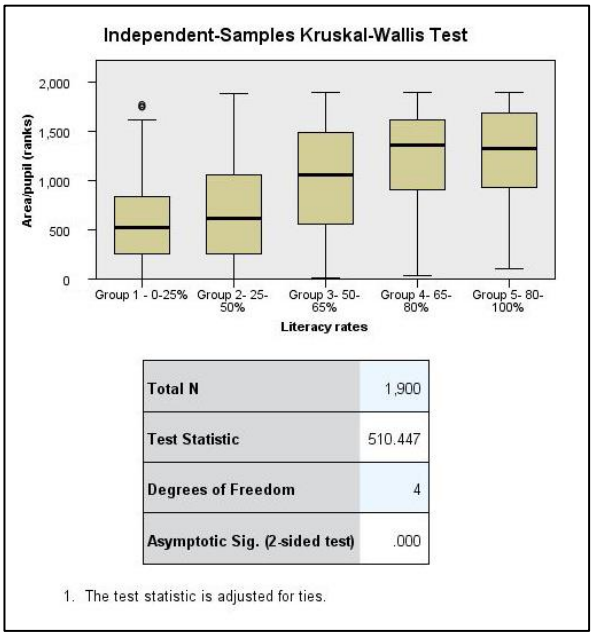
Figure 6. Relationship between Poverty index (at LGA level) vs. Area (m^2)/ pupil

Table 2. Results of a regression analysis on logarithm area/pupil (dependent variable) and logarithm Poverty Ratio (independent variable) for Local Government Areas in selected states in Nigeria.

Coefficient	Coefficient (SE)	t-value and significance
LN(a)	-1.563(0.055)	-28.34***
b	-0.843 (0.037)	-22.8***

R^2 = 57.9 %; F = 519.92*** (df = 1, 378)
*** P<0.001

In Fig. 7, the Kruskal-Wallis test indicates that lower rank (overcrowded) schools are associated with low literacy rates (up to 50 %) and, conversely, higher ranks correlate with greater literacy rates. Therefore, the table in Fig. 7(b) provides the information about the test performed where we can observe that Groups 1 and 2, and, Groups 4 and 5 data distribution are the same with the significance level over 0.05.



Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Group 1 - 0-25%-Group 2- 25- 50%	-102.342	38.794	-2.638	.008	.083
Group 1 - 0-25%-Group 3- 50-65%	-438.269	38.991	-11.240	.000	.000
Group 1 - 0-25%-Group 4- 65-80%	-665.230	38.650	-17.212	.000	.000
Group 1 - 0-25%-Group 5- 80- 100%	-700.802	41.823	-16.756	.000	.000
Group 2- 25- 50%-Group 3- 50-65%	-335.926	38.991	-8.615	.000	.000
Group 2- 25- 50%-Group 4- 65-80%	-562.888	38.650	-14.564	.000	.000
Group 2- 25- 50%-Group 5- 80- 100%	-598.460	41.823	-14.309	.000	.000
Group 3- 50-65%-Group 4- 65-80%	-226.961	38.848	-5.842	.000	.000
Group 3- 50-65%-Group 5- 80- 100%	-262.533	42.006	-6.250	.000	.000
Group 4- 65-80%-Group 5- 80- 100%	-35.572	41.690	-.853	.394	1.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.

Figure 7. Association between Area/pupil with State-level literacy rates (a) Data Distribution of area (m^2)/ pupil within the literacy rates (left hand figure); (b) Groups linkage of data distribution (right hand figure)

3. Discussion

This paper presents a novel application of EO satellite data in measuring the floor area of a large sample of rural public primary school buildings across 19 Nigerian States. We relate these measurements to nationally reported pupil enrolment data, thus determining how many of these schools would be deemed overcrowded. This approach identified that 71 % of the schools measured appeared to be overcrowded. In order to illustrate the potential value of our results, we performed further exploration of the distribution of the overcrowded schools and their interlinkage with poverty indices and literacy rates.

While measuring floor area could obviously be performed manually *in situ* by school staff or others, the collection and reporting of such data for the number of rural primary schools in a large and populous country such as Nigeria is a substantial, expensive and time-consuming administrative task, with potential for miscalculation and data gaps. On the other hand, EO data are readily available, provide accessibility in remote areas, are easily operated (convenient and free use of Google Earth) and easy to update over time as schools add more classroom buildings. For example, from the EO data, we were able to observe from the sample that 113 schools had been extended and 130 schools had been demolished between 2011 and 2019. Therefore, we suggest that EO data can provide appropriate reliability, accuracy and convenience for assessing classroom areas at the national scale and this clearly has the potential to be automated via Artificial Intelligent/machine learning approaches (see Yazdani et al., (2019) for rural schools in Liberia). We consider that the ability to rapidly and remotely evaluate overcrowding in the rural primary schools in this study should help in recognising priorities for government and government agencies to focus attention and investment.

As noted, EO data is convenient and easily available but some limitations exist. We based our analysis on the total area of the school buildings and assumed that this was primarily dedicated to classrooms. Classrooms are understood to be the major use of the space, but satellite images cannot distinguish other usages within the building (e.g. presence of offices, storerooms). In our calculations, we did subtract the areas for lavatory facilities (UBEC, 2010) minimum requirement is for one toilet at 1.2 m^2) using data for each school extracted from the EFN database. When doing this it was also found that only 37 % of schools are reported to have at least one toilet on the school premises. Secondly, the EO images cannot determine the quality of the classroom space e.g. internal condition of the building, availability of desks, availability of equipment, blackboards etc. Thirdly, the approach is not straightforward for schools that have more than one storey (mostly in urban areas). In Nigeria, the majority of rural schools were built to a common single-storey design, but urban schools often have multiple storeys due to the more limited space available. It may be possible to estimate height using shadow length taken at a particular time of the day, but even so, the assumptions become more complicated.
Finally, the results of this study would have been validated ideally by direct measurements of some of the schools sampled. Such validation was planned in the research, but regrettably, this has not been possible to date given restrictions caused by the outbreak of coronavirus in Nigeria and elsewhere. This will be undertaken in ongoing research.

In our previous work (Andries et al. 2018; Andries et al. 2019), we developed a framework for assessing the suitability of EO data for supporting the UN Sustainable Development Goal (SDG) framework. EO approaches can be important, efficient, enabling tools to help authorities progress on a number of the UN's SDGs. Figure 8 summarises how EO, as used in the present study, could support the Nigerian government to help to achieve SDG4 (provide quality education and promote lifelong learning), to provide equal access to opportunities (SDG 10) and eventually to reduce poverty (SDG 1). We hope that this study will increase awareness of the value of satellite EO approaches for identifying the specific example of overcrowded classrooms and, more generally, in supporting the socio-economic SDGs as well as the environmentally focussed ones. Given the challenges involved in implementing the SDGs then the adaptation of a number of indicators to enable them to make use of readily available EO date would seem to present a valuable opportunity to calibrate progress efficiently and economically.

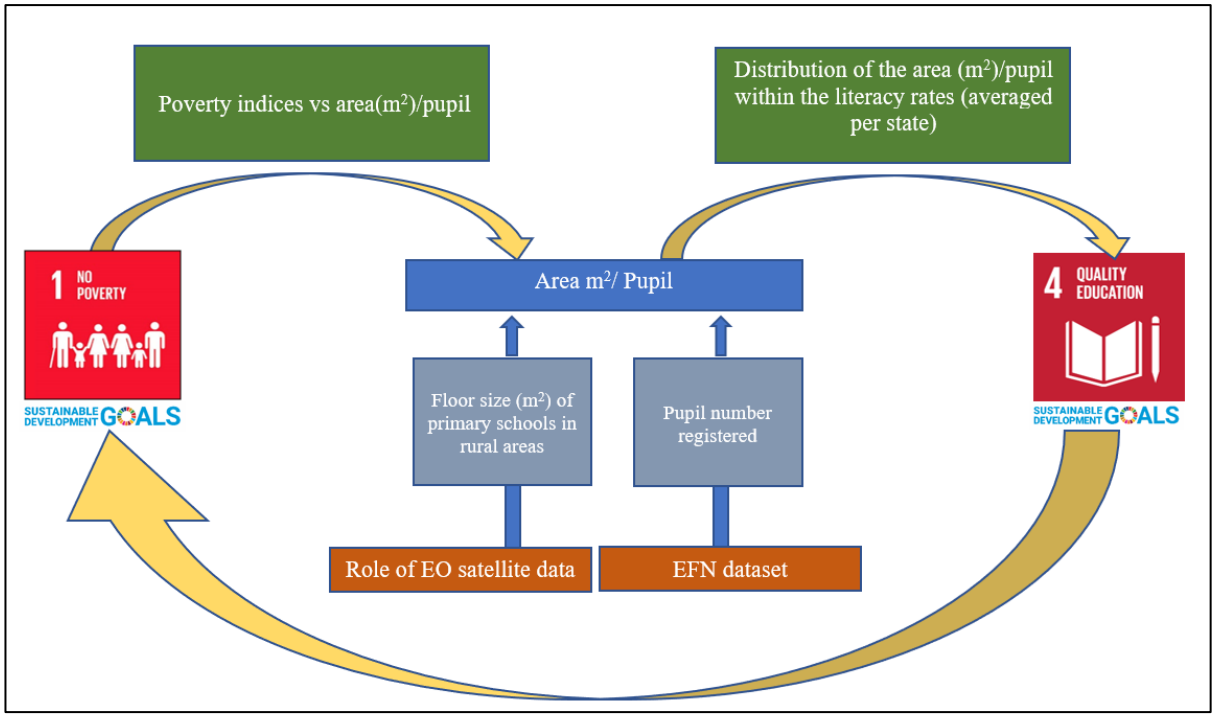


Figure 8. Role of EO in characterizing area per pupil (overcrowding) in rural primary schools in Nigeria as support for the UN SDGs

4. Conclusions

The following conclusions can be drawn from this research:

- Overcrowded classrooms with less than 1.2 m^2/pupil in rural primary schools in Nigeria were readily identified using satellite EO tools in combination with available school enrolment data.
- The use of such EO approaches offers a cost- and time-efficient approach to support improvements to education in Nigeria and elsewhere, particularly for those schools with one floor
- Identifying the location of inadequate classroom space using satellite EO can provide important information to help progress towards the UN SDGs for quality education and lifelong learning (SDG 4), equal access to opportunities (SDG 10), and reduce poverty (SDG 1).

In wider terms, this study has also highlighted how EO-derived information can offer effective and complementary support for sustainable development, including for indicators that are more closely aligned with social dimensions.

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Design Education for Sustainability

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Abstract

Currently, more scientists recognize education for sustainable development as an integral element of improving the quality of education and a key factor for the sustainable development of society. Do not leave aside the activities of designers who contribute to improving education for sustainable development. At first glance, the activities of designers are aimed only at creating new products and supporting the economy; in fact, their activities are quite diverse and affect the environmental and social spheres of society. This article aims to expand the knowledge of designers' contributions to education for sustainable development. The article describes design skills, which include: research skills; skills to create a new product; presentation skills; communication skills; reflective skills (Kadyirov, 2019). All of these skills allow designers to engage in professional creative activities, as well as contribute to education for sustainable development, for example, to develop and create products using recycled materials to maintain the environment and the economy; find new solutions that will help improve the standard of living and culture of the population. Moreover, these skills can be mastered by other professions, such as engineers, architects, etc. In order to increase professional competence and the level of cognitive interest of students, the question arises of improving existing and creating new methods of creative work with students, as well as highlighting the most productive methods from a number of existing ones. It should be noted that lifelong learning is also an important component of training designers, as it is important to consider not only formal training, but also non-formal and an informal (Kálmán, 2016). The most productive pedagogical technology is art-project activity, as it helps to increase the level of students' professional training by completely immersing students in activities important for achieving learning goals, as well as motivating them to engage in self-learning and education throughout all life in order to lead them to sustainable development (Kadyirov, 2019).

Keywords: Education for sustainability; Design skills; Lifelong learning; Art-project activity; Pedagogy

1. Introduction

The term “sustainable development” has become the most common after its actual adoption at the 1992 United Nations Conference on Environment and Development in Rio de Janeiro (UNCED). The main document adopted at this time, “Agenda 21” points to the importance of reorienting education systems to promote sustainable development and raising public awareness of the world's problems (Agenda 21, 1992). Nevertheless, a modern understanding of education in this direction was formed later, and it includes three components: environmental, social and economic. UNESCO’s current definition is: “Education for Sustainable Development is education that enables the social transformations necessary to create more socially equitable societies and achieve sustainable development” (UNESCO, 1997). The United Nations believes that education is a central element in efforts to develop and promote sustainable solutions for development needs of both individual countries and peoples, and the entire planet. Education makes it possible to understand the nature and scale of sustainable development issues; it makes it possible to formulate the critical, non-standard and creative approach necessary to search for more effective solutions to global problems; it allows people to understand the essence of those powerful factors that determine an unstable lifestyle; and it can help people develop self-confidence, organizational skills and optimism that will allow them to act individually and collectively for the benefit of the interests of a sustainable future (Ilyin & Ursul, 2016).

The international community began active work on education for sustainable development in the 2000s. Initially, environmental non-profit organizations dealt with such issues. For this reason, in many countries there is a misconception that education for sustainable development and environmental education perform the same functions. UNESCO in its publications emphasizes that these are different concepts. Paying tribute to environmental education and the roles of those who developed and supported education for sustainable development after 1992. Therefore, it is worth noting that environmental education is only one of the three parts of education for sustainable development, along with social and economic education. It is also important that education is usually referred to as the social sphere, since as a form of activity, education acts as an informational interaction of an individual, society, and nature. There is a close relationship between science, education and society (as well as nature), but this connection has features of its manifestation in various periods of development of culture and civilization. Education, being an important process and an integral part of cultural and civilizational development, mainly reflects the main

features of this development. Therefore, we can talk about the formation of an industrial society, a post-industrial society, an information society, a society with sustainable development, the future noosphere, etc.

Education for sustainable development is extensive, and includes aspects such as planning and development of political decisions, implementation of programs development, finance, teaching, administration, etc. Theorists divide education for sustainable development into two types. In the first case, it is an education about sustainable development, when students directly study its concept and principles. The second is education for sustainable development, when it comes to developing the skills necessary to achieve it. For example, systemic and critical thinking, which helps to consider economic, environmental, social and cultural aspects; the ability to establish partnerships, establish dialogue, participate in decision-making, understand human rights and freedoms, maintain and protect them.

The development of design skills of design students is impossible without certain specific exercises that contribute to the development of their design thinking. According to N. Cross, "design skills is a group of skills that stand out by such a feature as community in relation to project activities. The purpose of the project activity is the construction of a technological process for the design and manufacture of products and the solution of creative problems" (Cross, 2011). Taking into account the second type of education for sustainable development, we can notice the connection and references to design skills, which include a set of skills: research skills; skills to create a new product; presentation skills; communication skills; reflective skills. It is worthwhile to consider design skills more detailed:

Research skills are a person's ability to perform a set of certain operations to carry out empirical and intellectual actions, the ability to carry out research activities, which leads to new knowledge. Explaining in simple terms, research skills are a person's ability to make assumptions, establish causal relationships, look for solutions to various problems, put forward a hypothesis, conduct experimental work, draw conclusions and conclusions, organize existing material, work with information and text.

Skills to create a new product are set of conscious practical actions that allow designer to carry out creative activities for modeling, designing and creating a material product (the ability to sketch and model a new product, technological skills to create a material product). It is important to note that a new product is a service or idea that is perceived by potential consumers as new.

Presentation skills are the ability to speak publicly in order to present new ideas or products, the ability to convince or encourage listeners to take any action. These skills include: the ability to behave confidently during a speech, the ability to use various means of visibility, the ability to respond to questions from listeners, artistic skills, the ability to correctly present the results of work in a convenient form for perception by the audience.

Communicative skills are a set of conscious communicative actions that are based on a high theoretical and practical preparedness of a person, which allows him to creatively use the knowledge gained to reflect and change the surrounding reality. This complex includes the following skills: the ability to work in cooperation, the ability to listen and understand the interlocutor, the ability to enter into a dialogue with the interlocutor, the ability to ask and answer questions, the ability to participate in discussions.

Reflexive skills are the ability of a person to generalize his actions, understand the course of his thoughts, draw conclusions from feedback, as well as any rethinking of them. In particular, a person can turn his attention to the content and functions of his own consciousness, which include thinking, personality structures, mechanisms of perception, decision making, emotional response. Reflective skills include: the ability of a person to comprehend his own activities, the course, stages of an activity and its intermediate results, the ability to carry out self-esteem, the ability to determine the basis of activities, the ability to predict the course of his actions, the ability to return to the beginning of an activity and evaluate the correctness of a chosen plan, ability to take responsibility for the happened actions, the ability to organize his own activities step-by-step, the ability to correlate results with the purpose and etc. (Kadyirov, 2019).

All of these skills allow designers to engage in professional creative activities, as well as contribute to education for sustainable development, for example, to develop and create products using recycled materials to maintain the environment and the economy; find new solutions that will help improve the standard of living and culture of the population. Moreover, these skills can be mastered by other professions, such as engineers, architects, etc.

2. Methods

In order to achieve an effective level of mastery of design skills, special attention is supposed to be paid to the initial training and retraining of teachers and the creation of opportunities for them to exchange experience among teachers involved in the innovative process of establishing education for sustainable development. Strengthening of the innovative emphasis is obtained with close coordination with the relevant results in the theory and practice of education for sustainable development. Mastering the basics of education for sustainable development depends on the content, quality and availability of teaching materials on education for sustainable development issues, which are not even in a number of countries where the vast majority of the population has not heard about education for sustainable development (Sherman, 2008). The concept of education for sustainable development is evolving, new international agreements are adopted every year, many scientific reports on this topic are published, innovative approaches are being introduced. But not every teacher is able to track all these processes in

the current state of higher education. It is worth paying more attention to the competencies mastered in higher education, where these competencies reflect the ability and willingness of students to use the knowledge, skills and abilities gained during their studies in solving professional problems while realizing their own professionally significant personal qualities.

Sustainability refers to imply a capacity for human beings to continuously adapt to environmental and societal conditions (Scott, 2002). The principles and practices developed for sustainability education should have a flexible, adaptable character to ensure their relevance in a variety of different settings. Building healthy, responsive educational systems requires that schools continuously learn and adapt, rather than press on with the outdated education practices. Rather than simply meeting set standards and "checking off" that sustainability has been taught, the challenge lies in developing methods and actions through which students are effectively acquiring key competencies in support of sustainable actions (Sterling, 2001).

Competence-oriented education stresses student outputs, whereas traditional, didactic approaches in higher education have centered on teacher inputs. The input approach is often related to standards for whether the teacher has covered the material pertaining to conceptual strands (Arizona Department of Education, 2005). In contrast, the output-oriented approach focuses on students gaining the "concepts and abilities for social action" (De Haan, 2006). Taking an output-oriented approach herein, sustainability competencies embody the concepts and skills that will enable students to understand and resolve complex sustainability problems by equipping them with the ability to become change agents (Wiek et al., 2011). In discussing educational approaches that reinforce the competencies, we emphasize pedagogy in terms of the teaching and learning methodologies and strategies that support the attainment of sustainability competencies (Frisk & Larson, 2011). In order to increase professional competence and the level of cognitive interest of students, the question arises of improving existing and creating new methods of creative work with students, as well as highlighting the most productive methods from a number of existing ones.

Subject-subject relations, involving an equal interaction between the teacher and the student in the process of achieving educational goals, unfortunately, are rare. This is a serious problem that requires timely solutions, since the use of the subject-subject approach significantly increases the effectiveness of the learning process and gives an opportunity of the efficient solution of such educational tasks as: activation of the learning process, increasing motivation for learning, building subject-subject relationships in the human-nature system, brake the barriers between the student and the teacher, activation of thinking, establishment of dialogical relations, promotion of the manifestation of personal qualities, creative their abilities, desire for cooperation and social activity (Akhmetshina, Kadyjrova, 2017).

It should be noted that lifelong learning is also an important component of training designers, as it is important to consider not only formal training, but also non-formal and an informal. The education policy of lifelong education (UNESCO) primarily focuses on the widening of the meaning of education, which has been unnaturally narrowed down to formal (university) learning, together with all its practical consequences. As opposed to the rapidly spreading misunderstanding, it is not about the fact that society should transform into being university, however, its reverse. It essentially means an amendment, that is, the broadening of the horizon of education, which, in this way, will include non-formal as well as informal learning in addition to formal learning. The new, extended concept of education incorporates learning outside the university, whether it is less formalized course attendance (non-formal learning), learning formalized with non-learning purposes or informal learning related to non-formalized activities. As a result of the broadening of the definition, all the support activities of education (counselling, development, assessment and evaluation, as well as organization, management and financing, among others) should also cover all types of learning. This, on the one hand, will lead to the transformation of the traditional roles at the university. On the other hand, all other life activities should be organized in a way that they could enable and inspire everybody to learn and develop, or at least they should not eliminate learning or make it superfluous (Kálmán, 2016).

3. Results and Discussion

It should be noted that design can not be attributed to any single, narrow sphere of human activity, which specializes only in a certain aspect of the production of a range of services in the modern consumer market. The designer's activities include the following types: design and material science, art and science, socio-economic and psychological-analytical activities. Thus, we can say that design is at the junction of art, science and production. It turns the product manufacturing process into a predictable act of creating a consumer services market of the modern, so-called "consumer society".

We can say that art-project activities are complex synthesis of art and science, theoretical and practical activities of a specialist in the field of design. Art-project activity requires an initial good theoretical base, using art history and scientific knowledge, the universality of their application in various situations, the use of experience accumulated by mankind throughout the history of the formation of the objective world. In addition, the person involved in art- project activities requires the ability to form a creative design, ideas, the ability to find optimal solutions to design creative tasks, choose the right materials and means of expression, the ability to plan the creative process taking into account the specifics of the project situation (Grigoriev, 2007).

The most productive, in our opinion, pedagogical technology is art-project activity, as it helps to increase the level of students' professional training by completely immersing students in activities important for achieving learning goals, as well as motivating them to engage in self-learning and education throughout all life in order to lead them to sustainable development. Art-project activity, which is based on the merger of a variety of already developed methods and technologies, is an effective foundation for the development of design skills of designers, since it helps students to be included in the creative process of transforming reality, forms the skills of original thinking and reveals their creative potential (Kadyirov, 2019).

Conclusions

It is well known that a design product is a product that is optimally solved in terms of technology, aesthetics and economics. The specialist's activities in the field of design are focused actions to create and translate the idea into the final result (i.e., art-design project), and in this process, the designer uses both borrowed and his own knowledge, skills that solve the tasks. The designer defines and accepts ways to solve the problem of a functional, stylistic, volumetric, spatial, nature, taking into account historical, cultural, material, social, moral, etc. conditions (Asessorov, 2009).

In our opinion, the formation of education for sustainable development will become the main educational process in world education in the current century. It is important to pay attention to global environmental issues, the economic status of countries, as well as the standard of living of the world's population. The solution of such global issues is possible only with the united interaction of the whole world. It is even possible to assume that this will be a kind of "educational revolution", which can be called a "sustainable revolution" in education and the world.

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IMR Research Day – 7th of January 2019

Fatima Homor

Abstract

Change agencies in the society are understood via research and education. Business schools according to the recent literature tend to be rather traditional, not meeting the new requirements of the society concerning societal transitions. Business schools, which are the nests for business knowledge transmission and as part of academic institutions provide practical and experiential knowledge base, may become change agencies in the societal transitions due to changes in the society such environmental, innovational or social expectations.

Analyzing the currently available literature, elements are collected in this article. These elements are based on a three level analysis starting from change agency theories (change agents on an institutional level), through academic institutions as change agents till business schools as academic institutions being agencies of change to meet the new requirements of our society. The elements form a framework, which frame the role, responsibilities, barriers and challenges of the business schools in these change processes.

Pursuing the most key actors makes a change agent; therefore individuals willing to initiate change at business schools to meet the new requirements of the society must be persuasive towards the decision makers at a supreme level. Action-gap is to be filled in via the personal motivation of change agents at business schools independently from their position. Business schools were first funded by the church, later mostly by the states, which inevitably creates dependence, therefore the interest of the business schools' owners have to be met. Business schools being part of academic institutions can become change agencies in countries that are on different levels of economic innovation but ought to choose a diverse pathway.

Business schools as academic institutions have been acting as reactive change agencies, responding to the outsider economic, social, political, religious expectations, though these institutions have never acted as pro-active initiators of

changes for public service, which was originally one of the three missions of academies. They have been adaptive change agencies, instead of transformational ones.

It is generally going to be a significant win for the society at large when business schools step onto the road of becoming change agencies at a rather significant scope instead of local, smaller scale and the knowledge transmission will be based on mode 3 type of knowledge production releasing the hands of future intra- and entrepreneurs acting as responsible business personnel to meet the new requirements of our society. This article provides the framework for it built up of elements gained with the comprehensive understanding of high-value research articles.

On-line Collaborative Learning Approach to SDGs in the Pedagogy Studies

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Abstract

Recently the teachers training programs have an essential role in the development of competencies on sustainability for the students of vocational education and training. According to the new on-line learning environment and good teaching practices with Information and Communication Technologies (ICT), we need to implement the Sustainable Development Agenda of the United Nations for the year 2030. In Sustainable Development Goals (SDGs), medication has a special role in developing inclusive equity, justice, and property within the environment limit. According to applied methods, the central point was the improvement of student activity in the frames of collective open content development. We assumed that this pedagogical approach through the new program based learning as content construction effects the student's cognitive domain, to enable develop sustainability competencies. Serving the modernization of the subject named Digital Pedagogy, our project aims to develop an innovative method, relying on the principle of open access, allows the students to do everyday development activities in a framework system (Moodle). The project has offered the opportunity of cooperation in developing learning content, involving the lecturers and students (46 persons) into the construction works on various micro-content manageable online with the help of the method. Our original target was an opening up the possibilities of the online collaborative system of the new media with the help of an open curriculum development model, which supports the digital learning process of students.

Keywords: Collaborative Learning, Open Content Development, Sustainability, Teacher Training

Introduction

We aimed to address new sustainability changes in work relations, attitudes, and values using transformative collaborative learning tools. This paper presents going-on research forwards to change the vision and needs for new content development in vocational education and training (VET) through online, collaborative learning. We were starting from our original construction of the collaborative open content development (OCD) based on the results of learning content digitalizing projects (Benedek&Horváth, 2016), which was built upon the stimulation of the change in the teaching-learning paradigm. Nowadays, in the VET content development, the rapidly changing elements determined by digital transformation aspects (Beetham&Sharp, 2013), and the dynamics of the changes are challenging to be forecasted.

This study reviews the pedagogical micro-content produced by our MSc vocational teacher students in our Open Curriculum Development Project, which was created in the online collaborative learning process. The pedagogical course provides an opportunity to analyse global issues and challenges that have provided significant educational potential for VET students in terms of interdisciplinary interactions and the recognition and discussion of global challenges. The results of this project illustrate the potential of the everyday problem of sustainability in the methodological application of open curriculum development by analysing the thematic and genre specificities of micro-content (system thinking, future-oriented thinking, collaboration, strategic thinking, modelling sustainable behaviour) analysis in the school environment is a means of communicating students' motivational development. In conclusion, the process, which has already been introduced and tested in the teaching practice, shapes the teachers' content development culture at the micro-level. The development of

micro-content allows collaboration while the size of the task and the time demanded by the applied process can be adjusted to the teachers' everyday activities. An essential condition of this method, which focuses on a training field broader than the traditional discipline-subject-based view, is that teachers get targeted preparation to use it.

Methods

According to our practical project activities, it builds on the empiric performances that evaluate the new approach of pedagogical content development: community content development, which means the collaborative development of learning units or micro-content taking place with the participation of teachers and students. In a modern pedagogical sense, it is highly attractive to examine the notion of modality in terms of teaching and learning in the new technological environment. In its everyday connotation, modality means manner, the speaker's relation to the coverage of the scope of reality. It means the imparter's and the recipient's connection to the content or its coverage of fact. In the wake of the 20th century, "modern" learning materials have remained unchanged in terms of verbal and image communication, linear structure, written text dominance, and static image conveyance.

Emerging media and its practice can support open curriculum development and online learning. It can process content on using multimedia support, interactively, both in individual and community action forms. The open education content produced by digital devices reaches the audience through multimedia channels, with significant potential for learning motivation and modernizing training materials. In our presentation, we will point out the adaptation possibilities of the online collaborative system of the new media with the help of an open curriculum development model, which supports the digital learning process of students. The new methodological approach - building on our domestic and international research and activities in the field of vocational training - is the practical application of the developed methods and procedures. It includes the development and implementation of new types of online learning materials and the monitoring of teachers' effectiveness. The open education content produced by digital devices reaches the audience through multimedia channels, with significant potential for learning motivation and modernizing training materials. In our presentation, we will point out the adaptation possibilities of the online collaborative system of the new media with the help of an open curriculum development model, which supports the digital learning process of students.

The core of our research is to involve teachers, VET students, and the students of teacher training into the open content development process formed according to the principles of interactive and collaborative online learning and teaching content development. The Open Content Development (OCD) model, which, based on the results of several learning content digitalizing projects, was built upon the recognition of the change in the teaching-learning paradigm presented above. Input factors are the descriptions of the Learning Outcomes worded by the current formal education; these descriptions connect to the requirements of the European Framework for Education and Training, and it is easy to achieve their operationalization at the itemization level. The output factors can arrange into three groups: we consider the content development results elaborated by the teachers/students, which can present in the forms of micro-contents, case studies or practical problem solutions, as direct outputs. The system opens for BYOD (Bring Your Device) proposals that serve the methodological support of the innovations implemented within this system.

Public thinking about pedagogy, in many cases, envisions rather schematic and archaic educational methods. The public mind identifies engineering sciences as rapidly changing knowledge, that is why sharing innovation practice and the fast adoption of new results in methodological development is important (Colons&Halverson, 2009). The recognition that the educational process, learning and teaching had become a more and more open system was a significant precondition of our research. Openness is partly related to a change in the attitudes as well as to the characteristic that has resulted from the spread and wide-range usage of ICT tools: learning can be taken as communication independent in space and time, in which

most of the information is not included in closed body texts but series of image and media elements in specific choice algorithms.

At the beginning of our century, we came to the understanding that in the current (and even more the future) learning processes, we considered communication using images, icons, or comics as a natural way of human communication. In searching answers to the new questions, the BME VLL (BME Visual Learning Lab and the series of Visual Learning Conferences 2009-2019) undertook an especially significant theoretical role; within these frameworks, we tackled to examine the issues of pedagogical construction to establish a new forum (Benedek-Nyíri, 2012). Modern e-learning materials (Open Education Resources, OER) search the response also to the basic question of how educational content, the learning material to be attained, could be made open and be transmitted in structures that are open for the students, as well. The representatives of the connectivist learning theory make the theoretical background of this; their penetrating appearance strengthening the openness of higher education at the beginning and the spread of MOOC (Massive Open Online Courses) can be considered one of the most important educational innovations in higher and adult education.

Our previous researches was targeted at the digitalization of teaching materials and the possibilities of their use in an online teaching-learning environment as topics that may open up enormous perspectives in the future. The pandemic, having evolved during the spring of 2020, put these ideas leaning back to a decade ago into use in the practical educational fields (remote teaching) at a more rapid pace than expected. It is also a reason why the model construction researches of Geng Sun and his peers (Sun, 2020) that have become known during the latest years and examined the application of open education resources (OER) as learning content units in adaptive micro-learning situations are so valuable. In 2019, they pointed out in their paper at a conference analysing the application possibilities of developed cloud services and Big Data that micro-learning content units, or micro-content according to the terminology of our research, can be used in online learning than MOOC (mass open online courses) programs that are extensive and time-consuming. Although there are several significant MOOC programs managing continuous student activity in the online environment requires considerable time and exceptional methodological support. In terms of these, it is outstandingly essential that considering cyclical learning periods, micro-content is suitable to awake and maintain pupils' motivation, and to develop it by delegating creative tasks to them. It was precisely the researches had explored the limits of the MOOC courses during the latest decade that notified that one essential reason for the drop-out of students, which is relatively easy to be analysed in distance learning, was the extent of the learning material and the partial nature of the connecting differentiated supporting activities.

In line with the latest methodological trends (Gessler&Herrera 2015), during our content development and methodological researches, we set out from the supposition that new frameworks (environs apt for digital learning) containing visual elements, too, were more and more suitable to provide innovative support for teaching and learning. We had a connecting recognition: after the millenary, a collaborative learning environment supported with computers could create new conceptual frameworks for developing and transmitting content in VET, as well. The analysis of this process has become a dominant research trend only during the latest decade. Examining the theoretical background, Hod and Sagy (Hod&Sagy, 2019) referred to important empiric researches, as well, and warned that the new educational environment differing from traditional ones requires new methodological approaches. These researches drew the attention to the fact that it was important to understand the role of personally tailored methods and student activities and the creation of a motivational system connecting to these, which network environment offers excellent opportunities for.

Results and Discussion

In terms of the opportunities offered by the new environmental impacts, several types of research examine primarily the pupils/students' experiences relating to the virtual/online learning environment (Hamutoglu et al., 2019). The analyses aimed at the exploration of students' content and learning preferences drew the attention to the fact that in an ICT environment, compelling interest appeared in content constructions in terms of which learning could be implemented in the virtual

learning environment using new content constructions. These detections were in line with our activities during the initial phase of our researches when we intensively examined the attitudes of both teachers and pupils/students partly in terms of the new learning environment and partly in terms of active participation in open content development.

Acquiring the methodology of online content development is general when we speak of open content development, and it allows local innovation within the frames of a complex regulatory environment, searching answers to the very same practical questions that teachers in the everyday practice of VET try to find answers to. For this methodology, teachers' and students' activity is a clue issue, and it supports its development in the online teaching and learning environment using various forms of content development aimed at the learning units and at creating and using micro-content during the teaching process.

Concerning our domestic field, we have not seen mass distance teaching activities during the latest years. In VET, however, in addition to the structural and quantitative deficiencies in learning materials and the qualitative challenges, one of the central motifs of our methodological development aimed at putting content-based development into practice was to enhance students' attention and activity with the help of collaborative and short-cycle feed-backs and the possibility of horizontal communication. Geng Sun's pioneer researches (Sun et al., 2016) drew attention to the fact that in the online environment and parallel with the changes in learning patterns, the development of the learning content is a crucial factor. The potential role of this process, micro-learning, lies primarily in the fact that the transmission of content, i.e., learning paths for the individual, be it the teacher or the student, may assure differentiated and flexible solutions in the task or project-oriented activities.

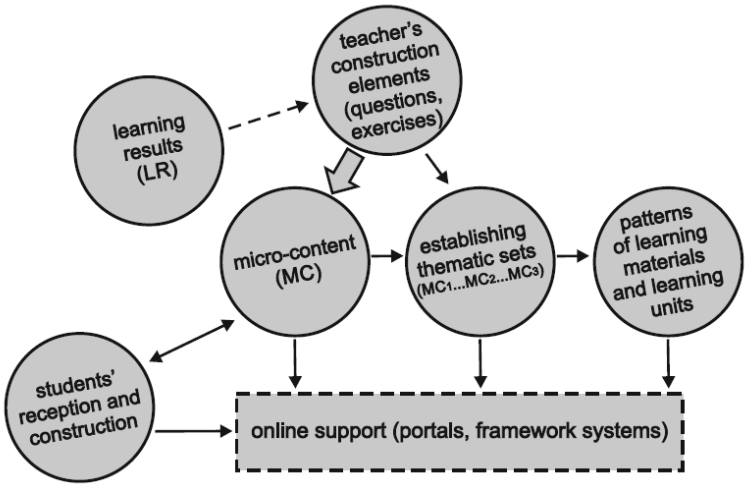

Figure 1. *Construction interrelations of OCD development (own figure)*

A critical feature of our development planning for the online environment is the construction of micro-content, which, as an alternative to the traditional vertical educational communication, allows reliable and effective horizontal communication stepping by this out of the narrow frameworks of formal education that are rather regulated in space and time. The creation of content formed within the open online learning environment can be considered as innovation results that possess the essential features of openness precisely in the new ICT environment and owing to the technical tools used here. This differs from the often closed system of traditional teaching materials. At the same time, the acquisition of experiential knowledge during the process of content development considerably reduces the risk that the more and more new elements of common knowledge necessarily bear pedagogical challenges, as well.

According to our implementation of the Micropedia-based method, which is mostly applied by the vocational teachers, the educational adoption seems a new methodical innovation in the content development for the VET system. Owing to practical applications, we have already met the opportunities of micro-learning. Still, we do not know a methodology adapted to our

learning environment and especially to the teachers' attitude to sharing our developed content. This learning innovation demands the creation of micro-contents and the establishment of the relevance network between them. With the help of these, the traditional materials can be digitally reproduced on the displays of the mobile devices tailored to the size, and the inter-connections of the learning material can be introduced to the student in a similar way. The knowledge elements can be collected by collaboratively developed content, and by analysing these collections, the contents and structural quality of the whole learning material can be estimated. In the next period of our research, the personal knowledge element collections can be built from the elements of various resources. Thus we can make estimations about the student's whole knowledge and can select the possible methods.

The results of our survey have proved our hypothesis according to which one of the possible ways of increasing teacher activity is to offer, besides methodological support in learning the theoretically instant material in the increasingly accessible online learning environment, the possibility to join in the Learning Management Systems (LMS). The new micro-contents, except for their different forms and topics, showed a significant potential for using them in the teachers' preparation for their lectures and practical work with students. Using the new set of micro-contents 2018-2019, we established an archiving system for distributing the result of content development; the next Figure 2 shows two-screen pictures about the teachers' support Micropedia (MP) portal:

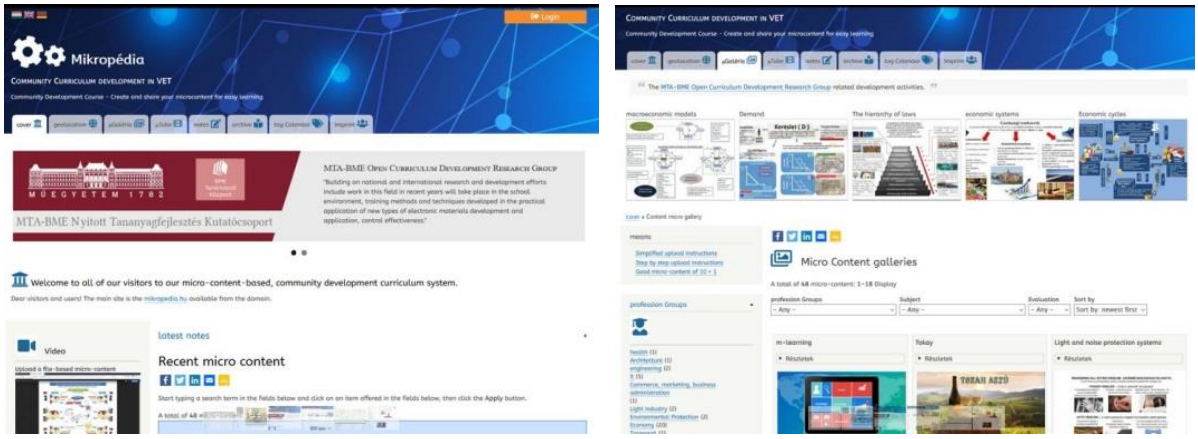

***Figure 2**. Micropedia (MP) as a content archiving system/portal (own figure)*

The requirements raised to the basic functions of MP are relatively simple. As Figure 3. shows, the micro-content created during content development must be searchable and labeled so that the professional public can get to know them within the network frameworks. Ensuring publicity is relatively easy using an internet portal; however, owing to the rapid growth in the amount of digital content, labelling, and structured archiving mean serious challenges.

Figure 3. *System functions of MP (own figure)*

The structure of the platform, see *Figure 3*. offered by the system, has to serve the users one hand and the presentation, visual introduction, text-based description, mathematical formalization, and other multimedia (sound, image, video, animation) presentation of the uploaded micro-content on the other. The entrance platform allows the registration of new users, the login function, and the use of password constructions or regeneration, as well.

Our researches aimed at renewing the methodology used in VET and vocational teacher training are theoretical, however, they are also directly linked to the innovation practice in teacher training. We discuss the topic of Sustainability within the Digital Pedagogy subject. We aim to equip our students with practical pedagogical knowledge using showing interrelation between major pedagogical problems and new technologies. In the spring semester of 2020, our highlighted objective was to develop the pedagogical interpretation of the so-called SDG Goals, set by the 2030 Agenda for Sustainable Development (SD) of the United Nations, using micro-content created by students.

Students discussed the structure and target system of the SDG beforehand. They were asked to create a micro content for the selected goal that visualized the issue, the connecting information and pedagogical problems for the pupils, was apt to serve communication with the students, and inspired the pupils to put and to discuss questions. The students were free to choose the SDG and the topic. They made their thematic questions individually, and, during the process of visualizing the micro-content, assigned them to the notions and information that they considered as necessary from the aspect of the communication /consultation carried on in the given topic about a pedagogical problem.

The main analyzation aspect for our research was the diversity of the topics, their genre characteristics, and interconnections. The students (46 people) were enthusiastic about this issue even though this task was optional; most of those having elaborated micro content (46 persons) had chosen this topic. The distribution of the topics by SDGs is worth attention (number of students choosing the given topic for micro-content development):

No Poverty	*3*
Zero Hunger	*1*
Good Health and Well-Being	*5*
Quality Education	*3*
Gender Equality	*3*

Clean Water and Sanitation	*8*
Affordable and Clean Energy	*4*
Industry, Innovation and Infrastructure	*2*
Reduced Inequalities	*1*
Sustainable Cities and Communities	*5*
Responsible Consumption and Production	*7*
Climate Action	*1*
Life on Land	3

Higher than average pedagogical sensitivity was observed for four underlined topics: *Good Health and Well-Being ,Clean Water and Sanitation, Sustainable Cities and Communities, Responsible Consumption and Production.* These accounted for 60 percent of the micro-content developed.

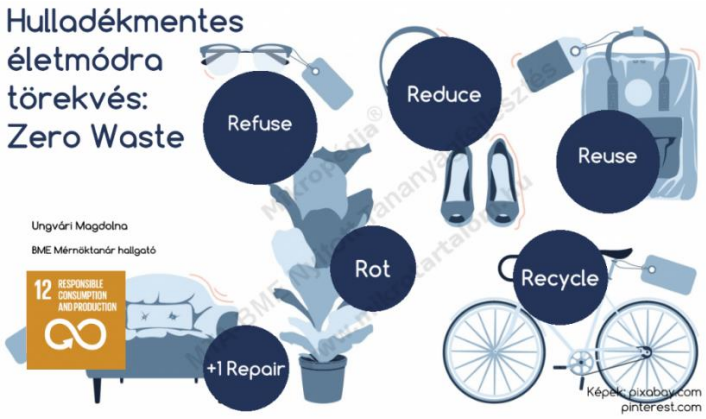

Figure 4. *Cover page of one micro-content outworked by PREZI (students work April 2020)*

The comparative analyses of the effective learning unit constructions showed a high level of creativity and sensitivity about the problem. Each of the graphic designs was of high quality and was suitable to support the classroom discussion of the topic effectively. In general, students chose the traditional PPT form. However, PREZI (as an example: *Figure 4.)* allowing interactive elaboration, was also used. The wide spectrum of topics served thematic connections, as well, which draws attention to the further methodological opportunities offered by collaborative educational content development. Uploading materials to and archiving them on the online platform in this case perfectly met the new requirements of distance learning ordered because of the pandemic that has evolved in the spring of 2020 as well as the aspects of the application of these content elements by students and pupils. This resolution, which has been introduced partly under constraint, offers a new solution for the pedagogical elaboration of sustainability in the future, as well. *Figure 5.* shows some of the micro-contents developed by the students with some opening pages.

Figure 5. *Micro-contents' cover pages from the students' contributions (students' works April 2020)*

Conclusions

To sum up, it was a significant antecedent of our project to realize that the educational process, learning, and teaching, had become a more and more open system. Openness is partly related to changes in the attitudes, somewhat exactly to the feature that has been a result of the spread of ICT tools: learning is communication independent in space and time in which most of the information is not included in closed body texts, but series of visual and media elements in unique algorithms of choice. This recognition urges us all in education to revise our paradigms used so far. In VET, it establishes the epochal opportunity of the development of innovative methodology in vocational teacher training and the school practice.

Result of our learning innovation, the presented online platforms (Micropedia) aims to introduce collaborative methods with OCD technique in VET to publish and access most up to date open educational resources. Teachers and students of VET in the 21st century all have to face formerly never experienced challenges. This new, well-accepted in VET practice can extend and subsequently dismiss our traditional schoolbook with new kind of visual-based educational materials like online accessible at the same time well organized easily searchable and consequently available micro-contents.

It is impossible not to mention the limits. However, the research and development work done during the latest more than three years and the deep and complicated process of change going on in the Hungarian VET system urges our research group to provide a detailed professional picture of our researches done in terms of VET content development. Finally, an aspect related to the epidemic was included during the finalization of this manuscript at the end of April 2020. The radical change is going on in the teaching and learning methods that exert a profound impact on the traditions of education and teaching forced open system learning and content development and transmission to implement forms of methodological innovation worldwide, and in this process, our former experiences and methodological results may serve as references in terms of the possibilities and the difficulties, as well. According to applied methods, the central point was the improvement of student activity in the frames of collective open content development. We assumed that according to the Sustainable Development

Goals and their implementation as a constructive pedagogical approach through the new program based learning as content construction effects the student's cognitive domain, to enable development sustainability competencies.

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Educating for Sustainability

Climate innovation and entrepreneurship in primary and secondary education in Hungary

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Abstract
Climate change is one of the biggest challenges of our age and education could play a key role in preparing young people to find innovative solutions to the many problems related to this phenomenon. An improved education system focusing on problem-solving, creativity, and soft skills can support students to provide complex answers to the heterogeneous problems of climate change and sustainability-related issues as well. This paper analyses how to effectively develop personal competences of Hungarian students putting emphasis on environmental education within the existing education frameworks and curricula. To answer this question, we introduce how the Hungarian public education system is structured with a strong focus on outcomes and challenges regarding primary and secondary level. The description of overall career development pathways of teachers, administrative responsibility for schools, educational funding and teachers' qualifications are also involved. The framework curricula are analysed describing how the curricula contents stimulate critical thinking, creativity, spreading innovations, entrepreneurial thinking and ability to teamwork. A brief summary of comprehensive literature is provided about potential solutions and existing research questions in the Hungarian thematic journals from the field of pedagogy, sociology and psychology. Briefly, the expenditures regarding the Hungarian educational system by analysing time series data is described. Regional differences in educational outcomes, basic data and public – non-public comparison are also introduced. The main conclusions reveal specific features and challenges of Hungarian educational system with regards to the decreased ability of our students to become more innovative, climate-conscious and creative. There are several Hungarian and European initiatives that aim to improve the knowledge and commitment of students at different educational levels with or without the official involvement of schools. We have collected the most significant local examples of these initiatives from the past few years targeting students of primary or secondary schools. These programmes boost either students' critical thinking, creativity, innovative and entrepreneurial skills or raise their awareness to some climate change problem areas, eg: waste management, climate sciences, etc. Some are examples of joint initiatives involving primary or secondary schools and non-public organisations (incl. NGOs, companies, religious organisations) and some are independent of the Hungarian school system. The shown examples include among others the short introduction and analysis of the Hungarian Nature School System, the Energy hunting program by Energiaklub, Speak Smart! by the Foundation of Democratic Youth, Eco-Pack Playhouse and "Waste to Product" Exhibition, Innovation Camps and Student Enterprise programme by Junior Achievement Hungary/Europe, CsoPa Science Center in Budapest, the Young Climathon and the Young Innovators programmes by EIT Climate-KIC, etc. The analysis and the results of these programmes could be a source of guidance and inspiration for schools to improve their curricula which is needed to unleash the creativity, programme-solving and entrepreneurial potential of the students to tackle the climate change challenges.

Keywords: Climate change, Innovation, Entrepreneurship, Education, Hungary

1. Introduction

One of the most pressing issues of our times is climate change - threatening not only our environment and society, but also the global economy (Vrontisi et al., 2020). It is a complex and diversified problem area where conventional and traditional solutions are not effective; there is a strong need for interdisciplinary approach (Klink et al., 2017) and creative problem-solving skills (Krauss, 2020). As the actual course of climate change cannot be accurately forecasted (Deser et al., 2010), soft skills such as persevering, and being able to change continuously to adopt to new circumstances are essential for overcoming the future problems and create climate innovation (Aghion, 2019). The higher level of knowledge paves the way for innovation and thus, the improvement of economy, it also helps nature preservation and contributes to almost all areas of sustainability. Expanding the knowledge capital depends on the length and quality of education. The National Framework Strategy on Sustainable Development aims to improve both factors - it encourages time spent in education, teacher training reform, the improvement of the recognition of teachers, and the dissolution of the selective character of the Hungarian education system. The problem-solving ability and the expansion of students' knowledge decreased in recent decades and is still below the EU average. Early school leaving rate has been higher in Hungary than the EU average since 2013 (Schmitsek, 2020). The growth

of the proportion of students in tertiary education was broken in 2015, since then, fewer and fewer people continues their studies at tertiary level, thus delaying the results to reach the 40% target by 2020 (Szakálné Kanó et al., 2017). Knowledge-based society, the better utilization of knowledge in society and economy means a more practice-oriented usage of already existing systems, methods and knowledge. The innovation performance of Hungary is still below the EU average (Ivanova and Cepel, 2018), the productivity knowledge of foreign owned companies cannot spread to the nationally owned companies due to the lack of local professionals capable of transferring innovations. Students need far more market experience and practice during their studies. The overall goal is to equip students with skills that encourage professional development and lifelong learning beyond the core competencies by the end of their studies. Education also plays an important role in the transmission of sustainability values (Nousheen et al., 2020). The network of green kindergartens and eco-schools have been the main assets of awareness raising in the last decades in Hungary (NFFT, 2020). The improvement of the education system contributes to achieve some of the Sustainable Development Goals, namely Goal 1 – no poverty, Goal 8 – decent work and economic growth, and Goal 17 - partnerships for the goals (UN, 2015).

As shown above, education could be a key lever to move our society towards sustainability and be the source of climate innovation and entrepreneurship. However, despite the presence of the new challenges, education has not transformed its methods and ways developed in the last century (promoting memorization of facts and figures, and respect for teacher's authority etc), which are no longer suitable to prepare today's generation for the future's problems. A crucial point in the Hungarian socio-economic system is the low ratio of the working-age population in the labour market and the large differences in employment ratios according to gender, age group and primarily educational level (NFFT, 2013). Despite the improving educational level of the whole population, a substantial group of low educational level is continuously reproduced. Usually, the most endangered are those students who drop out of vocational schools. Causes of early dropping out are very complex and paired with regional disadvantages that can indicate special problems. The reduction of early dropouts' proportion is one of the most important goals supporting the educational success of the most disadvantaged students based on socio-cultural and economic aspects fostering the effectiveness of the Hungarian education system. There is a strong correlation between the low employment data and the quality of the educational system in Hungary. Qualification and labour market opportunities are more determining in Hungary than in other parts of the world. People with lower educational attainment are particularly at risk: 28% of young people (25-34-year-olds) with below upper secondary education were unemployed in 2012 compared with an average rate of 20% for OECD countries (OECD, 2014). Half (52%) of the 25-64-year-old population of Hungary has upper secondary education as the highest level attained, below only the Czech Republic, the Slovak Republic, Slovenia and Poland. Only 13% of 25-64 year-olds have a bachelor's degree or equivalent as the highest level of education attained, below the EU23 and OECD averages of 17% and 14%, while 9% have a master's degree or equivalent, also below the EU23 and OECD averages of 14% and 13% (OECD 2018).

Hungary has been taking part in the most important international testing programs since the beginning of the 1970s, therefore an enormous data collection is at our disposal to present the performance of the Hungarian public education in international and historical context. (NFFT, 2013) The majority of the data is available from the areas of reading-literacy, mathematics and natural sciences, primarily as part of the FISS (First International Science Study), SISS (Second International Science Study), TIMSS (Third International Mathematics and Science Study), PIRLS (Progress in International Reading Literacy Study) and PISA (Programme for International Student Assessment) survey results. These assessments show a quite diverse picture of the performance of the Hungarian public education: in the TIMSS and PIRLS surveys students traditionally show a good performance, while in the PISA testing they achieve much weaker results - according to the 2018 PISA tests, more than 25% of students are functional illiterate (NFFT, 2020) but still in line with or slightly below the OECD average (http 7). Currently, the Hungarian school system is unable to cope effectively with differences at the individual level (NFFT, 2013). Furthermore, as the teachers' incomes are relatively low compared to the average graduate wage in Hungary, there is a lack of teachers in many places, and fewer students choose the teaching profession (NFFT, 2020).

This paper examines how personal competencies can be connected, associated and developed through environmental education in the current Hungarian education frameworks and curricula. We analyse how the Hungarian public education system is structured with a strong focus on outcomes and challenges regarding primary and secondary level. The overall career development pathways of teachers, administrative responsibility for schools, educational funding and teachers' qualifications are also examined together with the framework curricula. We provide a short overview of comprehensive literature from the field of pedagogy, sociology and psychology, and the expenditures regarding the Hungarian educational system is also described. Regional differences in educational outcomes, primary data and public – non-public comparison are also introduced. We also showcase some European and local initiatives that already aims to foster non-cognitive skills in order to overcome certain sustainability-related challenges. By bridging personal skills and the environmental problems, today's youths would be supported on their way to becoming more innovative, climate-conscious and creative when it comes to overcoming climate change related or other crucial challenges in the future. Recent research was funded by EIT Climate-KIC as part of an education-oriented multi-step research program conducted in the Visegrad Group countries. This climate-related research focusing on this specific group of European countries has started in 2018 and still in progress.

2. Methods

Soft skill is a term more and more used when talking about complex problem-solving. Over the last decades, soft skills were realized to be essential when it comes to facing challenging situations, being innovative, entrepreneurial, and providing effective solutions to complex problems such as climate change and sustainability. However, the education system has not succeeded in integrating soft skill development into the Hungarian National Framework Curricula. Old ways of teaching – promoting memorizations and the authority of teachers – are still in the focus of the education system rather than encouraging debate, independent thinking, cooperation, etc. To map the relation of soft skills and curricula in the environmental education in Hungary, a policy analysis was carried out to identify the characteristics of the Hungarian public education system with a strong focus on outcomes and challenges regarding primary and secondary level. Description of overall career development pathways of teachers, administrative responsibility for schools, educational funding and teachers' qualifications are also involved. A content analysis of the framework curricula of primary and secondary schools followed describing of how the curricula contents stimulate critical thinking, creativity, spreading innovations, entrepreneurial thinking and ability to teamwork. After introducing the main problems and challenges regarding previously mentioned aspects of the Hungarian educational system, a brief summary of selected comprehensive literature review contributes to deepen our knowledge about potential solutions and existing research question in the Hungarian thematic journals from the field of pedagogy, sociology and psychology. For this reason, relevant articles have been revised since 2006, mainly in the Hungarian language. Also, regional differences in educational outcomes, basic data and public – non-public comparison are introduced through data analysis. Finally, desktop research was conducted of the local, and international initiatives and best practices. The main conclusions shall reveal specific features and challenges of the Hungarian educational system with regards to decreased ability of Hungarian students to become more innovative, climate-conscious and creative.

3. Results and Discussion

Structure of the Hungarian Public Education System by age, grade and by ISCED- 2011 level can be seen on Figure 1. The figure shows the theoretical age and length of programmes in full-time education. A systematic change has been made on the Hungarian public education system in 2016 when secondary programmes were repositioned significantly. A systematic review of the whole education system, therefore, is unquestionably needed to be able to understand the main challenges with regards to the spread of entrepreneurial knowledge and innovativeness.

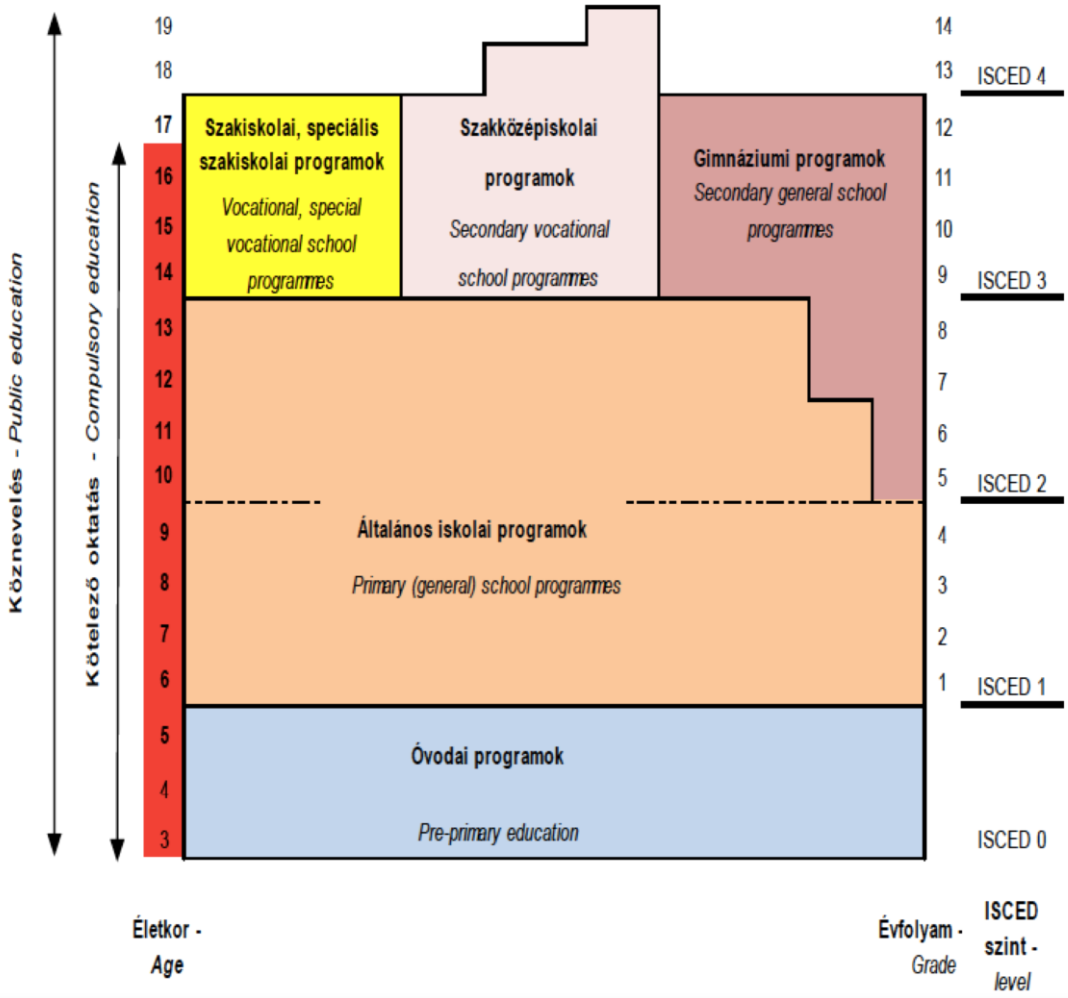

Figure 1. *Structure of the Hungarian Public Education System. Source: Statistical Yearbook of Public Education 2015/2016*

The pre-primary education, mandatory school age in Hungary is between age 6 and 16. Basic education – which is equivalent to ISCED 1 and 2 levels – is basically an 8-grade single structure school dividing into primary (ISCED 1) and lower secondary education forms (ISCED 2). Primary education (ISCED 1) includes grades from 1 to 4, however lower secondary education (ISCED 2) lasts grades from 5 to 8. In parallel with it, some upper-secondary schools can provide secondary programs by connecting lower (ISCED 2) and upper secondary levels (ISCED 3), consequently grades 5 to 12 or grades 7 to 12 can be done without school changing. The basic qualification is provided after the successful completion of grade 8. Having acquired this, pupils can (or have to) continue their studies in an upper- secondary school. There are three main types of upper-secondary schools in Hungary after above-mentioned reform of educational system enforced in 2016: general secondary schools, vocational secondary schools and vocational schools.

From among the 3 main programmes, the school-leaving examination certificates can be obtained in the 4-year or 5-year secondary school and vocational secondary school programs. Students with this certificate have the chance to enter higher education. The 3-year vocational secondary school qualification ends with the school leaving certificate of a state-accredited vocational qualification listed in the National Qualifications Register, but such students may not enter higher education, because they do not have the school-leaving examination certificate. In the case of this school type, students may stay for 2 more years and continue their studies in order to obtain a school-leaving examination certificate at the end of the second year. The secondary school leaving examination is a state-led and -controlled examination type, which is also part of the entrance examination to higher education institutions.

Vocational schools provide education and training for students with special educational needs. In vocational schools, vocational education is provided for the vocational qualifications listed in the National Qualifications Register – depending on the type of the special educational need – according to the vocational framework curriculum or the special framework curriculum.

School administration and career development pathways of teachers

From 2013 the administration of the Hungarian public education institutions was taken over from the municipalities by the state. In 2017 Klebersberg Institution was appointed as the main operating body for public schools. The institution is responsible for the management and control of the activities of all public educational institutions (pre-primary, lower secondary and upper-secondary education institutions) through 60 deconcentrated maintenance centers. The school heads' main responsibilities are limited to the preparation of the pedagogical program, and to organise the working time of teachers, they do not have any employer rights (http 8).

The teachers' career development pathway was introduced in 2013 in Hungary. According to this system, teachers can reach five possible levels. Starting from a two-year internship period, then moving on to Teacher I, Teacher II, Master teacher and Research Teacher level. The Teacher I and Teacher II. levels are mandatory for all teachers to progress to, the last two offer further opportunities for teachers with academic ambitions. The teachers' evaluation is based on indicators related to the pedagogic competences (NEM, 2013). The salaries of teachers are also based on the wage matrix of the promotion structure. After a 30% fall between 2005 and 2013, teachers' salaries increased radically between 2013 and 2014. However, teachers' salaries remain low compared to the other OECD countries, and progress slowly: it takes lower secondary school teachers 42 years of service to reach the top salary level, compared to 25 years on average across OECD countries (OECD 2019).

Main characteristics of the National Framework Curricula

As one of the main goals of the present study is focusing on the main characteristics of the Hungarian educational system with a strong emphasis on students' innovativeness, science- orientation and entrepreneurial attitude, relevant consequences can be made after analysing the proportion of subject areas in different secondary school programs in Hungary. The National Core Curriculum (NCC) is a strategic document that is compulsory for all schools.

Table 1. *Framework curricula for general secondary schools, annual number of hours, Source: NAT (2012)*

	Grade 9.	Grade 10.	Grade 11.	Grade 12.	Total
Hungarian Language and Literature	144	144	144	128	560
Foreign language 1.	108	108	108	96	420
Foreign language 2.	108	108	108	96	420
Mathematics	108	108	108	96	420
History	72	72	108	96	348
Ethics			36		36
Biology		72	72	64	208
Physics	72	72	72		216

Chemistry	72	72			144
Geography	72	72			144
Music and Singing	36	36			72
Visual Culture	36	36			72
Film and Media	36				36
Arts			72	64	136
IT	36	36			72
Life and Practical Skills				32	32
P.E. and Sports	180	180	180	160	700
Form master's class	36	36	36	32	140
Optional	144	144	216	256	760
Total	1260	1296	1260	1120	

It can be seen from Table 1. that framework curricula cannot help students from general secondary schools to acquire in-depth and useful knowledge about financial issues, natural sciences or entrepreneurial skills; however, they have 700 hours of P.E during their studies. In contrast, life and practical skills is taught in a 32-hour frame during the last year when everybody is focusing on being prepared to the final examination. The curricula mainly focusing on challenges regarding passing final examination, therefore optional courses with paying attention to creativity, entrepreneurial skills and broader sustainability is almost completely lacking. Even though some teachers might try to deepen their students' knowledge beyond the compulsory studies, lack of time for preparation and students' interest hinder this process. Based on these assumptions, it can be stated that systemic problems have been found in the field of spreading and strengthening students' creativity, innovativeness and teamwork ability.

Students in vocational secondary schools focusing on vocational and sectoral practice mainly, however Hungarian Language and Literature, Foreign Language and Mathematics are paid more attention to during their studies as well. Interestingly, finance and entrepreneurship as a dedicated subject is also introduced into curricula in vocational secondary schools, though only a 36-hour frame in grade 10th. Vocational practice and theory are strong and emphasised parts of the curricula with more than 1700 contact hours, which can be useful to boost creativity and innovativeness. Nevertheless, outdated and run-out infrastructure and under-motivated teachers seriously burden to increase students' ability to have creative thinking and to work as part of a given team. Apart from specific features of vocational secondary school programs, almost the same problems and challenges can be found as for the general secondary schools regarding the students' ability to increase and use their creativity, innovativeness and holistic views.

Current opinions of the Hungarian climate, environment and sustainability-related education

As it was mentioned above, some structural problems can be found in the Hungarian educational system regarding boosting creativity, innovativeness, and entrepreneurial skill of Hungarian students. In the following, a brief summary of selected papers in the field of pedagogy, sociology and psychology is introduced in a bullet list in ascending chronological order. These papers are written in Hungarian; therefore, they may be useful to reveal country-specific characteristics in order to be compared to other countries' performances, challenges and opportunities.

• Havas and Varga (2005) analysed the main criteria of sustainable schools in the sense of administrative and educational issues and emphasized that future schools shall be as much sustainable as they can. They stated that students in a sustainable

everyday environment might be more open to new ideas, they have numerous innovative thoughts and these features contribute to having more entrepreneurial skills in the future.

• Tóth and Király (2006) elaborated The Toth Creativity Assessment Scale (TCAS), which is a new instrument to assess creative personality traits. It is developed primarily for use with higher secondary students, but it is also appropriate for younger and older age groups. The article is related to reveal hidden parts of creativity of Hungarian students.

• Orbán (2007) investigated common points of language and sustainability learning and claimed to integrate sustainability issues into foreign language courses. She argued sustainability-related knowledge in a foreign language course may contribute to broadening students' ability to understand our world better; thus their other related skills shall be improved.

• Vőcsei et al. (2008) examined the environmental attitude of teachers regarding the broader context of sustainability. They stated that analysed group of teachers are open in having and spreading new knowledge about sustainability in parallel with the current National Core Curriculum, however, there is a lack of their knowledge in synthetizing contexts and interdependencies. Therefore, innovative tools and educational practices rarely appearing in the classrooms.

• Réti and Varga (2008) suggested that knowledge about sustainability shall be the part of everyday learning on primary and secondary levels by shifting current paradigms regarding fragmented and non-connected natural sciences. They claimed that broadening teachers' knowledge about everyday sustainability contribute to increasing students' awareness as well.

• Havas (2008) introduced a new education package related to global climate change, which has been tested in a 10-week period in primary and vocational secondary schools. Feedbacks were mainly positive; both teachers and students welcomed new teaching methods boosting teamwork and problem-solving along with holistic approaches instead of frontal education. According to the results, the authors of the paper suggested introducing the package in other schools in order to widen students' knowledge about climate change and its impacts on our everyday life.

• Markóczi-Revák (2010) examined scientific problem-solving strategies among 9- to 10-year-olds. Scientific problem solving is an essential element in the competence of understanding the world of nature. While this is improved, pupils acquire skills that can also be used in solving everyday problems.

• Molnár (2012) analysed whether the problem-solving skill is affected by the level of intelligence and socio-economic factors. The results did not conclude the level of problem-solving based on the mother’s level of education or even the children’s grades - only the children’s intelligence and sex proved to be predictors.

• Szabó et al. (2015) tested a six-week-long program for developing combinatorial operations of the reasoning of third grade students (9-10-year-old) in the science context. The results showed that the combinative reasoning tasks embedded in the science context can be effectively applied at early school age.

There is a noticeable lack of studies considering the challenges evolving around immigrants and ethnic minorities in the education system and around the barriers preventing teachers in primary and secondary schools from participating in continuous education or professional training.

Comparison of the public education expenditures in the Visegrad Group countries

Expenditures in the educational sector greatly determine its quality, the educational outcomes and the skills of students leaving the given educational system with a successful final exam. Figure 2. shows the expenditure on public and private educational institutions compared to GDP per capita in % from 2000 to 2014 in the Visegrad Group countries. Data are available on "Set of indicators of educational sector 2017" edited by the Hungarian Academy of Sciences. The expenditure rate in 2014 is almost the same in the Slovak Republic (22%), the Czech Republic (22,75%) and Hungary (21,5%), however this value reaches 26% in Poland, positioned to the first place. Most significant increasing in expenditures from 2000 to 2014 can be identified in case of PL and SK with appr. 6% surplus. In Hungary and the Czech Republic, educational-oriented expenditures remain at almost

the same level during the analysed 14-year period. In 2011, EU-28 average value was 27%, almost totally equal to Polish expenditures, however far beyond PL, SK and HU ones.

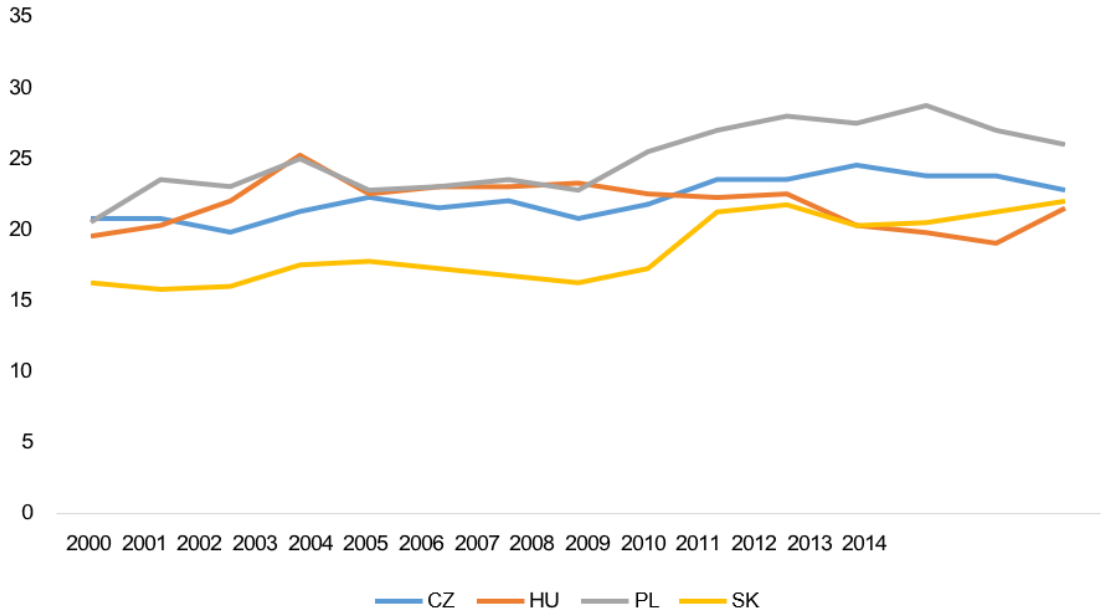

***Figure 2**. Set of indicators of educational sector 2017, Source: MTA (2017)*

Regional differences of educational outcomes in Hungary

Another main goal of the present study is to reveal the regional differences of educational outcomes in Hungary. To understand the main characteristics, challenges and potential solutions to weaken existing gaps in educational quality it is worth seeing the regional differences of some educational indicators on NUTS 2 level. As a start, Table 2. illustrates regional gross domestic product (PPS per inhabitant in % of the EU28 average) by Hungarian NUTS 2 regions. This very basic economic background shall be useful to basically understand existing economic gaps between NUTS 2 levels in Hungary, which is theoretically related to educational quality numbers of a given region. According to this table, regions from the eastern part of the country are well below EU28 average, consequently lower educational performance shall be assumed in the following.

***Table 2.** Regional gross domestic product (PPS per inhabitant in % of the EU28 average) by Hungarian NUTS 2 regions*

	Central Hungary	Central-Transdanubia	Western-Transdanubia	Southern-Transdanubia	Northern Hungary	Southern Great Plain	Northern Great Plain
2005	101	58	61	43	41	43	40
2006	101	56	62	41	40	41	39
2007	100	56	59	40	38	40	38
2008	104	56	61	43	39	42	39
2009	108	53	60	44	39	42	41
2010	107	56	64	44	39	42	41
2011	107	58	67	44	40	44	43

2012	107	58	66	45	39	45	42
2013	108	60	68	45	41	46	42
2014	106	62	73	45	43	48	44
2015	105	63	73	44	45	49	43
2016	102	64	74	44	45	48	43

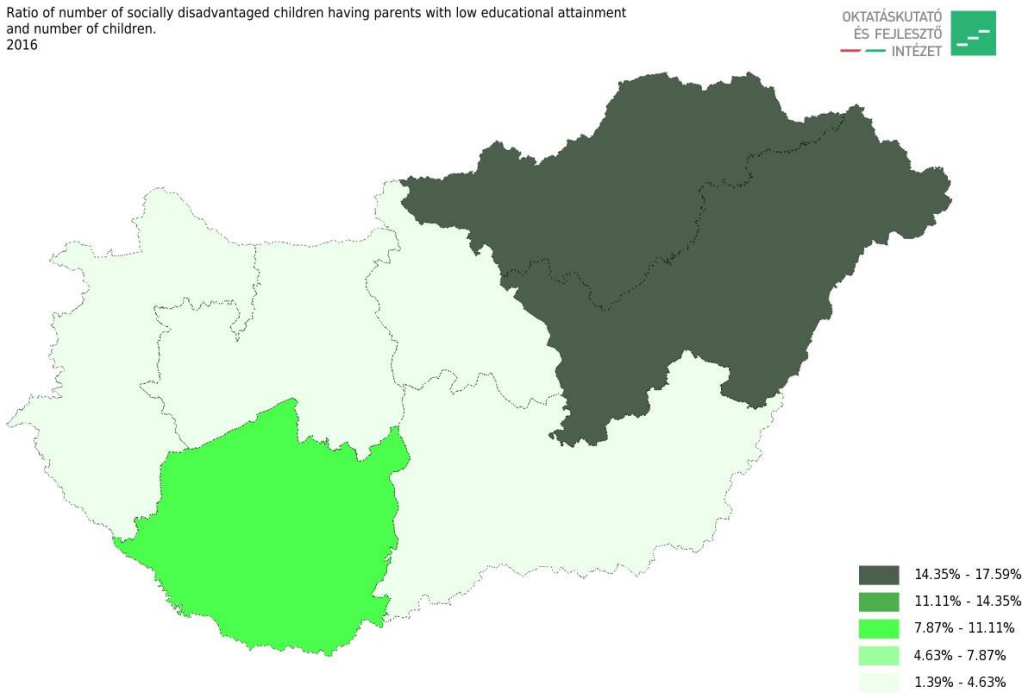

Figure 3. *Ratio of number of socially disadvantaged children having parents with low educational attainment and number of children, 2016, Source: Hungarian Central Statistical Office*

As we assume, economic power is strongly correlated to educational performance in each region and vice versa. The sociological background of students determines their performance during their studies, moreover socio- economic factors have significant impacts on students' openness for innovative solutions and teamwork. Northern Hungary and Northern Great Plain are the poorest regions in Hungary, thus not surprisingly - as Figure 3 shows, the ratio of the number of socially disadvantaged children having parents with low educational attainment and the number of children is the highest in these regions with more than 14%. Wealthier regions perform unquestionably better regarding the indicator.

Another good indicator is the percentage ratio of the number of career starter teachers and the total number of teachers. The highest proportion can be seen in the case of Central Hungary region with Budapest in its heart, but on the second-place Western Transdanubia as the second wealthier region in Hungary can be found. Career starter teachers usually have more openness regarding new and innovative teaching methods, which contribute to increasing students' creativity, teamwork ability and interest about new things. Moreover, these teachers are more motivated compared to those who are close to pension ages. To sum up, briefly, a strong east-west tendency may be determined regarding selected indicators of the educational system in Hungary, however, Central Hungary region with the capital of Hungary performs better than any other region in most cases.

Regional differences regarding public and non-public educational systems in Hungary

Revealing similarities and differences between indicators regarding public and non-public educational systems in Hungary, data from the Hungarian Institute for Educational Research and Development are used again. In the following, representative time-series indicators are introduced with a short description of results in a chart format. Each indicator is grouped by NUTS-

2 regions, however Hungarian names of them can be found on the charts, therefore translated form of them are the followings: Közép-Magyarország – Central Hungary; Dél-Dunántúl – Southern Transdanubia; Nyugat-Dunántúl – Western Transdanubia; Közép-Dunántúl – Central Transdanubia; Észak-Magyarország – Northern Hungary; Észak-Alföld – Northern Great Plain; Dél-Alföld – Southern Great Plain.

First, the ratio of the number of socially disadvantaged children having parents with low educational attainment and number of children have been taken into consideration. It can be seen in Figure 4 that this number varies from 17-19% (Northern Hungary and Southern Great Plain, the poorest regions of the country) to appr. 2-4% the western part of the country in state-owned schools. When it is compared to private schools, the values are significantly different compared to state-owned ones. Maximum values are about 10-12% in the same regions, moreover minimum values are appr. 2-4%, consequently two main conclusions can be identified: firstly, a difference between maximum values in case of eastern regions, and secondly, almost the same interval in the case of western and central regions.

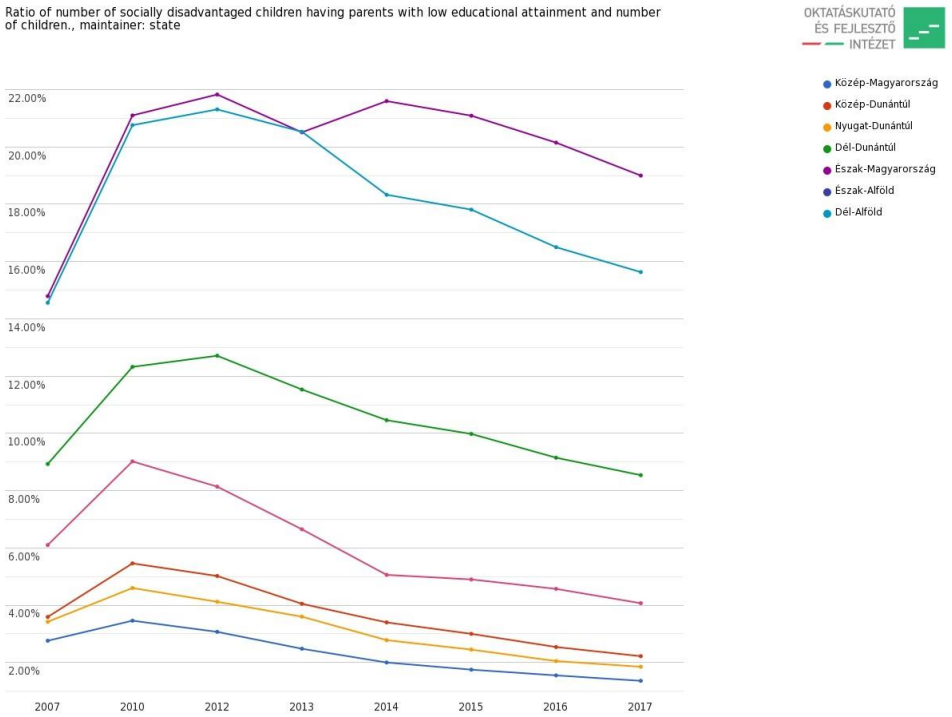

Figure 4. *Ratio of number of socially disadvantaged children having parents with low educational attainment and number of children, maintainer: state. Source: Hungarian Central Statistical Office*

Figure 5 shows the average school size in state-owned schools. This value is significantly higher in state-owned schools, for example, in Northern Great Plain more than 200 pupils study in a school in average, but the challenge is appearing in the other regions of Hungary with appr. 130-170 students/school value, which is an extremely high ratio. It can be stated that substantial school sites cannot ensure to spread innovative thinking or teamworking. In the private educational sector, the average school size is about 70-90 students/site, so higher students/teacher ratio is situated in a smaller school size.

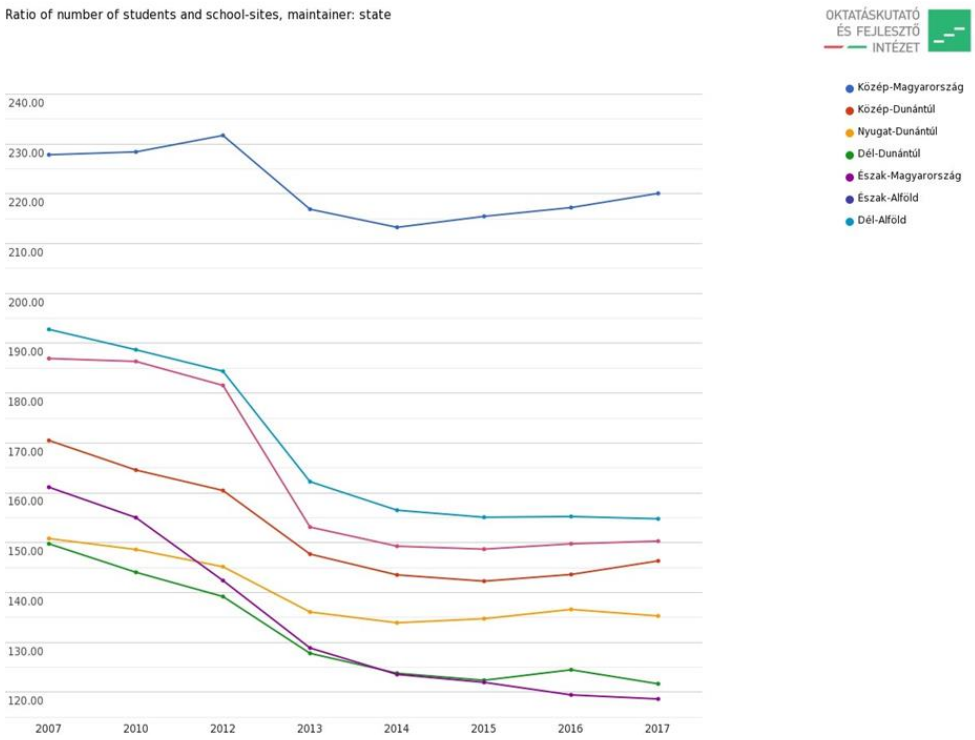

Figure 5. *Ratio of number of students and school-sites, maintainer: state. Source: Hungarian Central Statistical Office*

Local and international initiatives considering climate-related education in Hungary

It can be stated that there are several local initiatives that aim to improve the knowledge and commitment of the students considering climate change and entrepreneurial and innovative/critical thinking. We will show some examples of these in the below section.

The Eco-Pack (http 3) environmental protection programs are open educational activities for companies, non-profit organizations, state institutions, local governments, authorities, education institutions and schools. The mission of Eco- Pack is to change the ecological mindset. They believe in the practical, experience-based education, their „Green Portfolio" program consists of Green Exhibitions, ECO playhouses, Voluntary Programs. In the last years they have developed an awareness-raising and environmental protection communication and educational program. One of their exhibitions "Waste to Product" which is unique in Europe, has proved to be successful not only in Hungary but also on an international level.

Eco-Pack Playhouse: The program offered for family days, school and business events, team buildings, exhibitions and follow-up events of fairs for every age group. It provides playful learning about separate waste collection, conscious shopping and composting through thematic games for children and adults.

The Waste to Product exhibition and the Eco-Pack Playhouse are constantly on the move in Hungary and they are very popular throughout the country.

Junior Achievement Hungary (http 4) is a member of Junior Achievement Worldwide, helping 10 million young people to reach their goals every year in about 124 countries around the world. JA Hungary has been a non-profit organization in Hungary since 1993, working with local colleagues and local partners to bridge the gap between education and business. With the help of government and EU grants, JA Hungary is supported by the JA Europe Regional Coordination Organization. Their mission is to develop the entrepreneurial, innovative and financial competencies of the young generation to become successful

adults with solid knowledge. They intend to empower students with their theoretical and practical training programs like Innovation Camps, and Student Enterprise program.

Csodák Palotája – CsoPa Science Center, Budapest was the first science center (http 5) – interactive scientific playhouse in Central and Eastern Europe. Csopa (abbreviation of “Center of Scientific Wonders) was established by the Budapest Science Center Foundation with the aim of building up a so-called “interactive scientific playhouse”. They offer program for school groups, their aim is to spark the interest of children in learning natural sciences in an empirical way and make learning a great experience. Children can discover physical phenomena when playing with more than 250 games in the 5000-sq metre playing area of Csopa Science Center. They offer a tool for physics, chemistry or biology teachers to make their classes more colourful and practical. Csopa also aims to introduce natural sciences in a playful manner so teachers can take their specialized classes at Csopa as an external venue or use our thematic program service of interactive classes worked out by the education team.

The Energy Hunting (http 2) initiative was launched by the Environmental Ministry in 2019, it also involved NGOs like the Association of EnergiaKlub, the Environmental Association of Green Belt. The program is an awareness-raising school competition about the importance of environmental protection and energy savings for upper secondary school students. The competition was part of the "One Move" program.

In 2016 the Foundation of Democratic Youth (DIA) (http 1) launched an EU initiative project named Speak Smart! about innovation and creative problem solving. They invited secondary school teachers to apply for the programme. The project offered an opportunity for those high schools which are constantly looking for possibilities for their students to meet exciting challenges and practice the skills they need in the future. The goal of the program is to provide students with the experience and knowledge of innovative thinking and creative problem solving that can help them later in life.

In the 1980s, the forest school movement revived in Hungary. Nature School (Lesko 2017) is a several-day long program where teaching is strongly connected to the curriculum and the environmental conditions of the location of the teaching. The subject of the knowledge is the natural environment of the Nature School, where the learners acquire knowledge and develop skills through an active participation. Although it is not obligatory to organize a Nature School in primary school, it is a very popular form of learning, and we can say that many primary school students spend at least one week in so-called forest schools during their primary school years.

Young Climathon and Young Innovators (http 6) programme are initiatives by EIT Climate-KIC. The Young Climathon is a one to two-day climate hackathon where students work on a real climate challenge from an industry sector, city, company or school, while Young Innovators bring climate change challenges as part of the secondary students' studies at school. The program introduces a systems innovation approach through visual thinking and participatory tools, and trains teachers to o bring climate innovation into the classroom.

4. Conclusions

There are many aspects in the Hungarian primary and secondary education that is or could be the source of climate innovation and entrepreneurship in the country, such as the proper methodological background of innovative teaching methods as described by relevant scientific papers, or the existence of alternative education packages that could contribute to increasing climate innovativeness and entrepreneurial skills of students. The recently developed teacher career pathway could attract more well-motivated and talented young people to become teachers.

However, this study also shows and emphasizes that there are several aspects of the Hungarian education system that are or could be the inhibitor of climate innovation and entrepreneurship. The curricula are rigid and outdated, missing some key elements that would be pivotal in fostering climate, environment and sustainability-focused education. Also, the local system typically promotes traditional ways of teaching, such as frontal education both in primary and secondary education. In general, it can be stated that there is a lack of holistic-centred natural sciences teaching in vocational secondary schools where the quality of education is lower than in general secondary schools – where on the other hand there is too much focus on the final

leaving examination rather than improving soft skills of the students throughout their studies. In our research, we also found massive regional and maintainer-related differences, which also have impacts on students' openness for innovative solutions and teamwork.

There is a lack of career development aspects on the secondary level for teachers, At all levels, teachers are heavily overloaded weekly, and they do not have free time to organize events about sustainability, climate change, innovation, entrepreneurship, etc.

The number of local initiatives, though shows that the need is there for improved and skills-oriented education. Either with the schools, or outside of the curricula.

The main challenge and task for the upcoming years is to achieve a systemic change in the Hungarian education system which also promotes the necessary soft skills as well as knowledge to prepare the youth for the unpredictable future.

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Methods and effectiveness of environmental education in holiday camps in Portugal

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Abstract
Environmental Education (EE) has gained importance over the years. Holiday camps provide informal learning while entertaining young people, often in a context of contact with nature, which is particularly favourable for EE activities. The research reported in this paper has two goals: 1) Assess the methods of EE applied in holiday camps in Portugal; 2) Evaluate the effectiveness of EE practiced in the case-study ATL do Zoo - Summer 2018, regarding the change of participants' attitudes and environmental behaviour. A methodology based on questionnaires was used. A questionnaire was developed for the summer camps, to which 42 operators answered. Another set of questionnaires was applied to the ATL do Zoo, involving 425 participants and 75 parents. The questionnaire for participants contains 25 items on environmental attitudes and behaviours and was applied at two times: before and after attending the holiday camp. The parents' questionnaire provided practical examples of changing environmental attitudes and behaviours. Results indicate that there is an effort by the organizers of holiday camps to approach environmental themes in their activities, even if the "environment" is not the focus of their programs. But the effectiveness evaluation of these activities is practically non-existent. The effectiveness evaluation realized for the ATL do Zoo allowed to conclude that EE in the context of holiday camps provides positive changes in topics such as the reduction on the use of disposable plastic, the separation of residues and the reduction on consumption of foods that have negative impact on living beings. The fact that the activities are developed in a "living classroom" brings the youngsters closer to Nature. It is hoped that the results obtained in this work will contribute the dynamism of EE activities in holiday camps and their effectiveness evaluation.

Keywords: Environmental Education (EE), holiday camps, effectiveness assessment, ATL do Zoo, environmental attitudes and behaviour.

1. Introduction

We live with evidence of serious environmental problems: climate change, reduction of biodiversity, pollution, overexploitation of resources, among others. Although this is little recognized by society in general, the main cause of pressure on the environment is our consumerist lifestyle. In countries where the change in consumption habits should be more pronounced, society calls for consumerism, making it difficult to mature sustainable habits. According do Pope Francis, we are facing an educational challenge and need a "global ecological conversion" (Francis, 2015). “It is not possible for us to live a humanity that still extinguishes other species with which it daily shares the planet, which degrades the soil, air and water as if it spits on the dish it ate” (Sorrentino, 2006).

We have an urgent need to educate and raise awareness among citizens to live within the limits of the Planet. We need “an education capable of bringing about changes in mentalities, attitudes, knowledge, conduct” (Caride & Meira, 2004). Education systems must respond to this need, by setting relevant learning objectives, introducing pedagogies that empower learners and encouraging institutions to include principles of sustainability in their management structures (UNESCO, 2017). Despite the increasing number of educational institutions that support environmental education (EE), a very theoretical instruction dominates. More interactive awareness-raising actions, especially with young people, are an important step, making them come home enthusiastic about the theme and encourage the family to have more ecologically correct attitudes and actions.

EE must involve the whole community and should not be confined to the school. In EE activities, all dimensions of life must be inserted, since there is a link between the environment, health, the economy, the territory and the living conditions (Schmidt et al., 2010). The obsession with a consumerist lifestyle, especially in societies where there is no possibility of maintaining it, can only result in violence and destruction (Francisco, 2015). Educating for intervening citizenship means that "EE must be a critical and continuous learning experience, involving all citizens throughout their lives" (APA, 2017).

There are currently numerous entities that provide EE outside of formal education. The holiday camps seem to have a particularly interesting potential for civic and environmental education, in a non-formal environment, as they allow, in an organized and planned way, to combine fun with learning (CNJ, 2009). Membership is voluntary and focused on practical activities, with great interaction with Nature. Thousands of young people attend this type of activity during school holidays. Some studies carried out at an international level have shown positive results in the realization of summer camps with contact with Nature. According to Dresner & Gill (1994), a residential field of environmental education provides participants with an environment that can result in beneficial changes in several aspects, namely in self-esteem, interpersonal relationships and feelings of connection with the natural world, thus stimulating increased interest in reducing the impact on Nature. The contact with a natural environment, in a summer camp, reveals an increase in children's emotional affinity with Nature, as well as their ecological beliefs and willingness to show more environmentally friendly behaviours. Despite the high potential, summer camps have been relatively little studied as an EE tool. It was this set of characteristics that motivated the development of this research work.

2. Methods

The methodological approach comprised two lines of investigation: (i) a national survey of the holiday camps to assess their EE practices, and (ii) the evaluation of the results of the EE actions in a case study, namely the "ATL do Zoo" (Lisbon Zoo's holiday camp). Despite being a fundamental step, the evaluation is rarely carried out, and in cases where it occurs, there is usually only a concern to evaluate the acquisition of knowledge or satisfaction, without considering changes in attitudes, values and behaviours (Vasconcelos, 2013). In this work, special attention was given to this dimension.

A methodology based on questionnaires was used. A questionnaire was developed for the summer camps, to which answered 42 operators (out of 1039 contacted). Another set of questionnaires was applied to the ATL do Zoo, involving 425 participants and 75 parents. The questionnaire for participants contains 25 items on environmental attitudes and behaviours and was applied at two times: before and after attending the holiday camp. The participation rate at the second moment was 14%.

3. Results and Discussion

2.1. Holiday camps in Portugal

According to Decree-Law no. 32/2011 of 7 March, "Holiday camps" means initiatives aimed exclusively at groups of children and young people, aged between 6 and 18, whose purpose comprehends the realization, during a certain period of time, of an organized program of an educational, cultural, sports or merely recreational nature ".

The number of registrations by holiday camps organizers has been increasing over the years, as can be seen in Figure 1.

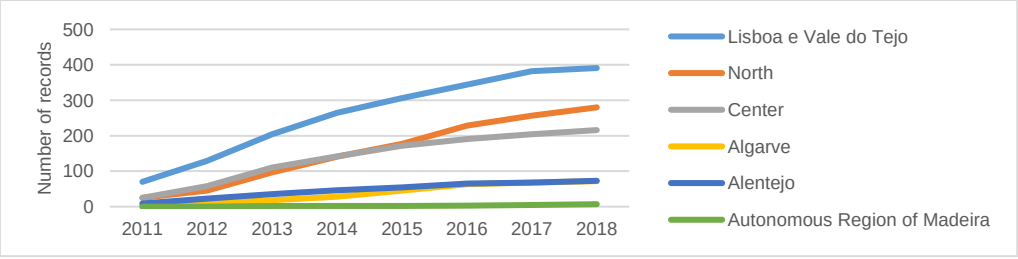

***Figure 1**. Evolution of the registration of entities organizing holiday camps from 2011 to 2018 by region in continental Portugal. Source: IPDJ, 2018.*

A questionnaire was developed for the organizers of the holiday camps in Portugal. 42 organizers of a surveyed universe of 1039 responded to the questionnaire, of which 28 confirmed the existence of environmental education (EE) activities.

As for the environmental themes addressed, the organizing entities seek to boost activities based on different themes, as can be seen in Figure 2, showing the interest in bringing about changes in attitudes and behaviours.

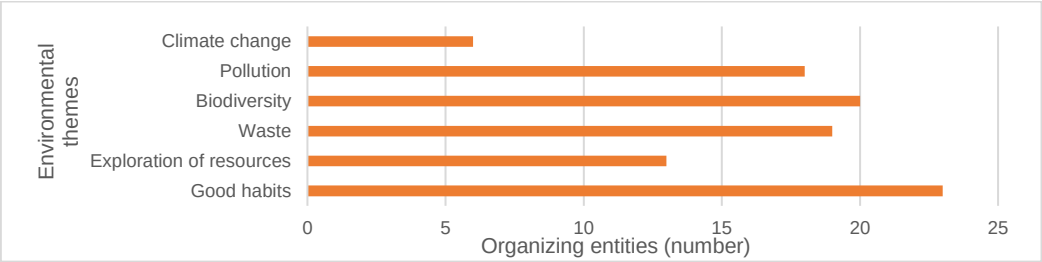

Figure 2. Environmental issues addressed in the holiday camps.

The type of EE activities developed in the holiday camps is quite diverse (Figure 3). It is important that the approach provides not only the acquisition of knowledge, but also awareness and change in attitudes and behaviours.

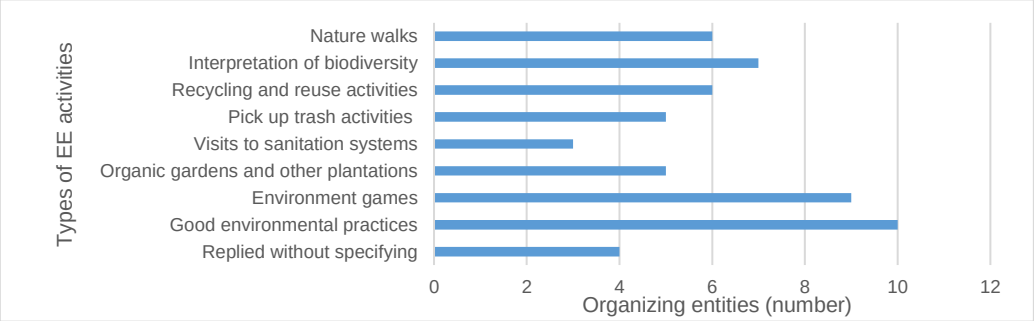

Figure 3. Typology of EE activities carried out in the holiday camps.

In the case of entities that do not develop EE in the holiday camps, this happens because this hypothesis has not been explored, or else because the entities consider that the character of the holiday camp that they dynamize is not suitable for such approaches.

It appears that in the overwhelming majority of cases there is no assessment of effectiveness in terms of changing attitudes and behaviours: only 2 of the 42 respondent entities report carrying out an assessment in this regard, in both cases only by observing behaviours.

2.2. ATL do Zoo

Open since 1884, the Lisbon Zoo (Jardim Zoológico de Lisboa - JZL) is a private non-profit institution. Currently, its priority goal is animal welfare, focusing its activity on the preservation of species through education for conservation and research.

There are several environmental education programs offered by JZL, and the ATL do Zoo is part of the school vacation program. It is a non-residential holiday camp. The program of activities is structured in five thematic days: day 1 - marine mammals; day 2 - terrestrial mammals; day 3 - reptiles and amphibians; day 4 - birds; day 5 - “Conservation”. The last day of the program is aimed at promoting activities related to the conservation of endangered species. Participants are divided into groups according to their school level. Activities include backstage visits, meetings with keepers, environmental enrichment activities, dynamic games, peddy-papers, treasure hunts, debates, among others. The dynamized activities not only aim to acquire new knowledge, but also to stimulate critical thinking. The general objectives of the activities developed in this program are as follows (JZL, 2019): to know and value the Zoo, its animal collection, its activities and its resources; develop

individual skills and team spirit; raise awareness and inform about the need for nature protection and the role of zoos in the conservation of endangered species, focusing on the Zoo and its mission; allow a lively dialogue with the Zoo that brings them closer to values that are beyond the perception of a "normal visitor".

An effectiveness assessment study carried out in a conservation education camp program offered by a Zoo, revealed that, after the experience, the participants improved their environmental attitudes and behaviours (Kruse & Card, 2004). However, the authors of this study claim that more research is needed to verify the long-term effectiveness of conservation education programs in changing attitudes and behaviours.

Within the scope of this work, the ATL do Zoo was the subject of an effectiveness assessment carried out in the summer of 2018. The methodology was based on questionnaire surveys. A questionnaire was created for participants (2nd and 3rd cycles of basic school and high school, ranging from 10 to 17 years of age) and a questionnaire for their parents (or other guardians). The latter allowed us to understand some changes in environmental attitudes and behaviours detected by the parents after the participation of their students in the ATL do Zoo. The questionnaire to the participants was applied in two moments: before and after participation in the ATL do Zoo. The first questionnaire got 425 answers, the second 60 answers. The questionnaire for parents got 75 answers. The questionnaire for participants consists of 25 items (Table 1) with a closed answer, on a Likert-type scale, where each respondent chooses the option that best suits their case. The scale chosen was the following: 1 = never; 2 = seldom; 3 = sometimes; 4 = usually; 5 = always.

Table 1. *Distribution of the questionnaire items to participants by categories.*

Category	Item
General / Interaction with family	1. I talk to my family about environmental issues. 2. I volunteer with environmental associations (for example cleaning beaches or cleaning forests). 3. I tell my family to buy organic and national foods. 7. I don't mind wearing clothes that belonged to my brothers or my cousins. 14. I like to offer gifts made by me.
Use of disposable plastic	4. When we go to the supermarket, we take reusable bags. 5. I don't use disposable plastic bottles to drink water. 6. I don't use plastic straws.
Resource saving: Water	8. I take quick showers so as not to waste water. 9. While brushing my teeth, I turn off the water tap.
Resource saving: Energy	10. When I can choose, I use the stairs instead of the elevator. 11. Turn off the lights when they are not needed. 12. My television is never on when I am not watching it.
Separation and reuse of waste	15. I separate the waste at home. 16. I encourage my parents to separate the waste at home. 17. I wonder if I can use something again before putting it in the container. 18. When I produce waste outside home, I look for an ecopoint to separate it.
Waste: marine litter	19. When I go to the beach, I take the waste I produce to the container and do not abandon it in the sand.
Biodiversity	20. I don't kill earthworms, ants and other animals and insects, even if I don't like them. 21. I am sad when I think of animals that suffer due to the human being's attitudes. 22. I feel right in the middle of nature. 23. I like to have contact with animals and to know more about them. 24. I like to have contact with plants and to know more about them. 25. I watch movies or read books about nature and life on Earth.

To assess the influence of the ATL do Zoo on the participant's environmental attitudes and behaviours, the results of the Pre- and Post-ATL Questionnaire were compared. The Mann-Whitney test was used to test significant differences between the two moments, for a 95% confidence level. Figure 4 shows, for the items that showed a statistically significant difference in the averages, the difference between the average of the scores of each item, before and after participation in the ATL do Zoo. Positive values represent positive evolution in attitudes and behaviours.

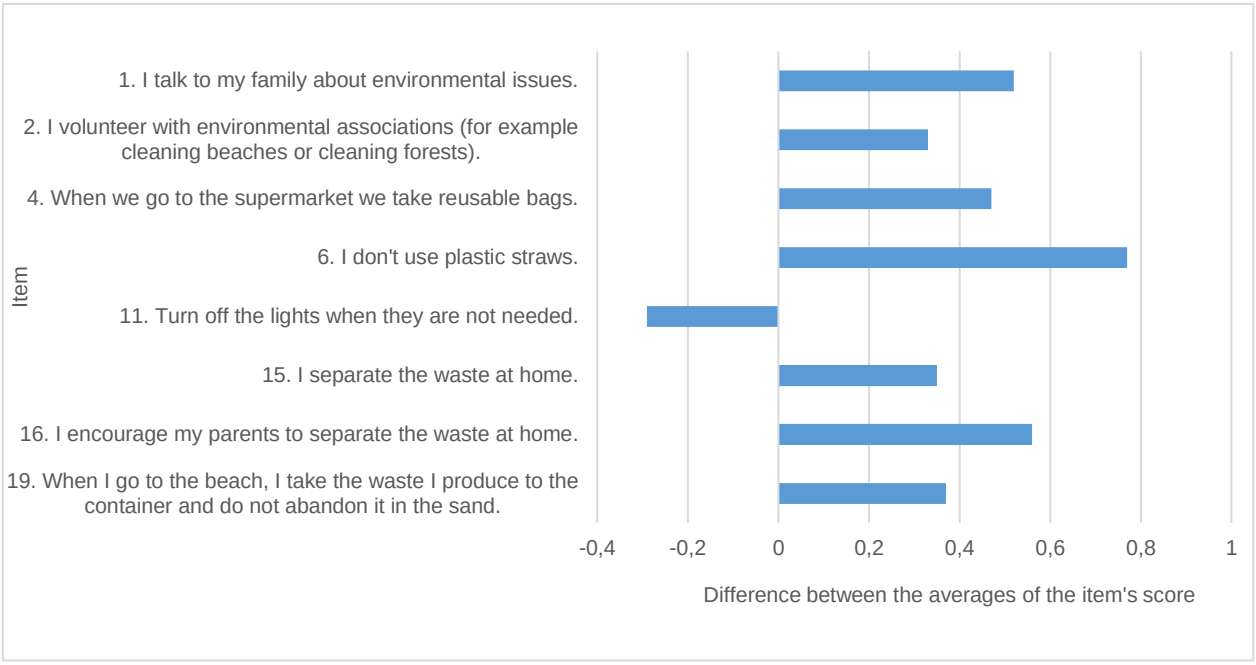

Figure 4. Difference in the average scores (1 to 5 scale) of the items before and after participation in the ATL do Zoo.

The use of plastic straws was the behaviour that obtained the biggest difference in the averages, with a positive difference. This result can happen with the empathy that is generated between the youngsters and the animals of the Zoo, since the plastic straws are related to the death and injury of countless sea animals, such as turtles, seals and sea lions; it is also a very simple action, a small change in habits.

Item 11 is the only one that presents a negative difference, leading to the conclusion that the ATL do Zoo was not effective in creating awareness of this theme, and should reinforce the activities in this sense (no special meaning is attributed to the negative value, which may occur due to statistical variability only, taking into account the samples for the first and second questionnaires were not equal). The remaining items show positive differences, allowing to affirm that, as a trend, participation in this vacation field provides positive changes. Young people show an increase in interest in sharing environmental issues with the family, an increase in interest in environmental volunteering, the use of reusable bags for purchases and the selective separation of waste.

To identify the most significant changes in the participants of this summer camp, parents were asked to briefly describe an example of these changes in their youngsters. Table 2 presents examples of the main changes observed. It is clear that the ATL do Zoo positively influenced these young people about environmental attitudes and behaviours. The activities developed provided, in most cases, an increased feeling of affection for animals. Parents say the youngsters show more respect for the animal world and are more concerned with its conservation since they participated in the ATL do Zoo. Palm oil is one of the subjects covered in the ATL do Zoo: the intense deforestation associated with Palm oil production destroys the habitat of many endangered species, including the Sumatran Orangutan, a species that can be found in the JZL and whose conservation status is considered "critically endangered" by the International Union for Conservation of Nature (JZL, 2019). JZL sensitizes visitors to the importance of looking at the labels and choosing products that do not contain this ingredient, and this awareness is also present in the activities promoted at the ATL do Zoo.

Table 2. *Responses from parents regarding the change in attitudes and environmental behaviours of participants in the summer of 2018.*

Category	Answers
General / Interaction with family	"They call attention to wrong behaviour." "Is more aware of pollution problems." "They are more concerned with wasting resources." "They show more respect for animals and nature (e.g. recycling, water consumption, etc.)."
Use of disposable plastic	"Against plastic plates and cutlery." "He stopped using plastic straws."
Resource saving: Water	"He started to turn off the tap when he was washing his teeth and hands." "Greater concern with the water that is spent on a daily basis."
Separation and reuse of waste	"He picks up garbage from the floor, especially plastics and is much more concerned with separating garbage (and warns others)." "It has been more participatory in recycling at home." "Now, my student separates the garbage willingly"
Waste: marine litter	"Greater concern about garbage on the beach (everything will end up in the oceans)." "Greater attention to plastic in the oceans."
Biodiversity	"Greater interest in programs on the animal world and nature in general." "They show more respect for animals, not provoking them." "Shows interest in protecting endangered species." "My son talks a lot about the characteristics of the animals he sees in the Zoo's activities. Has increased his compassion for animals."
Eating habits	"Change in type of food." "Do not consume foods that contain palm oil (e. g. some chocolates, some cereals, etc.)."

4. Conclusions

This study allows us to conclude that there is an effort on the part of the organizations that organize holiday camps to boost EE activities. However, many entities do not explore this theme because they consider that the objectives of the holiday camps they promote are not related to environmental issues. Considering the environmental problems, we face today, there is a need to integrate EE in all sectors, namely holiday camps that are a type of activity particularly conducive to the development of practical EE actions. In the case of the ATL do Zoo, it is possible to conclude that the dynamized activities arouse in young people a greater interest in environmental issues and in Nature, also promoting the acquisition of more sustainable behaviours, meeting the results of past case studies. In conclusion, it is considered extremely important to assess the effectiveness of EE activities in terms of changing the participants' environmental attitudes and behaviours, as this is the only way to adjust activities in the sense of an effective social transformation towards sustainability.

Acknowledgments

The authors wish to thank the participants in the survey on the holiday camps, and especially the ATL do Zoo, the main case study of this research project. We would also like to thank the young participants of the ATL do Zoo and their parents, without whom this work would not have been possible. We also thank Fundação para a Ciência e Tecnologia for funding CENSE, project UID/AMB/04085/2019.

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New approach in educating about innovative climate policy

A case study at the ISDRS

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Abstract

Limiting global warming to 1.5°C requires ambitious actions and systematic change, which need to be underpinned by a combination of innovative price and non-price policy instruments and a redirection of financial flows towards low-emission investments. Current public, financial, institutional and innovation capabilities however fall short of implementing ambitious actions in all countries. Policies including greening the economy, enhancing efficiency and Carbon Taxing proved to be inadequate to reach the 1.5°C target so far, but innovative policy instruments, having the potential to reach the target while addressing trade-offs with other policies have been already proposed. Among those, the Energy Budget Scheme (EBS) (RCC, 2015) is based on national proposals, which were debated (though eventually rejected) by national parliaments. The EBS would set an absolute limit for absolute fossil energy use, under which end users would receive energy entitlements to cover their energy consumption. End users could trade with their entitlements, for which they would gain an interest free currency. This so-called quota money could only be spent in a newly created secondary market for products and services with environmental and ethical certification. The EBS would include a Transition Fund, which would provide interest free loans on energy saving investments to everyone in need without requiring their own financial contribution. Even though the EBS has the potential to deliver systemic change in energy use, and thus reach 1.5°C target in a socially just manner, it has not caught significant attention from decision-makers, researchers or from the public. Therefore, we aim to communicate the effectiveness and sustainability impacts of EBS through a software-based strategy game, through which participants could also compare EBS with other tools aiming for CO_2 emission reduction while considering broader sustainability impacts. We believe that this innovative approach would not only bring education benefits but would also help to create a window of opportunity to debate and introduce policy innovation on a systemic level.

Keywords: Energy caps, Social justice, Interactive game, Policy innovation

1. Introduction

Limiting global warming to 1.5°C would make it markedly easier to achieve many aspects of sustainability including poverty eradication and reducing inequalities, but with the current pledges under the Paris Agreement achieving this target seems unlikely (IPCC, 2018). Meeting the 1.5°C target would require transformative systemic change based on a significantly increased ambition, which can be enabled among others by a combination of innovative price and non-price policy instruments and a redirection of financial flows towards low-emission investments (IPCC, 2018). Current policies including measures towards greening the economy and Carbon Taxes, however, proved to be inadequate to catalyse the needed transformative systematic change. "*Evidence and theory suggest that carbon pricing alone, in the absence of sufficient transfers to compensate their unintended distributional cross- sector, cross-nation effects, cannot reach the incentive levels needed to trigger system transitions" (IPCC, 2018, Chapter 4.).* Though quality policy design of measures aiming for greening the economy and their effective implementation may enhance efficiency, they alone cannot drive the needed systematic change either (IPCC, 2018). Reaching the 1.5 target while mitigating trade-offs with other policies (such as Sustainable Development Goals) necessitates stronger coordination and disruptive innovation across scales of governance, which should also provide financial, technological and other forms of support for poor and vulnerable people. This could imply among others complementing carbon pricing with sufficient transfers to compensate for their unintended distributional effects. Innovative policy instruments aiming for systematic change, while mitigating trade-offs have been, however, already proposed. The Energy Budget Scheme (EBS) endorsed by the Resource Cap Coalition (RCC, 2015), a European alliance of NGOs and scientists has the potential to meet many of these requirements in a holistic way. It is based on the Tradable Energy Quota (UK) (Fleming and Chamberlin, 2011) and the Energy Entitlement Scheme (Hungary) (Gyulai, 2011), which were debated (though eventually rejected) by national parliaments. While the EBS has the potential to deliver systemic change in

energy use and transform our production and consumption patterns in a socially just manner, the reluctance of decision-makers, researchers and the public even to debate quota schemes for delivering sustainability objectives is a huge impediment today. Therefore, we aim to communicate widely the effectiveness and sustainability impacts of EBS and compare it with other tools aimed at CO_2 emission reduction while considering broader sustainability impacts.

2. Methods

In order to compare and communicate widely the effectiveness and sustainability impacts of EBS, we developed a software-based strategy game, where game players aim to reach carbon neutrality by 2050, while enhancing some key environmental, economic and social indicators. Among environmental indicators we assess change in CO_2 emission reduction and the tendency in the other pressures on the environment, i.e. the use of natural resources and the use of land. Among socio-economic indicators we estimate the change in the ratio of the population impacted by energy poverty, change in households' savings and in unemployment rate. This choice is substantiated by the easy availability of data (Eurostat, 2019a, 2019b, 2020a, 2020b) on one hand, and their capability to indicate the social and economic performance of a given policy instrument on the other hand. The teams participating in the game can choose from three policy tools to achieve carbon neutrality by 2050, and their success will be measured by these five indicators (1. CO_2 emission, 2. change in the pressure on land and natural resource use, 3. change in the ratio of the population impacted by energy poverty, 4. change in households' savings and in 5. unemployment rate). The three policy tools are the EBS, the Carbon Tax and a Green Economy Toolbox.

The three involved policy tools apply an inherently different approach to delivering the energy transition. The EBS sets an annually decreasing cap for fossil energy use. It is based on energy consumption entitlements allocated among all energy end users (citizens, public and private entities), covering high-carbon energy use, where under-consumers and over-consumers can trade through the assigned management organisation. Under-consumers would receive interest-free 'quota-money' for their unused and traded energy entitlements. The quota-money could be exchanged in a newly created secondary market for products and services with environmental and ethical certification (e.g. outstandingly energy efficient appliances, organic food produced with low-carbon energy input, solar panels, building insulation services). A Transition Fund would provide interest free loans for energy efficiency and renewable energy investments, as well as for research and innovation to pursue relevant new technologies. The teams choosing EBS can decide the available amount of energy entitlements in the national economy (i.e. the decrease of fossil energy use), the distribution mechanism of energy consumption entitlements within the population, as well as the remuneration of over-consumption at individual and national levels. The second possible choice is applying a Carbon Tax, a policy that is already introduced in several countries. Teams following this policy approach can set the price of the tax and decide about the (re)distribution mechanism of the collected revenue. The third policy option is the Green Economy Toolbox, with a mix of policy instruments already implemented in several countries. These instruments include several awareness raising campaigns targeting either the general public or companies; corporate tax benefit for research and development; support for renewables, for alternative fuels and gasolines, for renovation of buildings and for innovative technologies applicable for companies, phasing out harmful subsidies for non-renewable energy resources, as well as greening state funds. Participants can influence how the limited state budget allocated to greening the economy could be distributed among these measures.

The game can be played either in 3-4 teams altogether by 20-40 people (e.g. decision makers, researchers, policy campaigners, students or the general public), or by a larger audience online. Each team can choose from the three different policy instruments (EBS, Carbon Tax, Green Economy Toolbox). In case not all the three tools are chosen by the groups, the software can simulate the missed tool by creating a dummy team, as well. Therefore, comparing the effectiveness of the three policy instruments in reaching environmental, social and economic goals can be still made. The game starts in 2020 with the following baseline indicators for all teams, which all correspond to the current EU average:

- 8.8 tonne CO_2 emission / capita (greenhouse gas emission in tonne of annual CO2 emission equivalent, Eurostat, 2020)[1],
- 11 % of the population living in energy poverty (as no single aggregated indicator has been used widely so far, we calculated an average from the four energy poverty indicators of the European Union: arrears in utility bill, low absolute energy expenditure, high share of energy expenditure in income, and inability to keep home adequately warm, Eurostat, 2019a)
- 12 % to gross disposable income saved by households (Eurostat, 2019b)[2]
- 6.5% unemployment (% of the active aged population, Eurostat, 2020b)

One round covers ten years, thus the game lasts for three rounds: first between 2020-2030, second between 2030-2040, the third between 2040-2050. During the 30-year period covered by the game, unforeseeable and unexpected events can impact the performance of each group in reaching carbon neutrality, while enhancing the environmental and socio-economic indicators by 2050. These events include economic recession, the arrival of climate refugees, more frequent occurrence of extreme weather events (droughts, flooding, melting glaciers, heat wave, etc.), the change in the accessibility of rare materials that are critical to the energy transition and the accessibility of fossil energy resources due to the high level of energy dependency.

At the end of each round, group members can discuss the social, environmental and economic indicators achieved by the chosen policy tool in the last ten years. In order to simulate multi-stakeholder and multidisciplinary discussion, group members have different roles to play to represent various interests. These roles can include for instance the minister responsible for climate and energy, minister of economy, minister of social issues, representatives of different interest groups including firms or socially marginalized people. In case the group agrees that with the chosen tool they are not on track to achieve the environmental, social and economic aims of the game, they are free to adjust their strategy or even switch to another tool. Each role and measure under the three policy tools have a detailed description, which group members can use in their strategising and argumentation. Group members playing the different roles while making use of the provided background materials negotiate the instruments and their implementation details that they are going to implement in the upcoming ten-year period.

We are going to organize events throughout 2020 to test and validate the three policy tools and their parameters, the socio-economic indicators, as well as models in the software. One of the events was planned for 2020 April in the framework of the Hungarian Climate Bill campaign, but this event unfortunately got cancelled due to the COVID-19 pandemic. We also aim to test the game during the ISDRS conference.

3. Results and Discussion

Teams following different policy approaches can decide upon different sets of input parameters. The impacts of these parameters have been modelled in the game based on a set of broad assumptions relying on literature review. Under the EBS, teams primarily influence the decrease of fossil energy use, i.e. how much the country aims to consume annually (see Table 1.). Secondly, they can make decisions on how the energy consumption entitlements are distributed within the population. They can choose from the following options: 2.1. everyone receives the same amount of entitlements that equals

[1] The indicator does not include emissions and removals related to land use, land-use change and forestry (LULUCF); it does not include emissions reported as a memorandum item according to UNFCCC Guidelines but does include emissions from international aviation as well as indirect CO2 emissions.

[2] The gross saving rate of households is defined as gross saving (ESA 2010 code: B8g) divided by gross disposable income (B6g), with the latter being adjusted for the change in the net equity of households in pension funds reserves (D8net). Gross saving is the part of the gross disposable income which is not spent as final consumption expenditure (ESA 2010 8.96).

the average energy consumption in the country, 2.2. a distributional mechanism is introduced considering social diffusion among households with different housing and living conditions (those receive more entitlements, who are more in need), 2.3. everyone receives the entitlements based on their current level of energy consumption, meaning that everyone is pushed to save energy from year to year as the cap tightens. Thirdly, participants who choose EBS can influence the remuneration of over-consumption at individual and national level. They can choose from the following options: 3.1. overconsumption is priced progressively and paid throughout the year, the more one over-consumes, progressively the more they pay for one extra entitlement, 3.2. the first option is complemented with a premium for all members of the society which has to be paid in case the nation does not meet the annually decreasing target. 3.3. overconsumption is paid at the end of the year, meaning that over-consumers pay their extra consumptions progressively in one amount at the end of the year, 3.4. the third option is complemented with a premium for all members of the society, which has to be paid in case the nation does not meet the annually set target, 3.5. there is no progressive pricing (every extra entitlement costs the same) and nor premium (no payment if the country trespasses the set target), 3.6. no progressive pricing exists (every entitlement used above the originally distributed amount costs the same, payment is made when over-consumers buy the extra entitlement throughout the year), premium has to be paid when the national target is trespassed.

The below table shows the list of inputs in the EBS scenario and the available parameter options for each input.

Input parameter	**Decision by teams**
1. National cap on fossil fuel consumption	Percentage as of the 2020 fossil fuel consumption level
2. Entitlement distribution	
2.1 Equal per capita distribution	One option can be chosen from among 2.1, 2.2 and 2.3
2.2. Distribution considering social diffusion	
2.3. Distribution based on current energy use	
3. Pricing mechanism	
3.1. Progressive pricing throughout the year, no premium	One option can be chosen from among 3.1, 3.2, 3.3, 3.4, 3.5, 3.6
3.2. Progressive pricing throughout the year, with premium	
3.3. Progressive pricing at the end of the year, no premium	
3.4. Progressive pricing at the end of the year, with premium	
3.5. No progressive pricing, premium	
3.6. No progressive pricing, no premium	

Table 1. *Input parameters in the EBS scenario*

Based on the data available in the literature, we have set broad assumptions on how the different options would influence the five environmental and socio-economic indicators:

- energy price influences household energy consumption,
- Income-poor households consume less energy than affluent households (Ekins and Dresner, 2004; elosztoprojekt.hu, 2019; White and Thumim, 2009),
- many poor are locked in inefficient or centrally heated dwellings (Ürge-Vorsatz, 2019), which results in that their financial status is not correlated with their energy consumption
- progressive pricing of energy overconsumption is more effective in constraining energy consumption in more affluent households than linear pricing,
- energy pricing has greater impact on energy consumption choice, if the payment is closer in time to energy consumption itself,
- the decreasing amount of energy entitlements linearly correlates with the GHG emission (Tombácz and Mozsgai Katalin, 2009; White and Thumim, 2009),
- the energy entitlement scheme has a little job creation effect (it can create in a 10 million population country 44000 workplaces, but there is no data how many jobs would be lost in related industries (Tombácz and Mozsgai Katalin, 2009),
- energy poverty can be diminished with wide-scale energy efficiency and renewable investments in the households,
- the Transition Fund can provide the capital needs for energy efficiency and renewable investments for poorer households without putting an additional pressure on household savings,
- the increasing price of fossil fuels (trends before the COVID-19 pandemic) results in an additional pressure on land and other natural resources, such as more fuelwood used for heating, biodiesel used for transport, or hydropower or wind power inevitably affecting land structures and biodiversity,

Arrows in the table 2. below aim to show the direction and the scale of influence of the chosen option on the five indicators. Green marks the most beneficial option for the given indicator among the options of a concerned input (among 2.1., 2.2., 2.3. and among 3.1., 3.2., 3.3., 3.4., 3.5., 3.6.). Horizontal lines indicate impact neutrality.

Options under EBS	GHG emission	Energy poverty	Household savings	Unemployment	Pressure on land and resource use
1. Decreasing fossil energy use by 2050					
2.1. Equal per capita distribution	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.
2.2. Distribution considering social diffusion					
2.3. Distribution based on current energy use					

3.1. Progressive pricing throughout the year, no premium	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.
3.2. Progressive pricing throughout the year, with premium					
3.3. Progressive pricing at the end of the year, no premium					
3.4. Progressive pricing at the end of the year, with premium					
3.5. No progressive pricing, no premium					
3.6. No progressive pricing, premium					

Table 2. *How the different options under the EBS influence the five environmental, socio-economic indicators. The arrows under options 2 and 3 are the additional impact above the baseline changes indicated in option 1. The direction of arrows shows the direction of the additional change as compared to the baseline change. Thus, for instance if an indicator is expected to decrease in the baseline option (indicated by downwards arrow), but the option selected under 2. or 3. is expected to diminish that decrease, then the arrow in 2. or 3. will point upwards.*

In table 2. we can see that the decision about the distribution method is expected to have various social and environmental impacts. Social indicators, such as the drop in the number of people living in energy poverty or the growth in household savings are expected to enhance the most (marked with green arrows), when entitlements are distributed considering social diffusion (Option 2.2.). Decisions made on the distribution mechanism, however, would not impact the two environmental indicators in the same direction as the more the CO_2 emission decreases, the more land use and resource use pressure is put on the environment in terms of enhanced biomass consumption and other types of pressures on land and natural resource use as we can see under option 2.3. Under this option even though CO_2 emission reduction is the most ambitious (marked with green arrow), pressure on the land and natural resources is the biggest (marked with red arrow). Considering both environmental and social impacts, option 2.2. would be more beneficial since it mitigates energy poverty, enhances household's savings, while delivering a major decrease in CO_2 emission at the same time. Regarding the options defining the pricing mechanism the picture is even more complex. Under option 3.2 where the highest CO_2 emission reduction can be achieved, none of the social indicators (drop in energy poverty, increase in household saving) seem to be beneficial compared to the other options. Furthermore, pressure on the land and natural resources seems to be the biggest, due to the enhanced biomass consumption. Regarding option 3.5., only the energy poverty indicator seems to be comparatively beneficial. If we consider the trade-offs among the five indicators, option 3.1. seems to deliver the best outcomes, the aggregate impact of which would be the highest from both environmental and social points of view.

Teams who choose Carbon Tax as a measure to reach carbon neutrality, while delivering other environmental, social and economic benefits need to make decisions in two areas. First is the level of Carbon Tax, namely how much EUR should be paid per consumed kilojoule. The other input concerns how the revenue gained from the Carbon Tax is spent, namely whether the revenue is spent on decreasing income tax to realise the scheme in a budget neutral way or spent on energy transition or in between.

We used the following additional broad assumptions for the modelling this scenario:

- Small and moderate level carbon taxes can only achieve moderate CO_2 emission reduction. This assumption is based on available literature showing that with carbon taxing 5-9% drop in CO_2 emission reduction can be achieved (ABC News, 2013; Dussaux, 2020). This reduction could be achieved by 23 USD tax per CO_2 tonne (ABC News, 2013) and by a tax started at 7 euros per tonne of CO_2 in 2014 increasing to 45 euros per tonne by 2019 (Dussaux, 2020). Also analysing European environmental tax reform examples with the Energy– Environment– Economy (E3) model for Europe, the results show that these reforms caused just a modest reduction in fuel use and greenhouse gas emissions (with a maximum of 5.9% decrease attributed to the reform) in all the six examined countries and a very small increase in employment and GDP. In these examples, all the ETRs were assumed to be revenue-neutral (Andersen, 2010).
- Increasing carbon taxes achieve higher GHG emission decrease (Andersen, 2010).
- Using the carbon tax revenues for financing energy transition investments has a greater potential for reducing CO_2 emissions than making the tax reform budget neutral. Based on submissions to the International Energy Agency database (International Energy Agency, 2015), the collected carbon tax in Japan is used for several measures, such as subsidies and R&D support from the start. According to the estimates for Japan, the emissions impact of the tax by 2020 is expected to be around 0.5–2.2 percent of CO_2 emissions in 1990, of which a minimal reduction results from a "price effect" (reduction in energy use through taxation) and the large majority comes from a "budget effect" (reduction through the use of tax revenue for emissions reduction measures) (submission to the IEA database).
- Higher carbon taxes increase energy poverty and decrease household savings.
- Carbon taxes do not cause a significant change in employment. The net effect of carbon tax on employment is small in magnitude and even slightly positive at +0.8%. It found in the OECD countries that "*at the firm level, a 10% increase in energy costs results in a 9% decrease in carbon emissions, and a 2% decrease in the number of full-time employees within one year. However, these jobs are not lost, but are reallocated to other firms…. Large and energy intensive firms experience greater reduction in carbon emissions and greater job reallocation than smaller and energy efficient firms*." (Dussaux, 2020).

Table 3. shows what kinds of inputs are needed from the teams that choose the Carbon Tax policy tool in order to reach the environmental, social and economic aims of the game. Participants need to make which option of the concerned input they are going to use throughout the next 10-year period of the game.

Input parameter	**Decision by teams**
1. Level of the carbon tax	Level of Carbon Tax in EUR/KJ of energy use
2. Purpose of the carbon tax revenue	
2.1.Revenue is used to decrease the income tax	One option can be chosen from among 2.1, 2.2, 2.3, 2.4

2.2. Revenue partly spent on energy transition, partly on reducing income drop	and 2.5
2.3. Revenue is spent on energy transition	
2.4. Revenue is distributed equally among members of society as carbon dividend	
2.5. Revenue distributed as carbon dividend considering social diffusion	

Table 3. *Input parameters in the Carbon Tax scenario*

Arrows in table 4. aim to show the direction and the scale of influence of the chosen option on the five indicators. Green marks the most beneficial option for the given indicator among the options (2.1., 2.2., 2.3., 2.4., 2.5.) on how revenue gained from the tax should be used. Horizontal lines indicate impact neutrality.

Options of Carbon Tax	GHG emission	Energy poverty	Household savings	Unemployment	Pressure on land and resource use
1. amount of the tax (EUR/KJ)	Based on the amount, it decreases linearly 	Based on the amount, it increases linearly 	Based on the amount, it decreases linearly 		
2.1. state budget neutral (no funds for energy transition, revenue goes for decreasing income tax)	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.
2.2. Revenue partly spent on energy transition, partly on reducing income tax					
2.3. Revenue is spent on energy transition					
2.4. Revenue is distributed equally among members of society as carbon dividend					
2.5. Revenue distributed as carbon dividend considering social diffusion					

Table 4. *How the different options under the Carbon Tax influence the five environmental, socio-economic indicators.*

In table 4. we can see that decisions defining the amount of Carbon Tax as well as distributional mechanisms of revenue collected from the tax have various impacts from social and from CO_2 emission reduction point of view (since indicator of environmental pressure remains the same in all options). Social indicators, such as the rate of energy poverty and household savings is the least unbeneficial, when revenue collected from Carbon Tax is distributed in the form of carbon dividend considering social diffusion (under option 2.5.). This option, however, provides the least ambitious reduction in CO_2 emission. While option 2.3. provides the most ambitious reduction in CO_2 emission and is the only option where unemployment rate decreases, it does not perform adequate social indicators (energy poverty rate, household savings) compared to other options. Considering both environmental and social impacts, we cannot vote for a single option to deliver both environmental as well as social enhancement, we need to choose whether to reduce CO_2 emission or to enhance social well-being.

Teams that choose the Green Economy Toolbox as their policy tool need to select from the nine available options to reach carbon neutrality, while also delivering other environmental, social and economic benefits. They also have to consider the financial requirements of their choices i.e. how much burden they would place on the state budget). The options include awareness raising campaigns targeting either the general public or companies; corporate tax benefit for research and development supporting the energy transition; support for renewables and for alternative fuels and gasolines, for renovation of buildings and for innovative technologies applicable for companies, phasing out harmful subsidies for non-renewable energy resources as well as greening state funds. The latter and phasing out harmful fossil fuel subsidies can be chosen only once during the period of the game, since after choosing any of these options, it will have its effect in the short term. The relative financial requirement of each option is indicated in brackets in the below table next to the name of the measure, this relativity provides opportunity to comparison as well as to stay within the limits of the state budget.

We used the following broad assumptions related to the Green Economy Toolbox scenario:

- In case the energy bills do not mirror the level of consumption, people are not motivated to reduce their energy use. Besides bills reflecting real consumption level, the comfort of heat should be changed, practical advice on easy to use techniques, proper information but not too detailed, concrete examples from households with similar problems should be spread (Csutora et al., 2017). Residents of Budapest, however would pay even 19% more for environmental friendly products and services (Budapest Főváros Városépítési Tervező Kft., 2018).
- Buildings account for 40% of energy consumed (Cao et al., 2016) and today's annual renovation, including energy upgrade of the building stock is very low, varying from 0.4 to 1.2% in the Member States (Esser et al., 2019). Long term support for energy efficiency and saving investment, including renovation will bring benefit (Csutora et al., 2017; ENABLE, 2019). In case of proper renovation, the heating cost can be dropped to its previous one quarter on average (Sáfián, 2019).
- The expansion of renewable energy, especially solar and wind, has not only beneficially impact on people living in energy poverty (Stram, 2016). Improvements, however, have arisen through energy projects are not equal for everybody; it depends on power relationships, customs and values, access to information and one's social context in the community (Fernández-Baldor et al., 2014). This should be considered when designing the project in a view to correct the existing inequalities.
- *"Government investment in carbon capture and storage (CCS) is a large and expensive fossil-fuel subsidy with a low probability of eventual societal benefit. Deep systemic change is needed to alter the disastrous global fossil-fuel trajectory. Instead of continuing to invest billions in CCS, governments should invest more aggressively in*

technologies, policies, and initiatives that will accelerate a smooth transition to non-fossil-fuel-based energy systems. We need to divest from perpetuating a fossil-fuel infrastructure and invest instead in social and technical changes that will help us prepare to be more resilient in an increasingly unstable and unpredictable future."(Stephens, 2014, p. 1.)

- Official international and thus national targets, commitments and tools currently applied are not enough to reach carbon neutrality by 2050 (Alfredsson, 2018; Díaz et al., 2019; Ripple et al., 2017).

Table 5. shows, among which options the teams, who choose the Green Economy Toolbox can choose to reach the goals of the game. In one round participants can choose options (financial requirement of which is indicated with X) in each round until they deplete the available state budget (indicated with 4X).

Input parameter	**Decision by teams**
1. State scale public awareness raising campaign (1X)	All these options can be chosen until their cumulative financial burden (indicated with X) depletes the available state budget (4X)
2. State scale awareness raising campaign for companies (1X)	
3. Corporate tax benefit for research and development (2X)	
4. Support for innovative technologies applicable for companies (1X)	
5. Greening of state funds (0.5X)	
6. Renovation of buildings (3X)	
7. Support for renewables (2X)	
8. Phasing out harmful subsidies for non-renewable energy resources (-2X)	
9. Support for alternative fuels and gasolines (1.5X)	

Table 5. *Input parameters in the Green Economy Toolbox scenario*

Table 6. shows how the different options contribute to the enhancement of the five environmental and socio-economic indicators. Arrows show the direction and extent of these contributions, horizontal lines indicate impact neutrality. In case one cell has more arrows, it indicates that the expected impact is not linear in time, but often diminishes or on the contrary, would be felt only after some delay. Green arrows mark the most beneficial option for the given indicator.

Options under green economy box of tools	GHG emission	Energy poverty	Household savings	Unemployment	Pressure on land and resource use

1. State scale public awareness raising campaign (1X)					
2. State scale awareness raising campaign for companies (1X)					
3. Corporate tax benefit for research and development (2X)					
4. Support for innovative technologies applicable for companies (1X)					
5. Greening of state funds (0.5X)					
6. Renovation of buildings (3X)					
7. Support for renewables (2X)					
8. Phasing out harmful subsidies for non-renewable energy resources (-2X)					
9. Support for alternative fuels and gasolines (1.5X)					

Table 6. *How the different measures of the Green Economy Toolbox influence the five environmental, socio-economic indicators.*

In table 6. we can see the impacts of the various options in the Green Economy Toolbox. Social indicators, such as the rate of energy poverty and household savings are the most enhanced in the case of a building renovation programme, but this option (6.), however requires the most financial resources from the state budget (3X). While option 7.: support for renewable energy resources provides the most ambitious reduction in CO2 emission as well as a drop-in unemployment, it also requires significant financial resources from the state budget (2X). Option 4.: support for innovative technologies applicable for companies also delivers CO2 emission reduction on the long run, as well as a decrease in the rate of unemployment, while it does not require so much financial support from the state (1X).

In the below table we include the most effective options under all the three policy tools (EBS, Carbon Tax, greening the economy toolbox), which provide environmental or / and social enhancement. The size of the arrows has been modified in order to compare the three policy tools. (The arrows in tables 2., 4., 6. allowed the comparison of different options under the given policy tool). Here we need to stress that the effect of EBS and the carbon tax primarily depend on the set absolute energy consumption target and the price of the tax respectively. The more ambitious reduction target and tax price are set, the more GHG emission reduction can be achieved by the EBS and the carbon tax respectively. In table 7. we marked with green those areas, where the most significant beneficial impact can be achieved in terms of the concerned indicator.

Most beneficial options of the three policy tools	GHG emission	Energy poverty	Household savings	Unemployment	Pressure on land and resource use
EBS: 2.2. Distribution considering social diffusion					
EBS: 3.1. Progressive pricing throughout the year, no premium					
TAX: 2.3. Revenue is spent on energy transition					
TAX: 2.5. Revenue distributed as carbon dividend considering social diffusion					
Green Toolbox: 6. Renovation of buildings					
Green Toolbox: 7. Support for renewables					

Table 7. *The most beneficial options of each policy tool in terms of the chosen five indicators. The arrows indicate the absolute impacts of these options (irrespective of any comparison to a baseline option).*

We can see that EBS has the most beneficial impacts in terms of GHG emission reduction and energy poverty mitigation, especially if the energy entitlements are distributed on social diffusion consideration and are priced progressively without the duty to pay a premium if the nation exceeds the set cap. However, it must be noted that even the EBS should not be implemented in an isolated manner by the countries and accompanying measures can significantly reduce the adverse side-effects. One example for such an accompanying measure could be introducing new or tightening existing land use policies, which could prevent additional pressures made on land originating from shifting environmental pressures. Such possible accompanying measures, however, could not be included in the game for the sake of simplicity.

All the tools in table 7. has no effect on or only slightly decrease unemployment, while only renovating buildings enhances at least slightly households savings and put no more pressure on land and resource use

4. Conclusions

We find several benefits of utilising software-based strategy games in awareness raising and stimulating policy interest. The simulation game can contribute to the increased understanding of participants about the trade-offs that decision-makers

face when deciding about climate change policies. Their roles assigned within their teams force them to adopt different perspectives and test their understanding and reasoning skills during the team debates. While the background materials of the game provide some guidance and open questions on the interlinkages among the different socio-economic factors, they need to more thoroughly discover these relationships themselves and judge their relative importance. The modelling results for the ten-year periods provide direct feedback for the teams, which can be used to revaluate their approach and to modify their assumptions. In addition to their holistic understanding and analytical skills, their willingness for cooperation and compromise are also put to a test.

In addition to improving the understanding of trade-offs, the game also underlines the importance to include innovative approaches into the scientific, political and public debates. As the scientific literature suggests, the currently available policy tools are insufficient to achieve carbon neutrality in the coming decades, and it is also challenging to implement the various sectoral aims, such as the 17 Sustainable Development Goals at the same time. Innovative tools, such as the EBS might provide the missing tools to mitigate trade-offs and achieve ambitious goals.

Therefore, our game also underpins the need for further scientific studies and for modelling of different approaches. Even though some potential benefits of the EBS scheme are underlined by the strategic environmental assessment, the broader environmental, social and economic impacts would need to be modelled more thoroughly. It is also our declared aim to encourage modelling teams and research consortia to include innovative and so far neglected policy options in their modelling work.

The need for further research, however, should not prevent politicians getting familiar with new approaches, like the EBS. In addition to politicians, the public also needs to get informed about innovative and holistic proposals, as they will largely bear the burden of the energy transition. Therefore, they should be involved and given the opportunity to share their views on system level changes and new approaches. By this they could become a drive behind the energy transition as well.

Our study has, however, some important limitations. First, so far we could not test the simulation game with a real audience due to the pandemic lockdown. Real life testing will most probably reveal the weak points, where our strategy game requires improvement or fine-tuning. This testing will be realised as the pandemic situation allows. Besides, even more importantly the available literature has limited data on how the different options of the three policy tools would influence the five environmental, social and economic indicators included in our model. As described above, it would require further research into these policy tools to better substantiate our models and allow the comparison of the three tools. We believe though, that despite the scientific limitations of our models, this strategic game can still fill an important gap in communicating innovative policy options for addressing the climate change challenge, and in stimulating debate and exchange among not only researchers, but also politicians and the public.

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Old teaching-learning strategies in a new scenery. Barriers and possibilities to develop student teacher's competences to implement sustainability issues into school practice

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Abstract

Humanity is undergoing serious and unprecedented changes that evoke great threats and lead to raise basic questions about our common future. We live in "urgent" and "challenging" times so we need to undertake efforts to overcome unsustainable trends and disastrous effects of our pernicious practices. We face new demands which force us to deal with complex and contradictory situations. Mankind must make an effort to introduce and disseminate new concepts of functioning and recreating main dimensions of human life.

The expected transition will only happen if we engage teachers to implement sustainable educational solutions to school practice of every level. Teachers seem to be the most effective force to influence thousands of students to change their life habits and accept new priorities and global goals. The transition towards sustainability needs to be total and common. Education for sustainability emerges as a core challenge of our generation.

The conviction of multifaceted cooperation between schools and higher education institutions becomes more and more clear. In spite of that positive attitude towards ESD there is a strong reluctance and opposition against introducing sustainable development issues to higher education courses. Academics multiply barriers and prove that they have "more important" vocational obligations to complete, or they simply show the total ignorance towards sustainability issues. In Poland there are no formal and obligatory regulations about the amount and rate of sustainability topics to be referred to during academic courses. School education – just like higher education – do not recognize the importance of sustainable topics.

In the current Polish National Curriculum one can find only some slight references and connotations to sustainability challenges. Despite such „unfriendly" and unfavourable state of educational environment I persistently try to establish problems of sustainable nature as one of my flag topics among academic courses that I am responsible for. When I give lectures and run workshops my students have to encounter sustainable challenges. I endeavour to show them that entering into the "dimensions of sustainable life" opens unrecognizable, unknown, and even unimaginable spheres of their concern and possible activities.

The aim of the paper is to show actual possibilities to link the Polish National Curriculum content and contemporary promoted didactical approaches with university activities referring to student teacher academic training in terms of education for sustainability.

I will present a sample of a project method application – considered as a desired in Polish compulsory school education strategy. Students who plan to become teachers should gain competences to use it in various educational situations.

That's why academics should also feel obliged and introduce new issues and current problems to their work. The fusion of desired school strategy with sustainable issues seems to me a perfect match. Thanks to students' inter- and transdisciplinary individual and collective learning they managed to achieve complementary and holistic outcomes proving the integration of sustainable development, intercultural education, and artistic or scientific issues. Student teachers gained competences to implement sustainability issues into school practice. Thanks to making constant comparisons between local and global issues students experienced deep and significant development. Their understanding of sustainability in different contexts became multidimensional. Such profound student teacher education gives hope that future educators will be keen to interpret their school duties in perspective of sustainability and will spark the "greed for sustainability" among their students, parents, and colleagues.

Keywords: Education for sustainability, student teacher training, project method, higher education, barriers in implementing sustainable issues

1. Introduction

The world is undergoing a dynamic and profound transformation. Some innovations are spectacular, others are dangerous for human existence. Trends that make people concerned about the future effects of contemporary changes have indicated a global discussion towards sustainability. Though the idea of SD has been present in international debate since the 1970s of the 20th c. (Meadows et al., 1972; WCED, 1987) its realization is still weak and incidental. To make sustainability common transition towards social justice and individual happiness a fundamental and global change in compulsory education is needed. The goal shows the importance of student teacher education which should be immediately improved. Up-dated pre-service teacher training should look for new solutions and concurrently refer to well-known educational activities, methods, and some subject content. Such way of educational procedure is balanced and already sustainable.

Referring to the complex perspective of above-mentioned challenges a multifaceted discourse comes to mind. It constitutes the basis for four aims of the paper:

1. To remind that there are well-known teaching-learning approaches which can be used in ESD. The project method is one of them as it has a constructivist-based theoretical framework (Knoll, 2014). That trait has been acknowledged as cardinal and influenced the decision of writing down the project method into the Polish National Curriculum.
2. To show that academics are a group of educators who make the process of implementing sustainable education slower. They are reluctant to engage in SD, so they do not introduce adequate content to their courses. Universities should be obliged to modify their working routines, influence academics to change their teaching habits, and "attend the demand from students for new, learner-centred approaches to teaching, integrating SD competences and fostering them in an interdisciplinary way, deploying for this purpose innovative learning methodologies, teaching concepts and didactic tools" (Leal Filho, 2020).
3. To present that student teachers (an example from Poland) are interested in sustainable problems, keen to undertake new challenges, and open to engaging themselves in problem-based learning.
4. To emphasize that individual and teamwork through project method smoothly develops sustainable development competences indispensable for each educator.

2. Methods

1. Project method – its development towards sustainability demands

Thinking about student-centred learning approaches one may recall many teaching-learning activities that are effectively used in various school situations referring to concrete tasks and levels of education. There is a common acceptance to develop collaborative and teamwork learning by using: small group discussion, brainstorming, presentation, Oxford debate, panel group or roundtable discussion, simulation, role-playing, games and competitions, jigsaw, drama, experiments, laboratory tasks, demonstration, workshop, inquiry-based learning, mental models and mind maps, teacher-led or student-led storytelling, open space for dialogue and enquiry, studies of films, videos, photographs, critical media analysis, peer-to-peer teaching, future-problem solving, case study, fieldwork, etc. (Education for Sustainable Development Lens, 2010). Today we can also add – nearly to all of them – ITC versions, internet extensions, and mobile apps. They not only help a student to become independent in his knowledge, decisions, activities, and attitudes (system of values), or to become aware of many interdependencies in his life, but they develop the ability to anticipate novel issues and formulate problems to be solved as well.

Many of those methods or techniques have become narrow, "specialised", and thus concentrated only on a chosen aspect of human development. Therefore though they present suitable grounds in their fundamental or general senses, they

chop, separate, and fragmentize human cognition at the same time. Sometimes they are realised schematically and predictably, following guidelines that do not allow any important subjective interpretations and contextual variances. Probably it is the time to reconsider a comeback of multifaceted and multidimensional educational strategies that could help to undertake challenges of sustainability by enabling students to pose truly important questions and to work out various ways to find out solutions and up-dated answers. The storyline method (Creswell, 1997) and project method are with no doubt such learning approaches.

In Polish National Curriculums (Regulation of the Minister of National Education, 2017; Regulation of the Minister of National Education, 2018) the latter one has been considered as one of the most desirable and suitable educational strategies in the context of comprehensive primary and secondary education.

The most appreciated advantages of using project method, underlined by Polish educational authorities, focus on:

- application of the method – it contributes towards the development of student's social competences (communication and cooperation) and ITC competences. It helps to develop student's enterprise and creativity skills, enables to undertake or follow innovative educational solutions according to the content of subject-curriculum, possible learning approaches, and organizational arrangements;
- students – are expected to present high autonomy, self-direction, and responsibility. They endeavour to develop those personal skills to become independent in their learning activities, choices, and educational routes;
- the project method itself – the method supports group integration, promotes teamwork, and creates participants' confidence about their unique value as individuals and members of the community;
- possibilities of enhancing student's self-respect and self-esteem while dealing with the method;
- possibilities of developing organizational competences (concerning planning and projecting intended steps and actions);
- finally, deepening and extending student's self-evaluation skills and making his/her motivation for the process stronger.

As a procedural perspective is concerned it is worth to remind that:

- project method refers to cross-curriculum priorities, and gives space to formulate novel issues (adequate to new life challenges) and encourages to pose problems emerging from vague and unsustainable reality;
- the topic itself should present the cross-subjective issue that arises from students complex concerns and fears, or – in a positive version of their educational quests – from their interests and curiosity;
- a teacher takes the role of a facilitator and at the same time "a schedule keeper". Giving his/her students a lot of space and independence in deciding how to solve the problem, how to plan quests and solutions inside the methodological frame, s/he keeps the procedure to be passed in a proper order.

The last item of above-mentioned list concentrates on teacher's position. Savery makes interesting remarks about project learning processes in the prism of educator's role in it: "Within a project-based approach learners are usually provided with specifications for a desired end product (build a rocket, design a website, etc.) and the learning process is more oriented to following correct procedures. While working on a project, learners are likely to encounter several 'problems' that generate 'teachable moments'. Teachers are more likely to be instructors and coaches (rather than tutors) who provide expert guidance, feedback and suggestions for 'better' ways to achieve the final product. The teaching (modelling, scaffolding, questioning, etc.) is providing according to learner need and within the context of the project. Similar to case-based instructions learners are able to add an experience to their memory that will serve them in future situations" (2015).

The quoted interpretation of a project learning strategy seems very optimistic. However, taking under consideration complicated socio-cultural, economic, and political realms, plus natural environment challenges it becomes important to raise a fundamental question: what kind of problems are truly essential for us and how can we learn to cope with them. Awareness of unavoidable problems and changes complemented by the ability to anticipate future challenges enhances the need to revise,

update, and improve teaching-learning methods. What would be the currently most satisfying version of the project method, then? Where can one find inspirations to implement desired modifications?

As history shows, the method has undergone five key phases of development (Knoll, 1997). The insight into the history of the project method clearly proves that the method is flexible and may be easily adapted to new conditions. Still, it may be judged ambiguously, like in Savery's opinion: "Although cases and projects are excellent learner-centred instructional strategies, they tend to diminish the learner's role in setting the goals and outcomes for the problem. When the expected outcomes are clearly defined then there is less need or incentive for the learner to set their own parameters"(2015).

One could agree with that statement if it was not presenting only one of many possible visions of educational philosophy and practice. In fact, there are variously accepted perspectives to construct teaching-learning processes. Teaching-learning methods and school activities along with determined goals and outcomes may be articulated, conventionally understood, and described more or less precisely. As an example, if a student is asked to sew an apron and s/he is expected to follow the instructions, s/he probably won't be very much motivated to do it. S/He might even feel oppressed. If – on the contrary – a student is asked to sew an apron following his/her imagination and fantasy, the school task might meet with a larger acceptance.

The idea of such an approach to the project method shifts the reader to the "classical" concept by Kilpatrick, who understood student motivation as the crucial feature of his learning idea, naming it a "wholehearted vigorous activity" (1918). Another famous wording for the project method "hearty purposeful act" also explains a lot of Kilpatrick's guidelines. According to the pedagogue's theory whatever a student did, was accompanied by his/her emotional feeling of sense and purpose, and should be classified as a project acting. Therefore Kilpatrick made reference to the psychological explanation of effective learning and the category of closeness worked out by Thorndike (Thorndike, 1924).

The above-mentioned ideas present apt counterarguments to Savery's standpoint concentrated on small or diminishing student's role in learning through the project method. The rationale refers then to the question of different and equally accepted perspectives of teaching-learning strategies and to the issue of feeling the sense and purpose of learning. It influences the state of satisfaction and boosts the motivation of student's engagement. That activity depends on student's ability to identify himself (a concept of closeness) with the problem, task or challenge. In other words, the category of distance – mainly – of diminishing the gap between learner and different, sometimes very strange, unknown, and odd matters becomes one of the most important challenges and goals of contemporary education.

Today, the complementary and multifaceted approach becomes the most desirable educational challenge. It expects learners to think holistically, to refer to the problem from different perspectives, and make use of its all three dimensions (the issue is perceived spatially, not as a flat and incomplete object). Knoll states: "Referring specifically to Dewey, Vygotsky, and Jerome Bruner, all modern educators situate the project method within a constructivist-based theoretical framework. They regard students as active agents engaged in authentic tasks, solving real problems, and generating knowledge and skills in dynamic interaction with their physical and social environment, thus creating meaning of themselves and the surrounding world. They acknowledge, however, that the constructivist approach must be balanced by a concept of structured teaching and direct, strong instructional guidance" (2014).

Therefore teachers as students' mentors and task coordinators should be aware of the new educational duties that emerge from current reality. Teachers, in fact, become agents of the truly important transition of one's attitudes and activities from unsustainable routines to sustainable and balanced choices and practices. Those are the most important issues to be raised, the most authentic and profound problems that humanity have to confront with.

In many countries, teachers may find desired guidelines and suggestions – how to understand sustainability issues and how to face them during school practice – in educational documents and national curriculums. Fundamental messages flowing out of the Polish documents are similar to those constituting main objectives and premises of the idea of SD and SDGs for years 2015–2030.

As one can read in opening sections of Polish curriculums, Polish schools take care of kids' and teenagers' education in the spirit of acceptance and respect for another man, develop the attitude of appreciation for the natural environment through

the dissemination of knowledge about sustainable development principles, and motivate to protect nature and develop ecology awareness. Young people should inter alia learn good practices to achieve skills in rational management, to broaden their knowledge and deepen awareness of the issue of ecological footprint, and to develop the attitude of responsibility for creating order and beauty in the areas of our living. The learning content should be chosen in compliance with the idea of education for sustainable development through making students aware and sensitive about the value of cultural objects and natural sights being a part of local, regional, national, and global heritage.

Looking for some inspiring educational approaches, with the intension to develop Polish educational achievements in sustainability, it is worth to compare it with an Australian offer. The Australian curriculum presents even more clear, unambiguous, and well-arranged structure of the document than the Polish one. In the document, we find three cross-curriculum priorities. One of them is *Sustainability*. The priority is "futures-oriented, calling on students to act sustainably as individuals and to participate in collective endeavours that are shared across local, regional and global communities" (2020).

The comparison of priorities and content of national curriculums from both countries shows the presence of mutual issues and tasks for school practice. On that shared platform of understanding and acceptance, the general sustainability objectives present a wide range of possible and detailed realizations. They should be locally embedded, which means – they should take into account local culture, tradition, social and economic capabilities, and natural conditions. A multiplicity of possible realizations becomes an expected and welcomed effect. Currently, students' motivation to work on such issues naturally increases, showing that even complex and multifaceted topics are not only trendy but worthy of true effort as well. Young people are eager to undertake meaningful challenges. The analogy of that expectation can be found in Kilpatrick's opinion that "the worthy life consists of purposive activity and not mere drifting" (1918).

Educators have more and more opportunities to engage themselves in the process of a sustainable change. Unfortunately, quite often they refuse to undertake the challenge what makes the idea of ESD weak and optional. To reverse that situation a proper and sustainably desired pre-service education seems to be an indispensable and awaited step.

2. Academics – one of the main barriers in developing student teachers sustainability competences

Existing theoretical paradigms and models of education, practical ways (strategies and methods) of working with students (Klus-Stańska, 2018), as well as ranges and types of problems presented to them during classes/courses, are not sufficient any more. The perspective of SD needs new approaches which lead to various research proceedings undertaken in many countries, like Great Britain (Summers, 2013), Canada and China (Liu, 2009), Norway and South Africa (Bentham et al., 2015), and Australia (Denby, Rickards, 2016).

When the question of "redirecting" or reorienting the pre-service and in-service teacher training arises – as the most demanded and socially desired one – some problems that accompany the main reflection come to light a) What should be the role of universities – historically treated as prime institutions of change and transition – in taking appropriate measures to evoke anxiety and serious reflection, and implement sustainable solutions? (Lozano et al., 2013); b) How to implement content focused on sustainability problems to higher education programmes, learning schedules, and individual work of each student planning to become a teacher or educator? (Summers, 2013; Leal Filho, 2016; Leal Filho, 2018); c) What are students' and academics' attitudes towards new content referring to SD challenges and obligations? (Bentham et al., 2015).

Results of researches show that despite a big interest to update learning issues among students themselves (Denby, Rickards, 2016; Nousheen et al., 2020), academics do not present the comparable, clear, and quick readiness to make any modifications. Although sustainable existence should be a natural state of each human being (while difficulties and dilemmas should be treated as challenges to immediate revision or adjustment), the resistance of academics to make sustainability a part of mainstream higher education remains astonishingly strong (Summers, 2013). Contemporary academics, regardless of the place of their living and working share common worries and present similar explanations of maintaining their distance against the idea of ESD. First of all, they emphasize a) the need of adjusting their academic activity (didactic and scientific work) for the constantly changing university regulations and expectations; b) the obligatory demand to get a PhD degree and to publish articles; c) authority's expectations to promote university valued skills and professionalism; d) the increasing workload due to

student numbers and changing academic roles; e) the need to fully engage in different academic community activities (Bentham et al., 2015).

Besides quite often university authorities demonstrate the lack of awareness and knowledge about the importance of ESD in local dimension in the perspective of global – meaning: our common – future. The constant approach of neglecting contemporary challenges towards sustainability, makes the academics believe that they are incompetent to refer to SD matters by their own because their knowledge and skills do not satisfy them, as they do not represent even an elementary range of each category. In addition, they distance themselves from SD issues because university and faculty authorities do not organize any training courses, seminars or other forms of vocational development, or do it in insufficient quantity and range of offers. In the face of being "abandoned" by the authorities, academics tend to prove that there are several other "objective" barriers making them unable to implement sustainable topics to the university subjects they are responsible for.

According to Moore (2005a) the most typical barriers refer to a) the disciplinary environment (disciplines determine organizational structure, they are focused on "production" of their "excessively specialized experts", they maintain boundaries between disciplines in spite of claiming the willingness to interdisciplinary transition); b) competitive environments (instead of creating better people universities and faculties compete for standardized excellence; culture of measurement and corporate game does not match with humanistic and complex development); c) misdirected criteria for evaluation (the simplest and most accessible scientific evaluation of academics refers to the number of publications and the position of the scientific journal they manage to publish in; such tendency does not help to engage in didactics: there are no clear guidelines how to evaluate teaching processes and how to evaluate learning processes of young generations in that field of interest); and d) unclear priority setting and decision-making (there is no clear "centre" how and where decisions about recreating curriculums towards sustainability are made; no one – nor faculty members, nor administration representatives – want to be in charge of such fundamental transition). In such circumstances teaching staff prefers to stay "on the safe side" and avoid "doubtful" changes in the "solid" routine. Such an attitude affects the acceptance of administrative regulations depending on hard and measurable indicators and the approval to reject creative engagement in striving to enable and develop unpredicted and "soft" human interactions.

The presented state of professional and moral student teachers' practice is of strong conservative nature. It does not give hope for quick and multifaceted realization of ESD. That also entails still poor implementation of sustainability issues and its weak recognition among contemporary students who – as the most appropriate generation – should, after all, aspire to achieve sustainable and spectacular changes for the common good.

The genuine change in higher educational institutions' practices needs up-dated policy-makers decisions. To quote Bourne et al. (2017) "as a consequence of the Decade on Education for Sustainable Development and the leadership provided by the UN and UNESCO, the themes that are the focus of this report [ESD and GCED in teacher education] have much higher prominence amongst policy-makers than they did at the beginning of the twenty-first century".

It is important to state that for the last few years a lot of modifications have been implemented to the educational sphere to change the vague condition of Education for Sustainability. Many new initiatives have been raised to enhance the common interest in sustainability and to build its capacity (Bamber, 2020; Leal Filho et al., 2020). A significant change has been noticed not only in the process of up-dating educational documents, national curriculums, and school recommendations, but in publishing new "traditional" and online resources and teaching materials too. Despite that visible movement towards sustainability real changes are happening very slowly. Many countries as Bourne et al. observe still treat those issues "as optional and marginal to the main purposes of teacher education" (2017).

A situation like this demands some pivotal decisions and solutions. They should spark "a *light* version of deconstruction" understood as a process of humanistic reconstruction of higher education in the interest of student teachers and their SD training. It should become a priority in changing paradigms and models of education, and content of curriculums and academic courses. Universities should promote and encourage their communities to create "spaces for pedagogical transformation" (Moore, 2005b). Broad improvement of higher education might be possible thanks to a refreshed understanding of the category of "culture of study" when a student and his/her university tutor would have more time and possibilities for reflective thinking, dialogue, acting and finding solutions. Posing questions, creating answers, experiencing

complex issues, exploring options, re-examining meanings, discovering new senses, being part of academic discourses, and at last, reaching significant remedies, are the main and constitutive elements of a new idea of studying and developing oneself in the spirit of sustainability.

Thus one may optimistically admit that the growing focus on sustainable topics is recognizable and progressively concentrates *on content*. But, still as Burns et al. suggest "there is far less agreement, understanding, and research about *how* sustainability competencies can be cultivated in college and university courses and programs" (2019). The second phase of incorporating sustainability into the educational realm has started. Examples of "good practices" are no longer sufficient and satisfactory. Educators of all levels of education need more clear and unambiguous theoretical approaches and procedural frames (strategies, methods) that would be clearly relevant to sustainable issues.

That methodological turn may be identified with a new culture of studying understood as a "*slow studying* model of development". The wording "slow studying" clearly refers to the "slow food" expression which promises extra time to enjoy the meal and spend happy moments with nice company. The concept is opposite to "fast food" nutrition – the one of doubtful quality of ingredients and short time for consumption. The issue of education for sustainable development in the perspective of slow studying concept (more individualized and thorough teaching-learning educational practice) should be understood as an attempt to help student teachers to "sharpen their senses", i.e. to confront novel dimensions of learning approaches, deepen possible understandings of a problem, and experience nuances of an object of cognition. Thus students may intensify their sustainability encounter by tasting – even "biting" – different levels and ranges of contemporary challenges aimed at harmonious, balanced, and hopeful education, leading to a safe and sustainable world. If not, educators will be wrongly prepared to their duties and will be unable to satisfy expectations of contemporary society which starts to recognize the dangers of unsustainability.

3. Project method as leverage to the development of student teacher's sustainability competences

The question of including SD into practical learning approaches becomes the most desired educational challenge. Sustainable Development Agenda and its 17 goals for years 2015–2030 constitute the basis for the whole process (with the special emphasis on Goal No. 4 *Quality education*). They reveal and highlight the significance of cross-thematic and multi-levelled education realized through many appropriate to the problem/school topic teaching-learning activities. In other words, advocates of ESD see in the Goal No. 4 (and especially 4.7) an overarching idea with various possible suggestions of educating people and making them aware of all of the core problems (and sub-problems) of present time and future condition of humanity (Osman et al., 2017).

Michelsen expresses his conviction in a similar way stating that "Education for sustainable development has become an established concept that fundamentally reinterprets the goals, methods and content of education, enhancing its quality, as well as creating opportunities for change processes in individual educational sectors." (2015). However, he concurrently acknowledges that "despite the countless political initiatives and activities as well as practical projects described, education for sustainable development is not yet 'mainstream'" (2015). A deep reflection and analysis of the reasons of that incomprehensible situation of keeping sustainable development issues apart from the main course of educational activities and priorities show that one of the causes lays in educators' doubled and "circular" fear. They keep the distance from sustainable issues because they wrongly interpret sustainable content assuming that it demands some extra "fresh", advanced or "sophisticated" methods. At the same time teachers discard well-known approaches as they estimate them not enough comparable to the new content they are not sure about.

To show that such conviction is totally wrong and inexplicable I tend to use the project method approach during workshops dedicated for student teachers of master level courses. New sustainable content has been introduced along with the expectation that pre-service teachers would be open-minded and keen to explore current world challenges. Many researchers, academics, and pedagogues highlight a similar belief (Maidou et al., 2019; Weber, 2020). As Weber admits "students carry a huge potential in order to experiment with new formats for active, problem based, self-organized learning, which are seen as key to individual and collective education for sustainable development (…). University in this sense needs to open the space

towards new platforms of learning, towards cross-sector-co-creation and the shift from ego-system to ecosystem awareness" (2020).

As everyone may perceive, possible solutions lay in adequate conjunction of the type and sense of educational problems, the importance of issues recognized by students, and the use of commonly understood procedures. As learning approaches require more than a single discipline or perspective, the capacity and diversity of higher education seem to be the best environment to develop sustainable attitudes, knowledge, and activities. Moreover, as Krogman and Bergstrom notice, "many educators are finding that students learn more and can more readily draw on knowledge from across the disciplines if they are posed with a problem for which there is no one right answer, although there are well informed and carefully reasoned answers" (2018).

In the light of those premises project-based learning seems to be an appropriate method for contemporary students to work with and become prepared to cope with worldwide challenges and menaces. As Krogman and Bergstrom underline "solutions-oriented, real-world projects like these can be very impactful because they help to generate hope and agency in students" (2018). It is even more significant when future teachers are intentionally engaged in having an influence on next generations and in inspiring them to become responsible inhabitants of our planet (in economic, social, cultural and environmental dimensions). Thus it is commonly perceived, what Bourn et al. repeat that "in relation to the themes covered in SDG 4.7, teacher education perhaps is most evident in recently published major academic publications on ESD" (2017).

In the context of above-mentioned characteristic, a sample of a project method application is to be presented (the one worked out during my workshops). It includes all of the essential features of the method expected in Polish educational practice (Szymański 2000; Gołębniak 2002). For students' activities, it has been revised and extended with the intension to implement modifications corresponding to social needs in local and global perspectives. The changes make the structure clear and updated:

- the topic of the project has to be worked out by the whole class community (a teacher should not only cooperate with students but present initial premises and goals of the project as well),
- goals and problems are formulated thanks to students' collective negotiations,
- the project cannot refer only to realistic, well known, and close to students' neighbourhood problems – the locality should be confronted with the context of global, holistic, and intercultural challenges,
- the project must be intersubjective of cross-curriculum qualities,
- the project not only enhances students' knowledge and improves their skills, but refers to the issue of values, convictions, and attitudes needed to be developed in the face of human and sustainability goals,
- to work with the project method students have to collect all documentation materials (prepare portfolio) and conduct the final presentation,
- students and their teacher sign a "Contract"; the document encloses: the topic of the project, its aims, listed working methods and techniques, time limits, deadlines, evaluation criteria and consequences of breaking the "Contract",
- students prepare the schedule of project tasks (realization stages), and appoint peers responsible for each part of the plan,
- the project is usually carried out by a team,
- criteria and rules of monitoring the effects of the project work are fixed by students themselves; the needed documentation consists of student's individual evaluation chart and final presentation template,
- public presentation of results, as a culmination of the whole project work.

Above-listed elements and clues of the project method present a clear scaffolding for students' activities, enquiries, and different solutions. Therefore they help to spark students' independence, creativity, and responsibility along with the awareness of existing frames and external expectations and rules. Equipped with such a " multidimensional tool" students may freely submit bold ideas and different realizations due to their intentions and ways of deciphering the reality. Concurrently, they are expected to declare the readiness for being accurate and precise while following all the steps of the method. Hence,

students' cognition and gained individual experience should help them in their future vocational activities. When they start to work as teachers, educators, tutors, etc., they will be deeply aware of the advantages and drawbacks of the method. They will lead it in the way that brings a lot of satisfaction to their students and to themselves as well.

As one starts to analyse effects of students' activity and their engaged development while using the project method on sustainable problems it comes clear that such thematic issues perfectly match to that teaching-learning method. Such an approach should be treated as a means of developing and expending individual sustainable competencies that should be later used in students' vocational activity.

Speaking about crucial sustainable competences, it is worth to take into account the 'learning for the future competences' targeted at student teachers and working educators (Rogalska-Marasińska, 2017). Those competences which create four separate realms clearly refer to four pillars of education. Thus one can speak about four pillars of teacher sustainable competences, which are a) Learning to know: The educator understands…; b) Learning to do: The educator is able to…; c) Learning to live together: The educator works with other in ways that…; and d) Learning to be: The educator is someone who…. **(**UNECE Education for Sustainable Development Competence Framework, 2012). Each of the pillars splits into a more specified list of features. They all create a cluster of inspiring directions of individual development. The warp and weft of possibilities to penetrate the density of sustainability fabrics are organized in three co-existing sub-realms: *Holistic approach* (refers to integrative thinking and practice), *Envisioning chance* (bases on an interdependence between alternative future being dependent on our past and present activities and decisions), and *Achieving transformation* (refers to ways of individual and system learning).

3. Results and Discussion

Before presenting some of project method realizations it is worth emphasizing that students have been encouraged to immerse their project thinking and acting in multicultural and sustainability realms. Hitherto, most interesting projects that have been carried out with my guidance (and slight encouragement) present valuable ways of students' thinking and a vast horizon of their questing after significant problems: 1) *Existing stereotypes in intercultural relations between Germans, Russians and Poles*, 2) *Polish tailors against famous international clothing companies*, 3) *Polish regional art on the course to promote Poland in the world*, 4) *Human trafficking – a contemporary slave trade*, 5) '*Naturally beautiful' – global need to care about our bodies*, 6) *Religions and their influence on local nutrition habits*, 7) *Social response to GMO products in Poland and in the world*, 8) *Film art inspired by European and Asian music*.

To reach such an advanced level of holistic thinking students are to take into account some initial requirements and enclose them in their concepts. They have to refer to ESD goals and four pillars of sustainable development. In addition the project has to be intercultural (showing relations between at least two cultures). The last condition refers to students' creativity forces. They are expected to include some kind of artistic ideas in the realization of the project.

Practical utilization of those benchmarks may be attractively illustrated by the *Religions and their influence on local nutrition habits* example. The project was realized by a group of 5 students. It lasted for 2 months. In "Contract" students enclosed four project aims reflecting the route of their theoretical deliberations: 1. Becoming familiar with food culture referring to each religion; 2. Perceiving and comprehending nutrition differences between people living in certain cultures and confessing faith in Christ or other gods; 3. Presenting and disseminating knowledge (cultural background, philosophy of nutrition, the interdependence between human and nature) of Polish (traditionally Catholic), Islamic, Jewish, Buddhist and Indian (Hindi) cuisine; 4. Realization of a mini-theatre performance "Union of Tastes" for the peer audience.

Looking closer to the above-mentioned work-plan it comes out that during the first phase of the project each of the group members had an individual task to realize. S/He was responsible for collecting information about separate cuisine, including a) written information about culture, tradition, and history of people belonging to that religion; b) looking for special dishes connected with concrete social customs and cultural behaviours; and c) collecting those data from various visual

materials and examples. Then all of the team members moved on to the juxtaposition stage. The accurate comparison followed by first evaluation showed what was done well and what needed to be completed.

The second phase mostly focused on a teamwork. The whole group worked on a survey and then, equipped with questionnaires started a tour round chosen restaurants (with traditional cuisine). The aim was to interview the restaurants' owners. Those owners who had earlier agreed to be a part of the research were happy to tell students about their culture, cooking recipes, and food specialities. The whole group could taste many dishes and explore the unknown world of the meaning of food and each cuisine rituals. Comments and suggestions as an effect of the second evaluation stage inspired the team to make proper distinctions between what they collected, learned, and experienced. The clear classification of main information, additional knowledge, and learned curiosities made a very interesting and multicoloured picture of intercultural cuisine. It proved not only to be "a tasty piece of human life", but a responsibly balanced sensual and intellectual adventure as well.

There is a well-known Polish proverb "Through the stomach to the heart". Here, the group of students explained its meaning by comparison of the traditional cuisine to a harbour that opens the door to start the journey and meet various cultures, different people who have a lot to offer. The balance of each cuisine hidden in tastes, smells, the composition of plants, meat, spices, water, and beverages should be transferred to the wider context of a possible, expected, and sustainable relation between cultures with their unique concepts of life, visions of a man, and his place in the world.

Deep experiences that became a crucial part of students' process of working on the project gave them a huge impact to prepare and present a short theatre performance which reflected their fascination of what they had learnt and felt. "The Union of Tastes" was not only a tour around "tasty tables" but an artistic story about – only seemingly different – people. The truth they wanted to emphasise was that all of us are culturally and historically rooted. We have equal rights and possibilities to support and develop our traditions, customs, and faith. We deserve a decent, safe, and good life. In conclusion they underlined the importance of such values like social justice (perceiving strong references with 1st, 4th and 10th SDGs), interdependencies between economic growth (8th SDG) and maintenance of both fundamental human environments – nature and culture (4th, 6th, 7th SDGs), and the improvement of the quality of life and good health (3rd, 6th, and 7th SDGs).

Summing up the project, students expressed their conviction that the overarching, crucial, and indispensable goal of all SD approaches is Goal No. 4 – *Quality Education*. They also became aware that education helps to understand each person (oneself and other people met in everyday contacts). It gives the chance to get closer to the world that we live in and brings hope that our endeavours will introduce and consolidate sustainable changes and improvements. In their individual evaluation charts, students underlined the growth of their competencies, especially in the sphere of knowledge and attitude of openness. They experienced in practice and through positive emotions a new and involving way of exploring various dimensions of human life which had been existing close to them but had stayed unseen.

4. Conclusions

Considering a contemporary category of teacher training and learning, a conclusion can be drawn that the process should be immersed in SD expanse and combined with such core SD competences as "critical systemic thinking, collaborative decision-making, and taking responsibility for future and present generations" (UNESCO Roadmap for implementing, 2014).

To meet such demands students need a double support: positively engaged academics and multitasking teaching-learning tools. A common change of academics' attitude needs profound systemic revision.

Much quicker is to look for effective educational instruments. There is no doubt that project method is one of them. It enables to undertake a vast range of topic/content possibilities, still keeping learners in understandable educational frames and expecting them to respect project method's criteria. Thanks to such dual conditions student teachers and later – their own students will manage to cope with various challenges to build a sustainable planet and responsible global society.

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Perceptions and attitudes about local Sustainability of young people

A case study in rural areas, Beira Baixa, Portugal

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Abstract

In 2015, the adoption of the Sustainable Development Goals (SDG) defined a new agenda and supplied a holistic and multidimensional view for development. These Goals are challenges to traditional teaching methods, and important to educate for Sustainable Development (SD) and involve young people in the participative model. Young generation can contribute to promote environmental conscience, and to the change in values and attitudes towards sustainability. Bearing in mind that each player has its own "language" it is essential to promote dialogue between science and society, namely among the youth. The case study of this research takes place in the context of a special program, that aims to establish scientific publication partnerships between Secondary Education Schools (SESs) and the Higher Education Institutions (HEIs) and it refers to the Beira Baixa region. This region is predominately rural, that represents approximately 0.8% of the resident population of Portugal (around 83 thousand people), having one of the lowest rates of young people in the country (10.6%). The main goal of this work is to reflect on the perception that the youth has about SD, based on the results from a questionnaire applied to a group from the region's student population in Secondary Education. The questionnaire comprises of five parts: i) characterization of the sample; ii) SD perception, iii) SD evaluation in the municipality of residence, iv) what is important to evaluate in the region's SD, v) voluntary activities. The results allowed to verify that the large majority of the students has heard of the term SD, having school and the media been the major contributors. When asked about the evaluation of SD in the region, referring to the four dimensions, and according to a traffic light, the majority considered the environmental dimension "green", the economic and governance "yellow" and the social dimension is divided between "green" and "yellow". About 40% of the students considers that their quality of life "is the same" as in previous years. When asked about what is important to evaluate in their region's SD and, specifically which of the SDG are more important to their region, the main ones are: Good Health and Well-Being (SDG 3), Affordable and clean energy (SDG 7) and Climate action (SDG 13). Most of them considers that the process for selecting indicators should have their opinion in mind. This project intends to improve the level of knowledge about SD (knowledge acquisition, skills and attitudes), mostly among young people, so that their future decisions are informed and efficient and promote a commitment towards a sustainable future. There is a continuous need, urgent and vital, to create and develop innovative tools to educate the young people on sustainability that allow for the improvement of their knowledge, their skills and their attitudes about SD and the SDG. This work demonstrates that the SESs, connected to the HEIs, can play a vital role in awareness about SD and, specifically about the SDG, so that SD can be reached from the local to the global levels, in order to contribute towards social change and a more sustainable future.

Keywords: Educating for sustainability, SDG, Youth, Rural Municipality, Beira Baixa

1. Introduction

The Sustainable Development Goals (SDG) emerged at the Rio+20 conference in June 2012 and arose in a context where the Sustainable Development (SD) triple-bottom-line was not being achieved (Sachs, 2015). They are global terminologies and frameworks, which are synonymous with how to respond to environmental, social and economic challenges, with local and global objectives, guidelines and solutions (Agbedahin, 2019).

The SDG provide a development holistic and multidimensional view, they focus on people, on the planet, on prosperity, with the motto: "Transform our world, leave no one behind". For the first time, they have become universal goals, there is a project for everyone everywhere (Leal Filho et al., 2018; Leite, 2017; Sachs, 2015). Many questions are posed to society to guarantee economic prosperity, equity and social inclusion and environmental balance. These challenges must be a global and not an isolated process. For this, the involvement of the whole society is essential because it allows the reinforcement of the society's commitment towards SD.

SDG bring challenges to traditional pedagogies, where Education for Sustainable Development (ESD) should promote awareness of the complexities and uncertainties facing planet Earth (Mogren et al., 2019); so it is important to strengthen the links between society and Higher Education Institutions (HEI), Secondary Education Schools (SES) and HEI, for example. Bearing in mind that each actor has his own language, it is essential to promote the dialogue between science and society, being an ongoing process (UNESCO, 2013).

It is essential to understand how and why ESD is so important, not only for the literature of international policies, but as an instrument for achieving the SDG (Sumida, 2017). From the analysis of the state of the art, it is possible to find several studies that relate ESD to HEI, but few focus on lower school levels, besides several initiatives that are conducted in schools. ESD, with its dual focus on (i) reorienting education for SD and (ii) strengthening education and learning to support SD is fundamental to the education of future society (Roofe and Ferguson, 2018).

ESD is an integral part of goal 4.7 of SDG 4, which aims by 2030 “(…) ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through Education for Sustainable Development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and nonviolence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development” (UNESCO, 2015:21). This goal suggests that ESD is not the only way, but it is a good way to achieve the SDG; on the other hand, it is implied that the potential of education to transform the world cannot be reached without the educational system embracing SD (Agbedahin, 2019; Gil-Pérez and Vilches, 2019; Shephard 2015; UNESCO, 2017).

ESD is a dynamic concept that integrates a new vision of a type of education that seeks to enable individuals of all ages to adopt the responsibility to create a sustainable future (UNESCO, 2002; 2005; 2014). ESD, therefore, enables all human beings to achieve the knowledge, skills, attitudes and values necessary to shape a sustainable future. ESD provides knowledge, information and facts about changing global contexts and environmental issues, as well as their risks and causes. ESD enables students to make informed decisions and to take conscious actions in relation to environmental integrity, economic viability and social equity, for present and future generations, ensuring respect for cultural diversity (UNESCO, 2018). It prepares individuals to deal with and discover solutions to issues that threaten the planet’s sustainability and social systems (UNESCO, 2007).

ESD provides lifelong learning experiences that are locally relevant and culturally appropriate. It incorporates the evolutionary nature of sustainability, considering the context, local priorities and global issues. ESD therefore aims at global needs, perceptions and conditions, although it admits that meeting local needs has effects and consequences on an international scale. ESD requires the use of participatory teaching and learning methodologies implemented in formal, informal and non-formal education systems

to encourage and enable students and teachers to learn, reflect, change their conduct and take measures for SD, promoting skills such as critical reflection (Michalos et al., 2012; Shulla et al., 2020; UNESCO, 2014).

In 1992, during the Conference on Environment and Development, the International Forum of NGOs (FIONGsMS / FBONGsMSMAD 1992: 193-194) suggests that "(…) environmental education for equitable sustainability is a permanent learning process, based on respect for all forms of life. Such education affirms values and actions that contribute to human and social transformation and ecological preservation. It encourages the formation of socially just and ecologically balanced societies, which maintain a relationship of interdependence and diversity. This requires individual and collective responsibility at the local, national and planetary level".

Later, the Manifesto for Life (2002: 5) considers: "Education for sustainability must be understood in this context as a knowledge dialogue-based pedagogy, and oriented towards an environmental rationality construction. This pedagogy encompasses a holistic view of the world and a complexity thought. (…) It is an education for participation, self-determination and transformation; an education that makes it possible to recover the value of sensitivity in complexity; from the local to the global; the diverse before the unique; from the singular to the universal."

Educating for SD means incorporating the fundamental SD themes into learning and teaching, for example, climate change, poverty eradication, inequality reduction, sustained and inclusive economic growth, with the aim of contributing to a holistic perception of the SD (Gil-Pérez and Vilches, 2019; Nordén, 2018; Sousa and Uceda-Maza, 2017; UNESCO, 2005). Thus, ESD should promote environmental awareness, promoting a change in values, attitudes of citizens towards the environment. Furthermore, it should encourage a participatory model considering current problems, especially environmental ones.

In the case of higher education, ESD provides essential support for the framing of educational activities, in particular the implementation of the SD (Disterheft et al., 2015), so HEI play a vital role in promoting the principles of sustainability, to reach SD from the local to the global level, in order to contribute to social change in favour of a more sustainable future (Disterheft et al., 2015; Rouhiainen and Vuorisalo, 2019; Yuan and Zuo, 2013).

But it is important not to neglect teacher training, in this case applied to initial training. Some authors stress the importance of raising teachers' awareness about SD (Cotton et al., 2007; Carew and Mitchell, 2008; Dyment and Hill, 2015; Nikel, 2007; Sund 2008). It is necessary to seek an understanding with the teachers so that the ESD becomes a continuous process, which understands the purpose and relevance of transdisciplinary approaches (Kalsoom et al., 2018; Nordén, 2018; Nousheen et al., 2020). It would be pertinent to introduce and/or deepen SD themes through different pedagogical strategies, which would reflect on a higher level of commitment to the topic.

According to Yuan and Zuo (2013), a top-down approach is essential for change, but there must be a bottom-up approach as this contributes to increased awareness. It is necessary to combine the two approaches to involve all stakeholders. An integrative approach, which allows a holistic view, based on routines and structures, which allows the creation of professional knowledge and practical pedagogical work, the Whole-School (Mogren et al., 2019), should be privileged. As an example, the Earth Charter stands out, specifically the principle 14 which refers to the importance of integrating, in formal education and lifelong learning, the skills, knowledge and values necessary for a sustainable lifestyle (Earth Charter, 2001).

Education is a fundamental tool in a society as a driver of change and a promoter of SD. In general, there is an interdependence between environmental knowledge and pro-environmental decision-making (Fadeeva and Mochizuki, 2010; Jacobi, 2003; Robelia and Murphy, 2012; Sousa and Uceda-Maza, 2017). In other words, the increase in citizens' knowledge of the environment will lead them to consider their actions (in favour of good choices), with an impact on future generations (sustainability).

Based on the previous literature review is indeed vital to create and develop tools to educate and engage young people on sustainability to improve their knowledge, skills and attitudes towards SD and SDG. Involving students in this process allows for awareness of challenges and solutions regarding SD and SDGs. The main goal of this research is to reflect on the perception that the youth has about SD, based on the results from a questionnaire applied to a group from the region's student population in Secondary Education located in a rural area in Portugal – Beira Baixa.

This paper is based on the development of a project and is part of the Portuguese 'Cientificamente Provável' Program (http://www.rbe.min-edu.pt/np4/2164.html), promoted by the Ministry of Science, Technology and Higher Education and the Ministry of Education (ME), through the School Library Network (SLN). This program aims to establish scientific dissemination partnerships between HEI and SES and disseminate scientific research carried out in HEI, through the promotion of possible partnerships that, involving SES students, bring the two realities closer together. The project aims to improve the level of knowledge about SD (that is, knowledge, skills and competences), especially among young people, so that their future decisions are informed and effective and promote a commitment to building a sustainable future.

Beira Baixa, the region where the project takes place, is predominantly rural, where most of the territory are farms, forests and pastures, it has an area of 4 614.64 square km and it contains the country's 3rd and 4th largest municipalities (Castelo Branco and Idanha-a-Nova respectively). Its population (about 83 thousand people) represents about 0.8% of the national resident population, what translates in the lowest population density (17.9 people per square km) in Portugal, having one of the lowest rates of young people in the country (10.6%). According to Intermunicipal Communities of Beira Baixa (CIMBB, 2015) the municipality of Castelo Branco has development and social cohesion levels that go along with the national average, while the remaining municipalities of a rural profile (namely, Idanha-a-Nova and Penamacor) have strong structural weaknesses, that are reflected in the demographic and socioeconomical indicators (aging index 279.5, total dependence index 67.7%, illiteracy rate of 10.7%, activity rate of 59.6% and employment rate of 40.9%).

The goal of this paper drifts from the results gathered after an inquiry by questionnaire applied to the resident population of Beira Baixa, Portugal, who attend the school (normally 13-14 years old), specifically in schools located in Castelo Branco, Idanha-a-Nova and Penamacor. This questionnaire had as main goal to know the perceptions, the knowledge and attitudes of this age population towards SD and in what areas there is a need to act for its implementation in the scope of the region where they reside. We will also compare these results with the similar survey that was applied to an adult population of the same region.

2. Methods

The development of the questionnaire to young people was based on an survey previous applicated to the adult population of this region (for detailed information of the questionnaire see Manso et al., 2019), which was adapted to the population under study, and went through the following stages: a) making of the first

version; b) input by school librarians and teachers; c) alteration of the first version after collection of input; d) pre-test in November 2018; f) final version.

The questionnaire is organized in five parts: i) characterization of the sample, ii) SD perception, iii) SD evaluation in municipality of residence, iv) what is important to evaluate in the region's SD and v) voluntary activities. In the first part, there was a set of sociodemographic questions about gender, age, place of birth, town hall, how long the student life in this parish and school year. The others parts are made up of closed questions, most of them multiple choice and in the fourth part, the question about the themes for the Indicator System (IS) of SD a Likert scale was used (where 1 meant "not important" and 5 meant "very important").

The authorization to the parents and questionnaire received the approval of each School Group in November 2018. The students completed the questionnaire online using LimeSurvey.

The questionnaire was applied to SES students from Beira Baixa region in May 2019 (in the 2018/19 school) and in October 2019 (in the 2019/2020 school). This collaboration involves the Castelo Branco's Nuno Álvares School Group, the Idanha-a-Nova's José Silvestre Ribeiro School Group and the Penamacor's Ribeiro Sanches School Group. This project includes 48.1% students of urban municipality (Castelo Branco) and 51.9% students of rural municipalities (Idanha-a-Nova e Penamacor).

According to ME statistics, there were 2 017 students enrolled in Secondary Education in the 2019/20 school year, so the students in this project represented 7.9% of the total students enrolled in SES of Beira Baixa.

A descriptive statistics and statistics tests relevant to the enquiry of relations between variables (Kruskal-Wallis test) were conducted. Statistical analysis was performed using the SPSS 25.0 software.

3. Results and Discussion

The sample being studied is made up by 160 students. Table 1 contains the characterization of the sample under study. Most students are male (51.3%) and are 13 or 14 years old (67.3%), with an average age of 14 years (standard deviation = 1,119 years). Most of the students are Portuguese nationals (95.5%), are from Castelo Branco (82.5%), and live in this parish (89.3%) for more than 5 years. The inquired students attend the 9th (51.3%) or 8th grade (48.8%) of schooling.

Table 1 - Sociodemographic information for the study sample.

Gender	**N**	**%**
Female	78	48,8
Male	82	51,2
Age	**N**	**%**
12	5	3,1
13	58	36,5
14	49	30,8
15	31	19,5
16	11	6,9
17	5	3,1
Nationality	**N**	**%**
Portuguese	152	95,0
Other	8	5,0
Place of Birth	**N**	**%**
Castelo Branco	132	82,5
Coimbra	6	3,8
Leiria	2	1,3
Lisboa	8	5,0
Madeira (RA)	1	,6
Portalegre	1	,6

Setúbal	3	1,9
Other	7	4,4
Town hall	**N**	**%**
Castelo Branco	77	48,1
Idanha-a-Nova	37	23,1
Penamacor	46	28,8
How long have you lived in this parish?	**N**	**%**
Less than 1 year	3	1,9
Between 1 and 5 years	14	8,8
More than 5 years	142	89,3
Grade	**N**	**%**
8th	78	48,8
9th	82	51,3

When asked if they heard about SD, most students (73.1%) respond affirmatively. Would be expectable that “all” of the students had already heard about SD, because they already studied ESD in the subject of Citizenship Education in SES.

School is the context most referred to as the source of this information (59.48%), followed by the family (33.62%), institutions (33.62%), the internet (32.76%) and the media (31.03%), as shown in Figure 1. The results obtained in the adult population showed the importance of the media (81%) and about a quarter referred school (Manso et al., 2019).

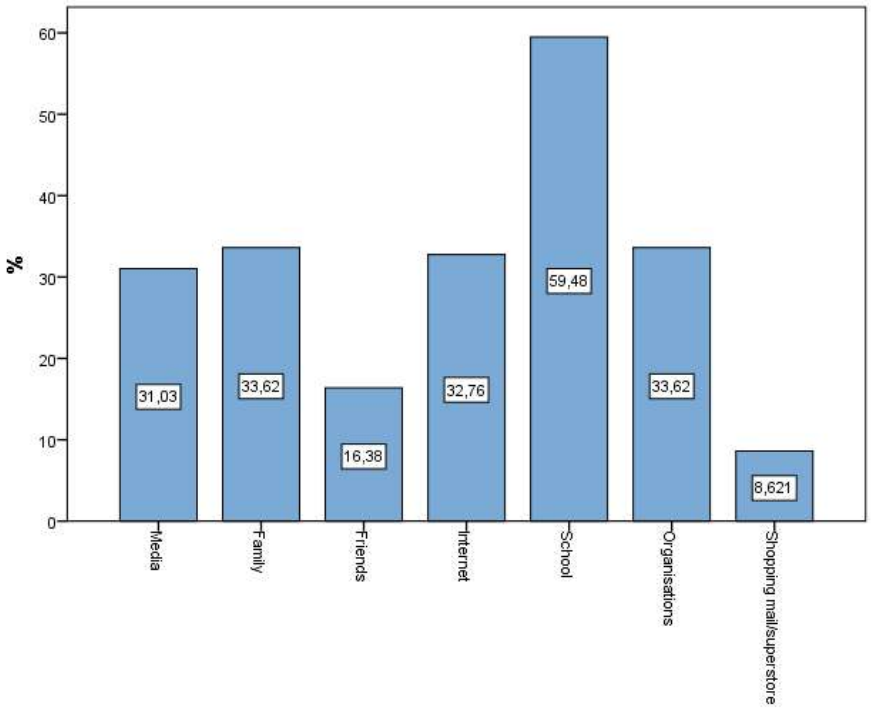

Figure 1. *In what context did you hear about sustainable development?*

When questioned about who is responsible for the Promotion of SD, most respondents believe that it is up to each of us (87.88%), to the European Union (46.46%) and to the National Government (38.38%), as shown in Figure 2. Of the respondents who selected "Other", we highlight Schools (21.9%). The results carried out

with the adult population most respondents believe that it is to each of us (79.8%), to the National Government (70.9%) and to the Local Government (60.6%) (Manso et al., 2019).

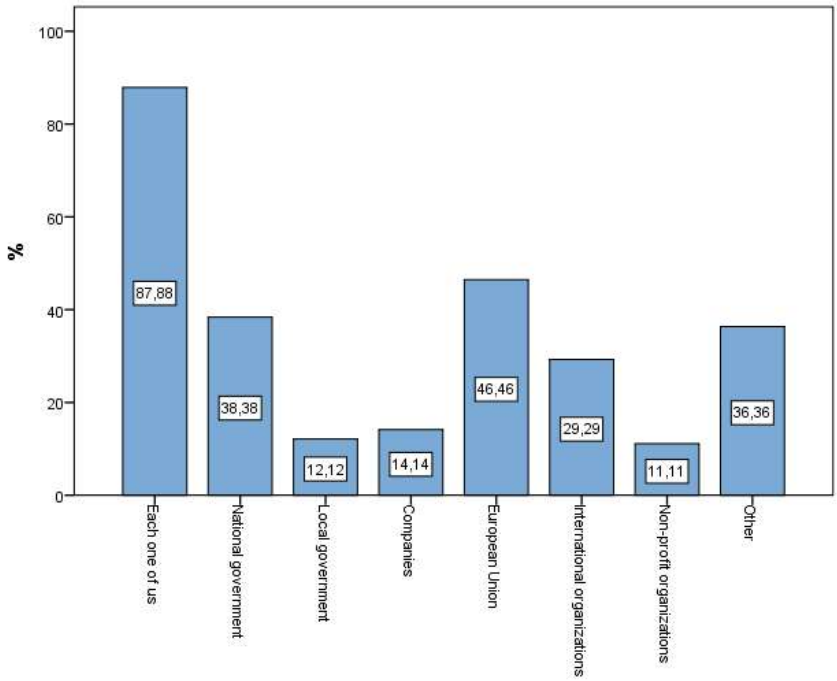

Figure 2. *Who is responsible for promoting sustainable development?*

The results highlight the importance of ESD in the learning of SD, especially among young people. Reinforced concept by the United Nations (UNESCO, 2015) which intends until 2030 that all the students acquire, through EDS, necessary knowledge and abilities for the promotion of SD and sustainable lifestyles, human rights, gender equality, a promotion of a peaceful culture and non-violence, a global citizenship and a valorisation of cultural diversity.

In the last question on SD Perception, with regard to the dimensions (economy, environment, social and governance / institutional), the respondents associate the SD in a larger percentage to the environment and economic areas of SD (Figure 3).

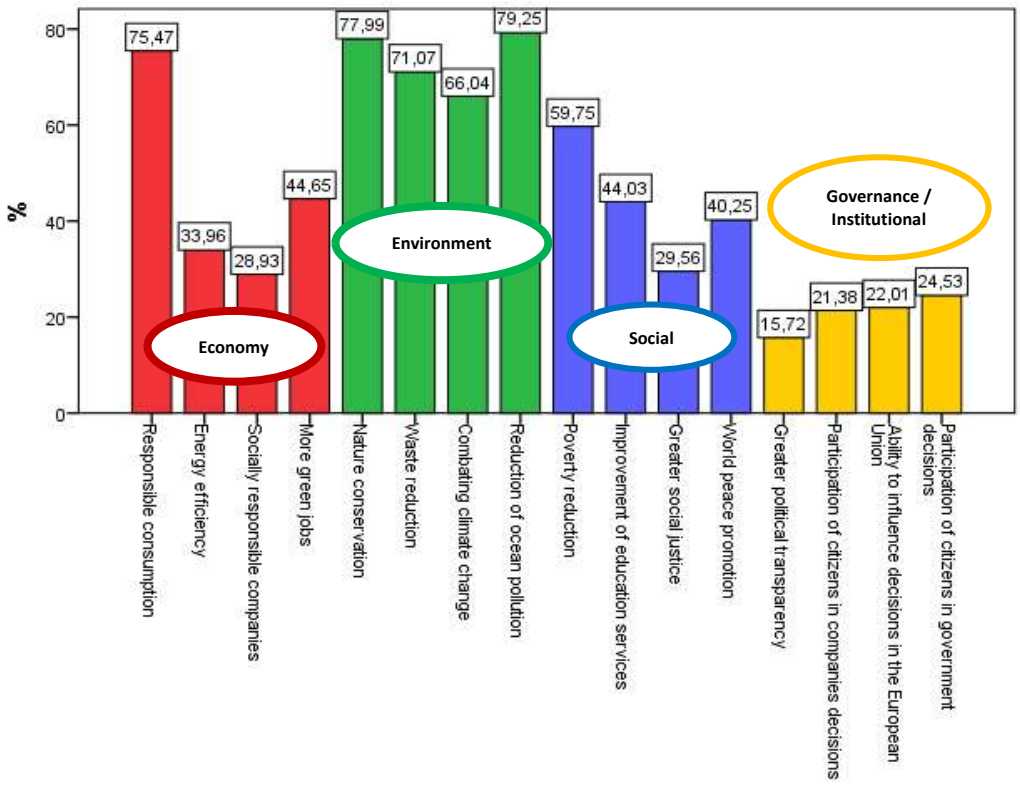

Figure 3. *In your view, what are the main themes associated with Sustainable Development*

An index was created that resulted from the sum of the scores obtained in the items that integrated each of the dimensions under analysis (economy, environment, social and governance / institutional), referring to the themes associated with the concept of SD and whose basic descriptive statistics are found in the Table 2. It is noteworthy that the environmental dimension is the most valued by respondents, followed by economic and social dimensions.
These results are in line with those obtained in the study previously carried out with the adult population (Manso et al., 2019). However, there is a decrease in the importance given to the economic component when comparing the results obtained in this study with those obtained in the adult population.

Table 2. *Basic Descriptive Statistics for the Environmental, Economic, Social and Governance/Institutional dimensions*

	N	Minimum	Maximum	Mean	Std. Deviation
Economy	159	,00	4,00	1,8302	1,09780
Environment	159	,00	4,00	2,9434	1,14320
Social	159	,00	4,00	1,7358	1,15536
Governance / Institutional	159	,00	4,00	,8365	1,11307
Valid N (listwise)	159				

In a subsequent phase, the existence of statistically significant differences between the scores obtained in the different dimensions for urban (Castelo Branco) and rural (Idanha-a-Nova and Penamacor) context was investigated (Figure 4).

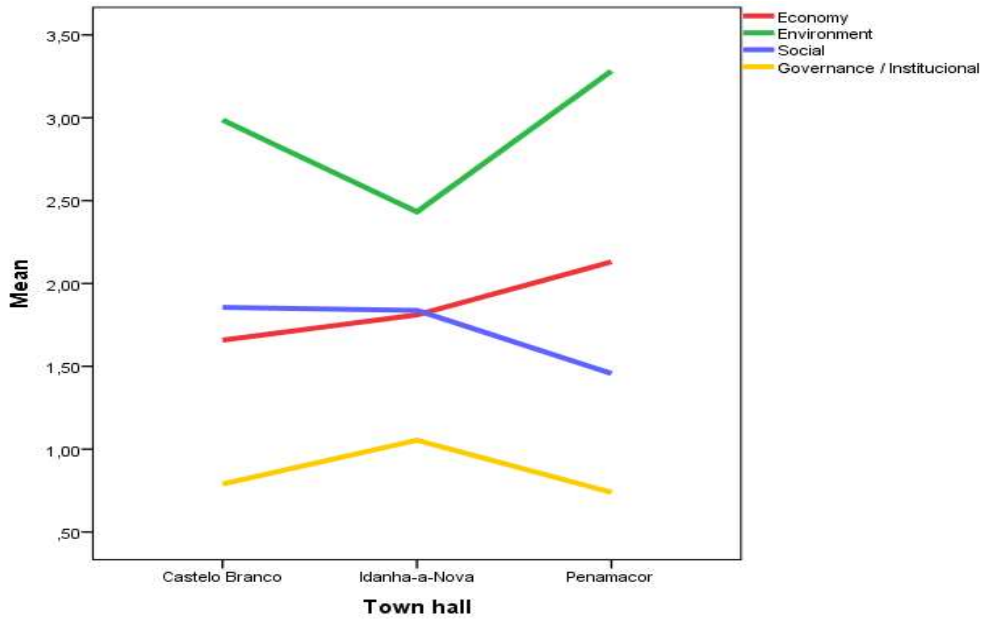

Figure 4. *Average scores obtained in the different dimensions for urban (Castelo Branco) and rural (Idanha-a-Nova and Penamacor) context.*

The Kruskal-Wallis test only identified statistically significant differences for the Environmental dimension (p = 0.013), with students from Idanha-a-Nova who tend to attribute lower scores in this dimension. Idanha-a-Nova has the lowest population density (6.0 people per square km) and the highest unemployment rate (10.8%) in Beira Baixa. A possible reason for this situation, is that in this municipality, where a lot of the territory are farms and pastures, the agriculture activities have an important component in the economic structure. In addition, the reduced industrial sector has a connection to the transformation farm products. Therefore, the students live surrounded by agricultural lands and probably have a different vision of Environmental dimension, that is considered good and with no problems.

In the second part of the questionnaire (Evaluation of SD of the municipality of residence), in the first question, the respondents using the traffic light analogy (green – go; yellow – careful; and red – stop), classified the performance of their municipality in the SD dimensions (Environmental, Economic, Social and Governance/Institutional).
More than half of the respondents (59.4%) classifies the environmental dimension as “Green”. The economic and governance / institutional dimensions are mostly classified as yellow (60.6% and 69.4% respectively). In the social dimension, responses are divided between yellow (47.2%) and green (46.5%), as shown in Figure 5. These results are in line with those obtained in the study previously carried out with the adult population (Manso et al., 2019).

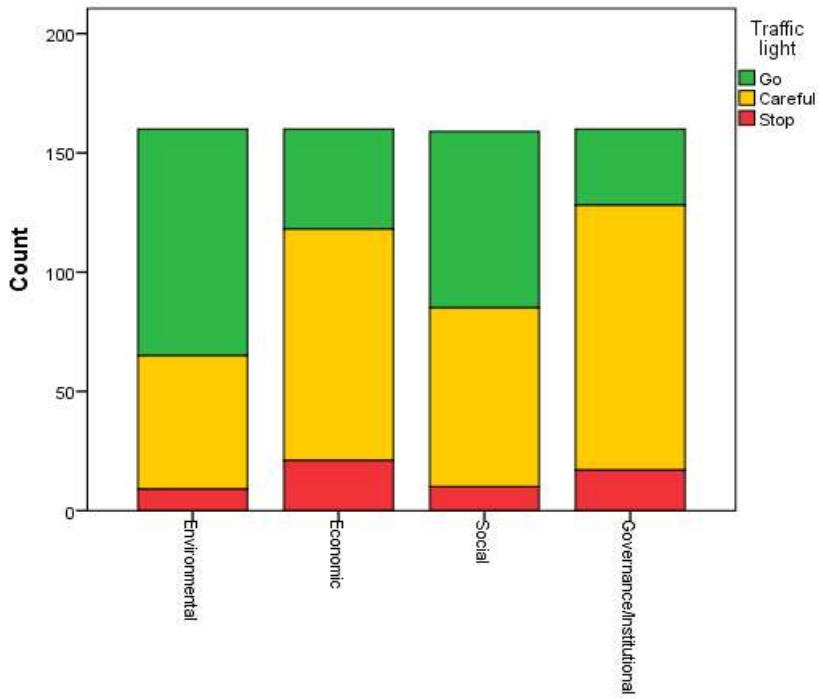

Figure 5. *Evaluation of the municipality in relation to the performance of the environmental, economic, social and governance*

When inquired regarding their quality of life in the municipality, in the last 5 years, most students consider it to be the same (40.25%) or that it has improved (33.96%), as shown in the Figure 6. These results are relatively different with those obtained in the study previously carried out with the adult population (Manso et al., 2019), in the adult population 26% considers that it is "worse" and 7% "don't know". The perception of student's quality of life, in general, is more positive when compared with the results of adult population.

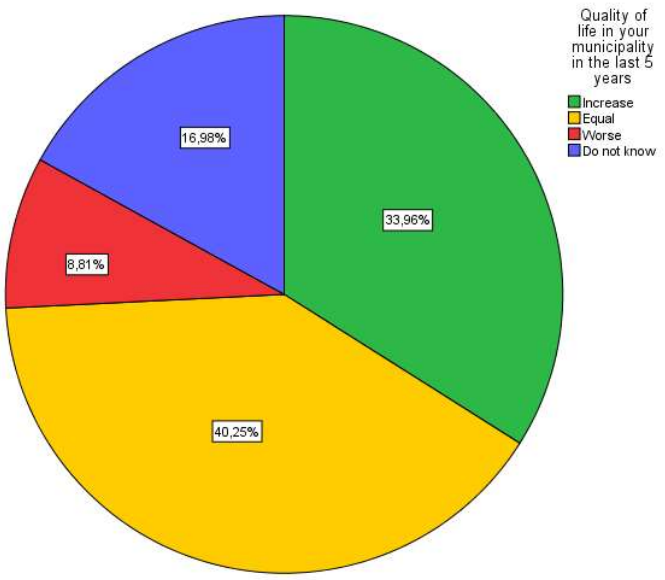

Figure 6. *Perceived quality of life in your municipality in the last 5 years*

When we asked about the sectors that should be invested in the municipality (Figure 7), most students refer to the Environment (72.33%), followed by Renewable energy (61.01%) and Education and training (58.49%). These results are in line with those obtained in an adult population (Manso et al., 2019) even though they primarily highlight the Education and training sector (75%), followed by Renewable energy (58%) and the Environment (58%). When we compare these results with the First Major Inquiry on Sustainability in Portugal (Schmidt et al., 2016), the appointed sectors by the students and the residents of CIMBB differ substantially from the national average (Education 46%, Renewable Energy 37%). The Forests sector was chosen by 50.94% of the students and 49% of the CIMBB residents while it was only 6% in the national inquiry. This might be due to the rural profile of the CIMBB and because it is a region in the interior of Portugal, with characteristics that are very distinct from the national average.

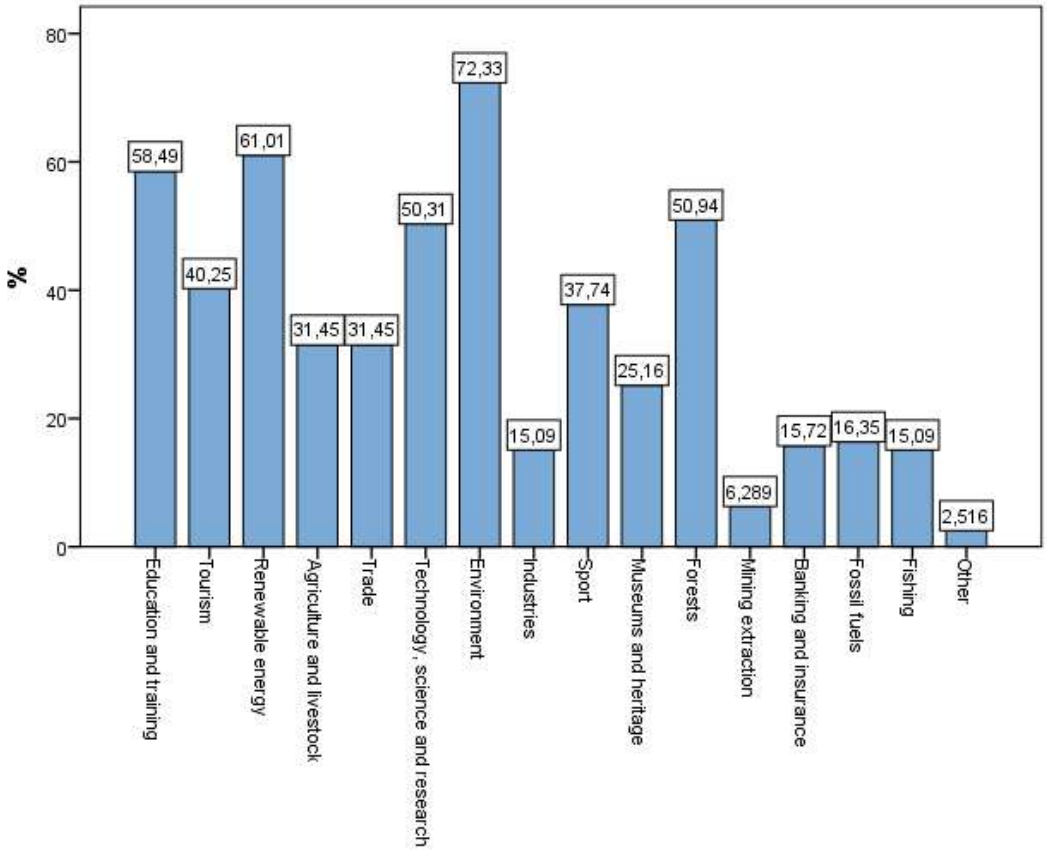

Figure 7. *Results from the question: Which Sectors your municipality should invest in the near future, to lead us to Sustainable Development?*

When questioned regarding what is important to evaluate in the SD of their region and, specifically which are the most important SDG for their region (Figure 8), 80% responded Good Health and Well-Being (SDG 3), 68.13% refers Affordable and clean energy (SDG 7), 66.25% indicates Climate action (SDG 13) and 62.5% mentions Quality Education (SGD 4) and Life on land (SDG 15). On the opposite side, the Industry, innovation and infrastructure (SDG 9) was the least indicated (16.88%). In a similar study conducted with an adult population (Manso et al., 2019), it was observed that over 60% highlights as the most important SDG for their region Good Health and Well-Being (SDG 3), Quality Education (SDG 4) and Decent Work and Economic Growth (SDG 8). On the opposite side, the Life Below Water (SDG 14) was the least indicated (about 18%), probably because it is a region in the interior of Portugal.

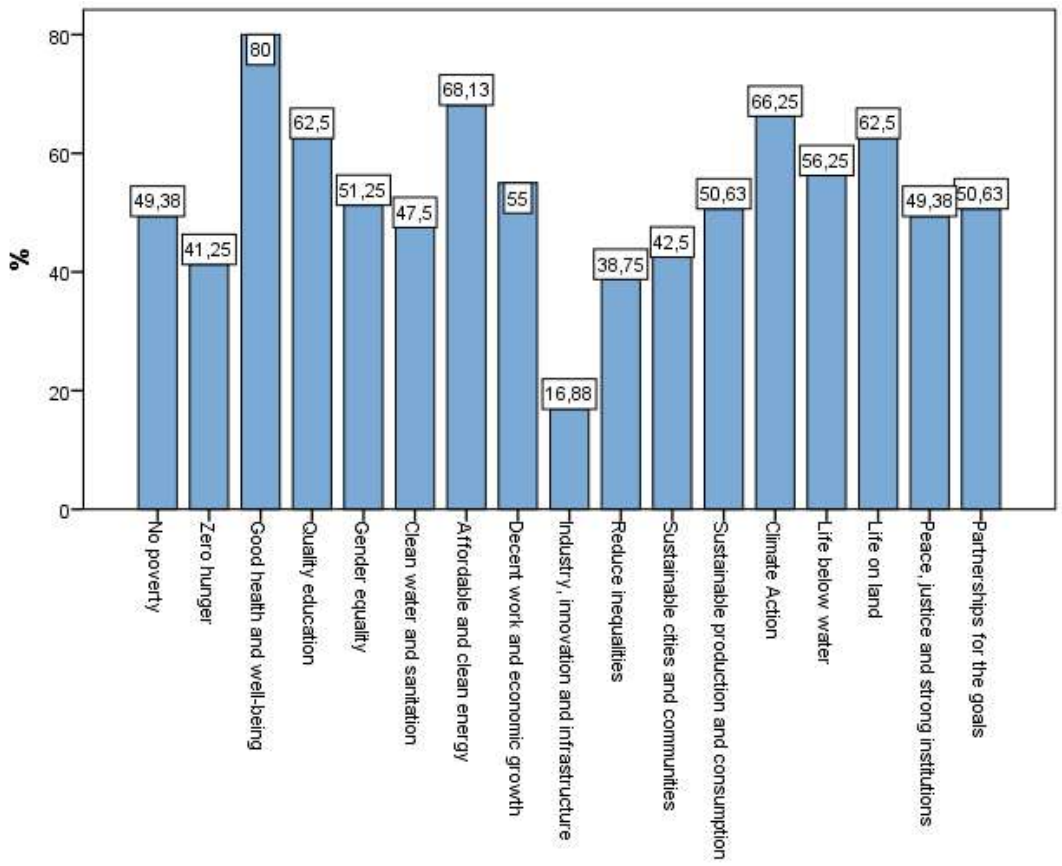

Figure 8. *Goals the respondents consider important for their municipality*

We agree with Giangrande et al. (2019:2832) referring that "Good evaluation schemes derive from solid goals, and the competencies allow us to define objectives for ESD and develop adaptive frameworks to support local and contextual learning whilst permitting the global analysis and monitoring required to address the SDGs. Perhaps paradoxically, in striving for global sustainability goals, we conclude that these can be achieved only through personal transformation and a shift in consciousness at an individual level, in which education must play an important role.". That ESD should not be just a chapter of one of the subjects in secondary education, it should be interdisciplinary, but also a continual process, between the different levels of education, both in time and space. Only this way it is possible to increase knowledge on SD and SDG, with the goal to promote sustainability.

In the last part, we asked the students about voluntary activities, specifically if they were involved in voluntary work in a nonprofit Institution/Organization. 35.6% of students are involved in voluntary work. A good part of the respondents that are members or do volunteer work do so in the areas of "Environment and social values" (32.8%) and in "Health and Social Work" (32.8%). As a way of conclusion, the associations and volunteer work are considerably low in the CIMBB (Manso et al., 2019) but similar to the numbers registered in Portugal (Schmidt et al., 2016). These results, even though they indicate progress, show the still low participation involvement of the citizens in the public life and in the defence of the environment (Schmidt and Guerra, 2013). According to Schulz et al. (2010, cited in Michalos et al., 2015:304) a rare example is the 2008–2009 International Civics and Citizenship Study (ICCS) across 38 countries, in which researchers found a positive correlation between teaching about citizenship and the subsequent participation of students in active citizenship (joining student organizations, volunteering in the

community, and so forth). That is, an ESD is needed that contributes to an increase in active citizenship, specifically, in the necessary actions that promote a more just and sustainable society.

4. Conclusions

The paper aimed to know the perceptions, the knowledge and attitudes of the young people towards SD and in what areas there is a need to act for its implementation in the scope of the rural and interior region where they live. Results showed the need to improve the level of knowledge about SD (that is, knowledge, skills and competences), especially among young people, so that their future decisions are informed and effective and promote a commitment to building a sustainable future, in which ESD must play an important role.

Most of the students has already heard of SD, where the Schools having an essential responsibility. However, there is an unbalance between the environmental and economical dimensions and the social and governance/institutional dimensions. The sectors of Environment, Renewable energy and Education and training, make up the largest investment in the region. All these questions were reinforced by the SDGs that the respondents considered as the most important for their region (namely, Good Health and Well-Being, Affordable and clean energy and Climate action).

A widespread promotion of SD and of the SDGs (via the media, in the schools, municipalities, companies, international organizations, and others) among the population is important, but the schools must have an essential role in production and dissemination of knowledge, because they are promotive institutions of "life changers" and in a general shape the people know what they should not do, but they keep doing it.

The development of the related issues to SD is notorious, especially in HEIs. This allows the "knowledge increasement" which has an impact in society awareness, but not always this awareness results in the bests choices of society. And, in the authors' opinion, we still have a long way ahead.

All the schools, politicians, organizations and citizens need to promote a change for more sustainable societies, where ESD with an active citizenship play a crucial role in transition to sustainability. Therefore, is urgent a new sensibility facing these issues, a deep transformation in values, especially as a human being with a relation with the nature.

It is in this global context that we consider this project bearer of validity, especially near of a public which will be the future of society.

As a future development, as predicted in the second phase of the 'Cientificamente Provável' Program, we intend to present the results of the questionnaire to students and teachers of SES. And use the Student Resource of United Nations, for example the "Go Goals" game (available at https://www.un.org/sustainabledevelopment/student-resources/) to deepen and consolidate the knowledges about SD and SDGs. At the same time, it will be conducted a selection of indicator system themes (based on the questionnaire results) to develop the first proposal of an indicator system based on a representative sample of population opinion. The region to be applied is a rural one with a high level of human desertification, and where this type of indicators are usually not developed and that could be relevant to assess and monitor SDG achievement.

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"I am committed to making my home better, so I am planning a sustainable future"

Students, education, designcommunication and the sustainable result of an action research

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Abstract

Sustainability is at the heart of communication. In addition to the school's communication and activation activities, elementary school students are also exposed to the concept and significance of sustainability from parents and the media. Thus, it is not negligible that background information and facts related to the topic determine their thinking. An important research question is how and in what amount of time this type of thought is transformed into action, whether in a participatory or an initiating role. In our study, we analyse why sustainability as a central topic is most prominent in an unusual innovative situation we generate. Nevertheless, we are looking for an answer to how this positive outcome can be deepened and influenced at the level of attitudes, transforming thoughts into action within the educational framework, using the methodology of design communication.

In the course of our action research, we present the results of a self-developed series of workshops in all Hungarian counties involving sixth grade primary school pupils and their classmates. As part of the action learning process, students set out to make their homes better by using design communication, a method based on creative interaction. As part of the workshop, we built on the tools of wikinomic cooperation, so the whole class needed to think together to develop the workshop and produce the result. Together, with the full agreement of all participants, the design process was carried out with the task of undertaking the task of improving their home. The reflections written by the children at the end of the workshop are an important part of the qualitative research concept, and the results of the content analysis of the reflections are also one of the important outputs of the study.

As a result of the research, it was noticeable that almost all classes identified the concept of home with the environment Almost without exception, home improvement was seen as showing a conscious attitude towards their environment and encouraging others to do so with their project. During the presentation the most important results will be presented. The main objective of the study is to present the projects created during the 21 workshops that focused on sustainability, and to explore the links between the products produced and the reflections. Building on these results, this article proposes a theme and structure for a built-in, education- integrated designcommunication workshop. A further goal is the conscious integration of sustainability into education through the focus on design communication methodology.

Keywords: Education, Designcommunication, Sustainability, Students, Teamwork

1. Introduction

Conceptual frameworks for sustainability

The title of our study addresses sustainability in several dimensions. A sustainable future refers to the result of a sustainable development, since sustainable development assumes meeting the needs of the present without compromising the well-being of the future (WCED, 1987). We separate the concepts of sustainability and sustainable development, and the widespread use of these two terms is associated with the name of Lester R. Brown (1981). Sustainability itself is a principle. If we are to survive in the long run, this concept must be the guideline. Sustainable development, in turn, means coming into existence and being realized (Gór, 2013). Action, active quality is already in development. To this day, we consider the Declaration of the World Academies of Sciences to be the most accepted definition, which is that: Sustainability is a response to the present needs of mankind, while preserving the environment and natural resources for future generations (CWSA, 2000). In practical terms, the issue of sustainability can be divided into several units. Sustainability comes through the focus of technological change (1), through changes in human behaviour, this includes changes in social preferences and lifestyles (2), and the third area of sustainability focuses on the restoration of natural capital (3) (Parapatits, 2019). In presenting the practical results of our action research, we will specifically address how these three dimensions emerged during our study, as described in the literature review (Blignaut et al., 2013 in Parapatits, 2019).

Pedagogy of sustainability

Training courses in sustainable development began in extracurricular areas, outside the curriculum, in the form of camps, in specialist areas, and from there they were integrated into the individual subjects. It is of paramount importance that the different aspects and economic connections of sustainability are integrated into children's thinking. It is important to recognize the parallels between the various appearances of the subject (Kosáros, 2007). Criterias needed to deliver sustainability education are an attitude of responsibility preparation, problem-oriented, multidisciplinary educational goals as well as unique, innovative educational approaches that aim to develop skills essential to sustainable development while being integrated into the school's specific set of rules (Kovács- Németh, 2010). In the following chapters of our study, we present some methodologies that help educate sustainable development by focusing on a holistic approach, focusing on the ability and need for lifelong learning, and can be understood at the local and global levels. In the meantime, it focuses on action-oriented education and, even if uncompromisingly and without resignation, it can fit into the school framework.

Education for sustainability through international cooperation

Children are the focus of our study. The relationship of the future generation, its relation to certain approaches to sustainability, is in fact for the welfare of a "future " generation. Education for sustainable development should promote solidarity and global citizenship (Abdullahi, 2010). Global thinking, awareness, responsibility, understanding and intercultural sensitivity are essential. The ideal of the concept of global citizenship is gaining popularity, one of the forms of implementation of which may be the implementation of learning co-operation between different development areas and countries (Dékány et al., 2018). We are basically talking about cooperation, creating shared values, and the process of mutual learning about each other's situation. However, when viewed through the goggles of sustainability, while in one country they are struggling to survive, to feed on a daily basis, in a more advanced area, the focus is on making existing processes and systems tools greener. This may shed light on an issue that is so far unexplored in students' minds, which can lead to responsible, conscious decisions, and encourages ethical and caring relationships within and beyond their community (Andreotti, 2011). Closely related to these initiatives is the British Council's Connecting Classroms (2014), a completely free and flexible sustainability program for all schools in England, Scotland Wales and Northern Ireland. It helps students to acquire knowledge, skills and attitudes that are thoughtful, ethical and responsible, thus contributing to the true essence of global citizenship.

Children's philosophy and sustainability

Conscious pedagogical behaviour has begun, but it still has ample potential for development. The child philosophy approach can also provide a toolkit for educators in sustainability education. Children's philosophy can be said to be "in the shoes of children", it does not have a well-defined theoretical position within the science of philosophy, many are sceptical, but it is certain that it raises questions worth pursuing (Karikó, 2013). In her critically acclaimed study (2013), Karikó mentions methodology as a "pedagogical treasure", so we considered it worthwhile to briefly introduce the method through the glasses of sustainability. The program was developed by American philosopher Matthew Lipman (1982). Douglas Martin, writer of the philosopher's obituary, sees the emergence and spread of child philosophy in that children and philosophers have the same motivation for thinking (Douglas, 2011). Openness, fresh attitude, new (like) vision. That's what the system of child philosophy is based on. It does not require students to learn philosophical concepts or complex concepts, but rather relies on the process of cognition. It focuses on and exploits childish curiosity, while at the same time building on problem sensitivity and creativity. Its aim is to teach critical thinking, to teach logical thinking, to approach the curriculum and concept in focus through discussion and guided questions (Lipman, 1982). It supports through the method making children more reflective, intelligent, able to interpret the world and thinking. An empirical study by an Italian researcher also confirms this, using the Lipman method, children are actually more effective in their critical thinking skills (Massa, 2012; Karikó, 2013). An important feature of child philosophy is that it does not educate through philosophical texts, but through the joint reading and interpretation of a story, a thinking tale (Lesku, 2010). The point is that children experience, are actively involved in the fact that their questions cannot always be answered in a definite, unambiguous and uniform way, and that there is not always a good solution. The

applied questioning, realized through real problems, makes the method more realistic and practice oriented. The methodology of child philosophy is effectively applied in the pedagogy of sustainable development. There are many legends that contribute to the exploration of the moral, ethical issues that accompany globalization, to understanding the environment, and to practice-oriented interpretation (Lesku, 2010).

The role of the teacher

In the best case, education for sustainability begins at a very young age in the primary, narrow social and reference group, in the family environment, followed by school education. Educators have a particular sense of responsibility towards the local community, and this concern may be able to expand through teaching. This is a lifelong learning process, so it is extremely important not only to educate children about the current sustainability issue, but also to fundamentally shift their thinking in the right direction (Wheeler - Bijur, 2001). This also confirms the conceptual importance of global citizenship. The transfer of information, the lexical knowledge, is very important, but it is far from sufficient to bring about changes in actual action (Zsóka et al., 2011).

Numerous researches highlight the need for a novel educator approach to integrate sustainable development more effectively (Lozano, Barreiro-Gen, Lozano, & Sammalisto, 2019). As a teacher, the task is not to expand passive knowledge across borders, but rather to prepare. The task is to be able to recognize the causal relationships inherent in certain dimensions of sustainability, to be able to screen and assess the harmful effects of human activity, and to develop further critical, problem-solving, creative thinking. For this, it is important for the child to acquire not only a cognitive role but also an active role as a receiver (Lesku, 2010). Action, active behaviour, is something that should be encouraged so that he or she can transfer this knowledge, even through action. Developed in the design communication approach used in our research, the workshop builds on precisely these pillars, which are discussed in detail in the relevant section.

Therefore, education, and especially the task of the educator, is to develop the knowledge that is relevant to life. It must be borne in mind that the true goal is sustainability, the dedication of all members of the community to this end, where education is the primary platform for developing that vocation (Novotni, 2017). This is also the focus of the “Education and Training 2020” Work Program. One of the key foundations of the strategic framework is that education and development must play a key role in overcoming many socio-economic, demographic, environmental and technological challenges. Innovation and creativity, including entrepreneurship, and its educational tasks are one of the key objectives of the established strategic framework. Here, I would also like to draw attention to another important point of connection with the methodology used in our research, design communication, which will be described in the next chapter.

2. Methods

Sustainable designcommunication

Design communication is a design approach that defines not every human being as a designer, but every human being is capable of creating creative interaction (Cosovan, 2009). The application of a Hungarian "know-how", which is basically an open problem-solving approach, is possible in any problem-solving situation, but it is essentially that the task is not defined as a problem but interpreted as an opportunity (Dorst, 2011). There are no ready methods or benchmarks. The result and the path to it are realized at the same time, communication integrated into development and development takes place (Cosovan, 2009). Design communication strives for the good realization of the objective. It integrates into the design process an approach in which it must become our own interest to consider the interests of others. Here I would like to refer back to the intercultural collaborations discussed in the literature analysis, where the aim is similar: They draw the children's attention to the fact that in the global realization of sustainability (of which they are a part), it is in our interest to learn about and support the Least Developed Countries (Dékány et al., 2018). This is how design communication interprets the good minimum rule. The link between the methodology and sustainable development is also reflected in the tripartite relationship that needs to be examined during the design process. This includes the unity of survival-development, that is, the creative result is environmentally conscious, formed from the past and encodes forward-looking guidance for development. The constant-changing thesis

highlights that the product designed and implemented is timeless, despite its ever-changing trend. Its material-intangible relationship emphasizes the importance of a value system that goes beyond material meaning (Horvath et al.,2018).
In our research and empirical research, the educational dimension of design communication has come to the forefront. The use of design communication methodology as a creative educational methodological tool is based on raising awareness among participants of their ability to create value. It provides points of reference, guidance for orientation, and does not provide a ready-made solution module. The initial chaos clears as the solution evolves, and the experience of success and result can lead to a flow experience (Csíkszentmihályi, 2001). The use of design communication in education is also unique because it represents a "networking approach that appears as a bridge between different disciplines and discourses, society and the economy. As the literature emphasizes not only cognition but also recognition, active, actionable, problem-solving behaviour is needed for creative, problem-solving, sustainable-focused education (Lesku, 2010). Design communication captures precisely this innovative approach in its methodology. Contrary to the well-known methodology of design thinking (Brown, 2008), the acquisition of knowledge and the solution of a problem are not recorded in cognition but in recognition. It does not frame creativity, it does not rely on systematic, but transnational, creativity, which, when properly applied, can also serve as an educational catalyst for sustainable development. Design communication enables real-time communication between education, research and business (Cosovan – Horváth, 2016, p.36). Our self-developed exercise, specifically aimed at elementary school students and their educators, presents the empirical findings of this connection in an action research study. Focusing on elements of the profession that contribute to sustainable pedagogy.

Action Research - "I Make My Home Better!"

The methodology of design communication and its aspirations for sustainable education were examined in a nationwide action research. The centrepiece of action research is a self-developed workshop aimed primarily at primary school students and their teachers, but with secondary focus on all actors involved in education. During the action research, the workshop was organized 23 times and reached all Hungarian counties and Budapest. The schools were all state-run schools with a normal curriculum, operating according to the National Core Curriculum, in the noblest sense of the word. The survey took place between September 2019 and February 2020, with a total of 700 students and 23 teachers. The surveyed students were aged 10-12 years, basically sixth grade students were the focus of the survey. During the development of the workshop, we paid particular attention to integrating it into the closed, tight-paced and rigorous curriculum of primary schools, and we considered it important to implement it with minimal equipment and extra financial effort. As a catalyst for the methodology of design communication, the method of wikinomical collaboration was used, where students were challenged with openness, peer-to-peer collaboration (Benkler, 2006), and previously unknown group-level collaboration. The main purpose of the approximately 150-minute session is community creation, proving the relevance of teamwork, developing problem-solving and creative skills within the school framework, examining the emergence of entrepreneurial attitudes and community building. In this analysis, we would like to examine and highlight a partial focus of the research. The title of the "I make my home better" workshop also immediately suggests the theme: we built our profession around the home. We felt it was necessary for them to be able to relate to a concept in an open problem-solving situation that they all understood as a common point of reference. The open problem solving situation, the mass collaboration in itself, led to a very difficult and unfamiliar situation for the children (in most cases even small group work), so we considered it important to focus on a topic, processes, reactions, results, they know what they have experience and opinion. The secondary objective of the topic was to assess how students are aware, how they connect their home to their environment, and to define "improvement" at the individual or community level. The results of this are described below.

The sustainable product

In an open problem-solving session, where there are no rules, no framing of creativity, where the result and the method are simultaneously, the students come together to make their home better. Following a presentation on design communication methodology, they first set up their own homes, then in randomly formed groups of 4-5 people, and finally at the class level to improve their homes. They were not given guidance, we did not define the concept of home, and students could apply it in

a narrow and broader sense. However, it was emphasized that they themselves are committed to making their home better, thus referring to the importance of their own role. At the end of the session, their job was to show the research leader, the workshop moderator, what they, together, at the class level were, what they created, and how they committed themselves to making their homes better. This result was also emphasized by a jointly drawn drawing. In our study, we seek to answer the question of why in the course of action research, the theme of 'making the home better' immediately and almost without exception induced a focus on the sustainable, environmental aspect of the topic. To explore this, in our analysis, we attempted to analyse the products we produce based on a set of criteria to formulate an action plan for how the design communication workshop, designed and applied, could be transformed into an active and applied educational and educational tool for sustainable development. We want to offer educators a method that not only in an extracurricular way helps students become active global citizens, but also offers a toolkit that can be integrated into the curriculum.

3. Results and Discussion

The analysis and coding of children's products was based on 3 sources. The results of the researcher observation and the reflection of the researcher, the individual reflection written by the children and the presentation of the product and the content analysis of the related drawing. Thus, the results were differentiated along the following dimensions: (1) the product produced (2) the product recognizes the concept of sustainable development, (3) the environmental / technological / social nature of sustainability, (4) global or local thinking, (5) the appearance of a call to action, (6) entrepreneurial attitude. The result of the coding is summarized in a table, the source of which is a self-construction based on the results of the recorded action research.

Table 1. *Products from the exercise from the perspective of education for sustainable development*

The place and time of the action research	(1) the product produced	(2) the product recognizes the concept of sustainable development,	(3) the environmental / technological / social nature of sustainability,	(4) global or local thinking	(5) the appearance of a call to action	(6) entrepreneurial attitude
06/09/2019 Kalocsa-1	rainwater collector at school	yes	environmental	Local: “The project leaders are members of the class community, each in their own neighbourhood.	It appears: this rainwater would irrigate the newly planted trees	Does not appear
í06/09/2019 Kalocsa-2	“Wardrobe Commando:” aimed to introduce individual wardrobes to the school	no	Does not appear	local	Appears: “First Aid for Classmates, Parents and Pupils Needs” - Signature Collected	Does not appear
17/09/2019 Tapolca	Self-sufficient farm (with renewable energies) and doghouse	yes	Environmental, social	Due to local, renewable energies, there is also a global character	It is minimally present	Appears
20/09/2019 Nagykőrös	Making the world a better place: Food for Africa, irrigation, reducing energy use	yes	Environmental, Social, technological	global	It is minimally present	Does not appear
23/09/2019 Budapest	Common environmental protection	yes	environmental	Local: Common local trash picking and flower planting	Appears: Every Saturday trash picking, every Wednesday	Does not appear

					planting	
24/09/2019 Eger	"Protect the Earth from Plastic!"	yes	environmental	global	Appears "Have a thought we can help"	Does not appear
01/10/2019 Bodrogkeresztúr	A school buffet that values garbage collection and gives you a reward for environmental awareness	yes	environmental	local	Appears	Appears
08/10/2019 Hódmezővásárhely	Garbage collection days	yes	environmental	local	It is minimally present	Does not appear
15/10/2019 Sajószentpéter	"Everything to work with solar panels"	yes	Environmental, technological	local	Does not appear	Does not appear
22/10/2019 Tamási	"Get yourself an action plan"	yes	Environmental, social: "Many people do not think about the future, they have to think not only about themselves, but also about our grandchildren"	global	Appears: "Our environment improves when we are cleaner, and we are also in the air and exercising" - 3 times a week	Does not appear
05/11/2019 Baktalórántháza	Helping starving children	yes	social	global	Does not appear	Does not appear
08/11/2019 Besenyeszög	BioHotel (cleaning robots, no electronics, all natural)	yes	technological	local	Does not appear	Appears
12/11/2019 Mezőberény	World Savers (garbage collection, recycling, electric cars)	yes	environmental	global	It appears: "We would divide the class, everyone would do different groups"	Does not appear
19/11/2019 Baracs	Christmas market and garbage collection, garbage-free Christmas market, helping homeless people with incoming money	yes	Environmental, Social,	local	Does not appear	Does not appear
22/11/2019 Dorog	Class Chair Concept: "the class president would plan for a common future for the class!"	yes	social	local	It appears: "I think we should think about something we can accomplish"	Does not appear

26/11/2019 Debrecen	Banana Joe is an application that we can use to help kids and adults live environmentally conscious.	yes	environmental	global	Appears: "teacher aunt, everyone has realized this"	Appears
03/12/2019 Tápszentmiklós	Supporter in need Electric Van (Solar Panel, Smart Cooler)	yes	Environmental, Social, technological	Local: "They go from village to village in a bus stop and stop, collect and pass where needed"	Does not appear	Does not appear
06/12/2019 Kaposvár	For a better earth	yes	Environmental, technological	Local and global	Appears: "You need to have a lesson about this topic once a week"	Appears as "economic cycle"
13/12/2019 Alsópáhok	Class Home: "The goal was to build a team and become a better community"	yes	social	local	Does not appear	Does not appear
17/01/2020 Tapolca	Marine rescuers, who protect marine animals, pick up trash from there	yes	environmental	global	Does not appear	Does not appear
21/01/2020 Pécs	"Conservation Unit" Environmental protection plus less rubbish, helping the poor, more e-cars.	yes	Environmental, social	global	Does not appear	Appears
23/01/2020 Szombathely	STV company- Save the World It motivates people to bring in the trash and use it in the company. The manufactured product they make is going to different stores.	yes	Environmental, social	global	Does not appear	Appeard
04/02/2020 Dejtár	Garbage picking	yes	environmental	local	Does not appear	Does not appear

Source: own construction based on research results

The results highlight that "making the home better" clearly directed children to the idea of sustainable development, whether or not it was a task, and the term "sustainable" was not said by the researcher. Almost without exception, all products created are linked to the concept of sustainable development (2), which suggests that children are aware of this theme. Solutions include organized garbage collection, making the world better by helping. We help nature to regenerate and those in need to make a living. The nature of departmental cooperation was reinforced by the fact that most solutions were based on collaboration and shared value creation. There have also been some initiatives specifically aimed at the sustainability of their narrow community, such as the class president's election, which can streamline day-to-day decision-making and class strategy design. Technology-based sustainable endeavours have also been established, such as "Banana Joe", an application that educates the smallest in sustainability. The protection of animals and marine life has also appeared in many cases as a starting point.

The reference group, the school, the family, the media are all part of the fact that sustainability is no longer completely unknown to children. Just think of the 2019 campaign series, where many supermarket chains have communicated to reduce,

minimize, minimizing the use of plastic, which has reached home through mass media, commercial TV and billboard surfaces (privatbankar.hu). There are children, of course, who are more interested and knowledgeable, but tree planting, garbage collection, and renewable energy are undoubtedly familiar and used concepts. Of the 3 dimensions of sustainable development (Parapatits, 2019), the preservation of environmental and natural capital was first identified during the joint planning process (3). Technology and social aspects were touched upon, which may also highlight the importance of emphasizing these two pillars in the pedagogy of sustainable development. A large number of groups focused on garbage collection and tree planting (1), as these were activities that occurred at school level and were related to this. This also reinforces the literature-supported notion that action is the one that should play a major role in the pedagogy of sustainable development. The global / local nature of their co-created products (4) shows a mixed picture. They roughly half-direct the focus of their project work on their local community scene (class, city) and make their jointly planned work "global". Rather, they are focused on helping, the "good deed", and the entrepreneurial spirit is barely in focus, if at all, mainly to be able to finance their own plan, give it to one another and help each other ("circular economy"). The emergence of entrepreneurial attitudes is negligible, and our empirical research highlights that it may be worthwhile to incorporate it more strongly into the curriculum. This is supported by the fact that, according to the literature, there is an extremely important skill in the pedagogy of sustainable development. In most cases, their own role, the action plan for action, falls short, although that could be the key, it alone raises sustainable development. Textbook knowledge is not enough (Zsóka et al., 2011), this knowledge has to be translated into action. Here is the role of the educator, who has to be a supporter of the student-initiated initiative, and one of the very important pillars of the design communication methodology, the idea of 'peer-to-peer collaboration' as a guiding principle. The 6 dimensions examined in our empirical research have shown that students' interest, openness, enthusiasm for the topic is given, design communication methodology initiates common thinking, and responsibility is realized on two levels by the school. There is a need for inclusion, for the integration of innovative methodologies into the curriculum, and for training of educators in the proper use of applied methodologies.

4. Conclusions

The methodological peculiarities of design communication described above, the development of an open, empathic approach that emphasizes the concept of good objective, the development of a shared value, the design process, the problem-solving profession, the creativity and the solution-oriented attitude. These characteristics show that, when used properly, they can be an excellent integrative element of education for the sustainable development of children within the school framework. The action research presented in our study supports this, in which we analysed how the pedagogy of sustainable development appeared in the self-designed design communication workshop “Make my Home better”. In the products created as a result of the joint design process, one can discover that sustainability and global thinking are clearly present in the students studied. The challenge is to translate the result into action so that it can be incorporated into thinking at childhood. It is of utmost importance to integrate this not only in environmental education classes but also in other related subjects, as the links between sustainability and economy, and indirectly the entrepreneurial attitude can be developed on a skill level as well. The elementary school designcommunication workshop has been developed to fit seamlessly into the everyday rigorous school framework. With the openness of the school and its teachers, the designcommunication workshop can be well-suited to include education for sustainable development beyond extracellular education. Students are able to work independently on either the home theme or a more focused and stronger theme of sustainable development through open problem solving. It is unique for the educator to be responsible for raising this to the level of action and delivering the product designed by the children, either in-class or out-of-class. The idea is thus transformed into action and the problem is transformed into a solution, the results, success and difficulties of which students can experience through a much more powerful experience of their own.

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Predictions and Responses (to Climate Change)

Strategy for a sustainable decarbonization of the energy sector in Portugal: economic and environmental implications

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Extended abstract

In line with the international efforts to mitigate climate change, Portugal has committed to achieve carbon neutrality in 2050. Fulfilling this obligation poses a great challenge that will require a concerted effort across all society systems. Particularly, the energy sector has to overcome serious constraints: despite notable progress in areas like wind and solar power, Portugal energy system is still characterized by a high dependence on fossil fuels, with coal, oil and natural gas accounting for 75 to 80% of consumption; energy intensity is above European average, improving very slowly; although energy intensity has been decreasing over the past years, this happened mainly due to technological renewal. Energy policy in Portugal has focused on supply management, lacking ambition and effectiveness in promoting energy efficiency. Energy market distortions amount to 3900 M€/year, half of which correspond to environmentally harmful incentives (e.g. tax rebates for fossil fuels, subsidies to large dams and to private cars). Energy savings potential identified amounts to 20% to 30% of current consumption in all sectors, particularly industry, transportation, residential and service buildings. Such measures are not being put to practice because most interested parties (families and small business) do not have the expertise or the financial capacity to perform the necessary investments. The recently approved National Energy and Climate Plan for the horizon 2030 (PNEC 2030) has interesting targets for decarbonization — to cut greenhouse gas emissions by half between 2005 and 2030 — but mediocre targets for energy efficiency, and no effective means to reach either. The goal of this line of research is to develop policy measures to ensure the energy transition to a more sustainable model. Previous work identified energy efficiency, low impact decentralized renewable energy and tax reform as critical focal points for action — both to implement cost-effective solutions for decarbonization, and to change our collective mindset to a more resource-efficient and sustainable development model. Shifting to a carbon-neutral energy system will entail high economic costs and incurs the risk of adverse social effects. It will also put a rising pressure on natural resources, particularly minerals and metals, linked to the shift to electricity. It is extremely important to ensure that the energy transition is carried out while minimizing social, economic and environmental impacts. The proposals developed have three major pillars: (i) the replacement of carbon-blind fuel taxes by a universal carbon tax (beginning at 120 €/t CO2 and increasing to 190 €/t CO2 by 2030), while eliminating harmful subsidies; (ii) the substantial upgrade of incentives to energy efficiency and decentralized renewable energy, especially residential and service buildings, industry, and public transportation, decreasing energy intensity by 2% per year; and (iii) a strict tax neutrality, where all proceedings of the carbon tax are used to either finance energy efficiency and renewables, or to decrease the burden on income tax and other taxes, for families and companies (to offset potential adverse social effects). The amount rearranged in relation to the previous tax system (maintaining tax neutrality) is about 1200 M€/year. The overall macro-economic and environmental effects were examined with a previously developed dynamic general equilibrium model of the Portuguese economy. Results indicate that the proposed approach (carbon tax + ambitious energy efficiency policy + tax revenue recycling) will result in the following effects in 2030, relative to the baseline: an increase of 2.4% in GDP; an increase of 1.4% in employment; an increase of 1.8% in welfare (improvement of revenue for lower income groups); and a decrease of 35% in CO2emissions. The proposed energy efficiency measures alone, representing a public investment of only 550 M€/year, would create savings of 12% of total final energy demand and 10% reduction of total CO2 emissions by 2030 (not including changes in transportation, land use and indirect economic effects). Work in progress includes examining more effects by economic sector and on other environmental indicators (land use, resource consumption, other pollutant emissions). In conclusion, our research indicates that, with this approach, it is possible to achieve a more just energy transition, with decreasing environmental impact and a positive macro-economic performance.

Keywords: Decarbonization, Energy efficiency, Energy policy, Life Cycle Assessment, Cost effectiveness

Affordable and Clean Energy

Renewable Energy and International Law

Should a Global Regulatory Framework be Established?

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Abstract
The debate concerning the global shift from fossil fuels to renewable energy has continued for decades. In the coming years, the discussion is expected to become more intense due to the increasing environmental problems associated with the use of conventional energy. Climate change is seen as one of the most important challenges that renewable energy can tackle in the long run. In this context, this article is seeking to examine the role international law can play in pushing toward such a shift. The article seeks to answer the following question: is the establishment of a global regulatory framework addressing renewables possible and needed? The authors will examine the various stages of energy utilization, which are relevant to foster a smooth energy shift from fossil fuels to renewables.

Keywords: Renewable Energy, Global Regulatory Framework, Energy Production, Energy Transfer, Energy Trade

1. Introduction

Much has been said about the importance of renewable energy in fighting climate change and ensuring the existence of a clean environment. This has sparked the interests of multiple stakeholders including nations, international organizations, civil society organizations, as well as a wide range of actors looking into the possibility that an entire energy shift may occur the coming years or the coming decades (Paltsev, 2016; Farah and Cima, 2013). Moreover, in recent years, scholars and practitioners have begun exploring the way the international community can support the development of this sector, as well as fostering cooperation among the different nations (Farah and Cima, 2015; Farah and Cima, 2015).

International lawyers keep assessing the possibility of establishing a global regulatory framework that tackles the problems with renewable energy. Lawyers and scholars attempted to use existing international regulations addressing either conventional energy or other issues to figure out whether a similar model can be established (Stephens, 2019). While many aspects have been widely discussed and agreements and disagreements have been noticed, one main topic always constituted the principal subject of arguments: whether the establishment of a global regulatory framework, applicable to renewables is needed in the first place (Leal-Arcas et al., 2014). Answering this question is of utmost importance.

Therefore, the authors will proceed to examine the different stages of energy utilization, which are relevant to ensure a smooth energy shift from fossil fuels to renewables. The objective is to examine three main different stages through two various lenses. These three stages are energy production, transfer, and trade (including aspects of consumption). It is important to examine whether the framework at each of these three stages is capable to ensure a global shift towards renewables. The assessment

will go beyond simply making an analysis of the current reality. Rather, the objective is to compare the current situation to what it ought to be at each of the three stages. The first of the two lenses is the "Fairytale" describing an ideal scenario, through which renewables would be used globally and the importance of global rules. The second is the "Reality" that describes the current state of things, the obstacles and challenges that need to be dealt with to ensure that a global energy shift toward renewables occurs, and the role of a global regulatory framework to ensure such transition. The authors will conclude with arguing towards the importance of such a wider regulatory system on a worldwide scale.

2. Energy Production

Currently, almost 50% of renewable energy worldwide consists of solar and wind energy, while the other two largest categories are hydropower and bioenergy (IRENA, 2019). The vast majority of consumed energy from these sources is from electricity and heat. The following sections will take into consideration both of these forms of consumption, putting more emphasis on electricity generated from renewables.

A. The Fairytale

Let us imagine a situation in which renewables are the main sources of global energy, where countries power their societies on that basis, and renewable energy is being used not only for electricity and heating, but also transportation and all kinds of activities that require energy. In this scenario, civil society organizations are no longer focusing on energy transition, as this objective has already been achieved. This ideal scenario would be reached if the existing potentials for energy production have all been fulfilled.

For instance, the Sahara Desert in Africa holds great potential for energy production via solar power, which would power entire countries for years to come, given that the sun is an inexhaustible natural resource (Labordena et al., 2017). Other inexhaustible natural resources are the wind and ocean waves, where numerous technologies have been deployed for producing energy, while research and investments into these types of renewables are still in their infancy (Kofoed, 2017). In an ideal future, these examples would be used for the production globally, while other conventional sources of energy would still play a role although a very marginal one, and therefore issues, such as energy security would be seen through the lens of renewables instead of conventional energy (Berkhout et al., 2012). This ideal scenario would only occur, if there is an international push via the introduction of regulations encouraging an energy shift (Oliveira, 2007).

Imagining such a scenario is a must, given the numerous challenges that currently exist such as climate change and global warming (Letcher, 2009). Another challenge is environmental pollution currently occurring at an exponential rate. Examples include oil spills, blowouts, and mankind's current consumption-based lifestyle (Oke, 2004). Despite all the developments that have been achieved in the last decades because of fossil fuels, a huge part of the population has still no access to energy. Renewables can play a very important role in changing this status quo too (Ritchie and Roser, 2019). The deployment of renewables has also had negative consequences, such as wind energy's danger to birds, the need for large amounts of land, and even the disruption of the private life of citizens. Nonetheless, when compared with the great environmental damage resulting from fossil fuels (Barbir et al., 1990), it becomes clear that the benefits far outweigh these negative consequences, which could be addressed through different policies and strategies e.g. technological innovation, well-targeted subsidization.

In this context, a global regulatory framework addressing energy production is needed, given the existing great potential for energy production, as highlighted through the two examples. In an ideal scenario, an established global regulatory framework would offer assistance and guidance for developing countries on how to best deploy and invest in renewables, but also for developed countries on how to address the negative consequences stemming from their utilization. A global regulatory framework would include provisions encouraging developed countries to provide financial and technical assistance for developing ones, while also including provisions offering guidance to developing countries on matters related to renewable energy deployment.

International organizations, like the International Renewable Energy Agency (IRENA) and the International Energy Agency (IEA) would play an important role. Energy production through renewables would also have sophisticated regulations at the domestic level, given that state parties to a global regulatory framework would have the obligation of including the provisions

of the framework within their domestic legislations, and amend existing rules, that are contradictory or prevent the efficient deployment of renewables for energy production purposes. A global regulatory framework would have short-comings and receive criticism even in an ideal situation. Nonetheless, it would represent the first step towards reaching the stage of solving the existing environmental problems and securing a wide energy shift.

B. The Reality

A shift is occurring where the production of energy is moving from "a traditional reliance on large-scale centralized energy producers and distributors to an increased reliance on distributed energy resources, which are smaller in scale and closer to consumers" (Heffron et al., 2018). This leads to the emergence of new players who are increasing competition (Heffron et al., 2018). In spite of the great focus on shifting from fossil fuels to renewables, there are several concerns that emerged naturally from the development of new technologies. The challenge is to phase fossil fuels out, which at this stage does not seem completely possible. There are also objections regarding the promotion of renewables arising from the great need for lands that may affect biodiversity, while additional challenges exist for developing countries, such as barriers to renewable energy technology transfer due to intellectual property rights. Moreover, energy governance is complicated whether it is being done at the domestic level or at the international level (Karim et al., 2018). Different scholars and researchers have examined the barriers that prevent the full-scale production of renewables, where the above-mentioned ones are the most known, with the list of challenges provided being non-exhaustive (Outka, 2012).

Attempts toward shifting energy production to renewables have been made since the 1990s (Gielen et al., 2019). The need for energy is increasing, given the growing needs for "human, social and economic development, welfare and health" (Owusu and Asumadu-Sarkodie, 2016). To ensure the sustainability of the planet and combating climate change, while still satisfying the energy needs of the population, renewable energy seems like the most adequate solution (Owusu and Asumadu-Sarkodie, 2016). In fact, "[r]enewable energy is now even considered a more desirable source of fuel than nuclear power due to the absence of risk and disasters" (Abolhosseini et al., 2014). Governments' policies supporting the dissemination of renewables are also growing globally, and almost all countries have certain renewable energy targets to reach (Murdock, 2018). Developing countries used incentives for the promotion of renewables since the 1990s, such as feed-in tariff policies, while new instruments have been developing over the years (Azuela and Barroso, 2011).

The problems around renewable energy production are being dealt with through various other instruments, either binding or non-binding (Leal-Arcas and Minas, 2016). These instruments are divided across different legal fields, while specific provisions related to energy have been included equally in e.g. trade agreements (Irish, 2014). Within this context, it has been stated that "the absence of internationally binding instruments setting a positive discipline for renewable energy generation" cannot justify the non-compliance with existing international rules applicable to renewables in other legal fields (Citelli et al., 2014).

An international legal regime, including provisions related to renewable energy production is a prerequisite, where numerous different principles and mechanisms can be included (Hildreth, 2014). Such a regime is needed as energy production differs between regions and countries when it comes to quantity and types, in particular the production capacity of developing countries being disproportionate in comparison to the developed ones. Even priorities, when it comes to energy production, differ between developed and developing countries (Bradbrook, 1996). The establishment of an international "framework is not to force national governments to adopt all the proposed measures, but rather to develop a range of laws, from which [they] may choose those measures most appropriate to their countries' current energy requirements and directions" (Bradbrook, 1996).

Suggestions have been made for the establishment of a legislative framework where e.g. Adrian J Bradbrook suggested the development of a "Protocol on Energy Efficiency and Renewable Energy to the United Nations Framework Convention on Climate Change" (Bradbrook, 2001). Yet, the regulation of renewable energy at the international level has failed to fully evolve in the last few decades (Ferrey, 2010).

3. Energy Transfer

Energy transfer is the second step after energy production, where a global regulatory framework is considerable to ensure efficient allocation at the international level and guarantee a proper renewable energy supply. The coordination of these allocation efforts between countries with dissonant interests (political, economic, social etc.), being crucial for the functioning of this framework.

A. The Fairytale

In an ideal scenario, renewable energy transfer would develop worldwide, energy produced from renewables being transferred from one country to another. Going back to the previous examples, the deployment of solar panels in the Sahara ideally can provide energy that can be transferred to European countries and even beyond, naturally paid for in exchange (Benasla et al., 2019). Similar reasoning would be applied to wind energy, which can also be transferred from one country to another. Such transfer would mostly occur through grids connecting countries together across long distances, similar to how oil and gas are being transported from one country to another through pipelines. In an ideal scenario, countries would be producing energy through renewables, but only to maximize their renewable production potential and not necessarily to cover their whole energy demand, as not all the nations have the potential to be self-sufficient. This is where interstate cooperation comes into place: once this reality is acknowledged by the international community and by the different nations, where long-term interests take over short-term potential political gains, and where pragmatism sets in.

The states that have the capacity to produce and transfer energy from renewables would be supported while the rest of the world will buy such energy instead of using fossil fuels for securing sufficient supply. Organizations such as IRENA and IEA shall play the role of a platform to ensure cooperation between the different nations. Renewable energy would be used as a resource bringing peace and prosperity among all the nations due to the dependence and need for such resource. This is unlike the case of fossil fuels where countless geopolitical disputes occurred for securing energy security (Vakulchuk et al., 2020). Peace and prosperity would be obtained not because of using good renewables versus bad and evil fossil fuels, but mainly because of a wider international cooperation between nations, via trade and technology transfer to ensure continuous and reliable supply.

In an ideal world, transfer of renewable energy globally is the most appropriate solution. Firstly, with the transfer of renewable energy, regardless whether through electricity or other forms, it would be possible for countries that have a potential to fully invest in this field, while the rest of the nations could be focusing on other fields that are equally important, such as agriculture, water or perhaps artificial intelligence (Seetharaman et al., 2019). (Other forms of renewable energy transfer may include the transfer of heat, or even the transfer of photons from the sun through direct light via optic cables, and then transforming the photons collected.)

Moreover, the transfer of renewables worldwide would ensure energy access to the entire population, in particular to the communities that still lack energy access, mostly in developing countries (Goldthau, 2017). Securing energy via alternative sources leads to the prevention of environmental pollution (air, soil, or any other type) mainly caused because of fossil fuels (Petraru and Gavrilescu, 2010). Hence, the ideal scenario of a global energy transfer between countries is the most appropriate scenario to tackling the existing problems resulting from the transfer of fossil fuels, mainly environmental pollution and climate change (Poltronieri, 2016).

A global regulatory framework is needed to regulate the transfer of renewables between the different countries, given the many factors that require to be considered such as the difference in capacities and capabilities, legal regimes and institutions, as well as technical know-how. A global regulatory framework would help easing the difference in the potential socio-economic benefits across countries, emerging as result of the energy shift, mainly because countries have different systems, capacities and reliance on renewables (IRENA, 2018a). A global system is vital, since “long-term sustainability of the global energy systems is essential to counter balance current demographic, economic, social, and technological trends” (Gupta et al., 2018).

B. The Reality

Renewable energy transfer globally is as important, as renewable energy generation, to ensure that the entire world is covered in terms of renewables (García-Olivares et al., 2018). Such transition will have a great impact on the geopolitical *status quo* worldwide (O'Sullivan et al., 2017). Already in certain places and regions in the world (e.g. Europe), a 100% transition to renewables across all sectors is feasible, if countries producing renewables transfer this energy to those lacking it, and in fact it is already happening (Ram et al., 2018). Substantial economic and political efforts can make a complete reliance on renewables a reality (Balat, 2005). Developing countries could benefit greatly from such transfer through "the protection of natural resources, reduction of health risks, increased access to modern energy, reduction of dependence on energy imports, and promotion of economic development" (Laumanns et al., 2004).

Transferring renewables from developed countries to developing ones would help addressing the challenges mentioned above (Laumanns et al., 2004). Besides production, access to renewable energy, which is "reliable, affordable, economically viable, socially acceptable and environmentally sound" requires improvement (Loibl, 2004). Questions are being posed regarding the potential developments that may occur in case "a new technology emerged providing a cheaper and more efficient way of transporting renewable energy" (O'Sullivan et al., 2017), where global rules would play a vital role in supporting such allocation.

There are many issues that must be regulated in the context of energy transfer (Heffron et al., 2018). The potential global regulatory framework applicable to renewables needs to deal with this question, since it is already being addressed in numerous domestic legislations (Wawryk, 2014). Given that the main product of renewables is electricity, a non-tangible good usually requiring transportation, and where numerous factors play a role, there is a need for clear regulations (Weber and Koch, 2015). Regulations are crucial to ensure the "reinforcement of the transmission and interconnections" to enhance electricity trade across borders through fixed infrastructure (Selivanova, 2017). Still, developed countries have better chances of adopting regulations tailored towards the generation of electricity from renewables in comparison to developing countries (Crossley, 2019), where the "priorities […] are often those of poverty alleviation, improvement of health and educational conditions and adaptation to a changing climate" (Crossley, 2019). Yet, these priorities require access to electricity that can be generated via renewables (Crossley, 2019).

Renewable energy matters also in the transport sector, when it is being used as fuel instead of other polluting sources and where the law plays an important role in pushing towards such a shift (García-Olivares et al., 2018). States are encouraging the use of green energy in transportation through regulations (Irish, 2014). Renewables in the transportation sector are seen in this context as an alternative to avoid greenhouse gas emissions (Bezergianni & Chrysikou, 2016), where such energy also needs to be transported to countries lacking the capacity to produce enough renewables for satisfying the daily needs of transportation, etc. (Mulyana, 2016). Enhancing the transfer of renewables to developing countries is a subject of concern to the international community, focusing on providing different types of support to developing countries seeking to install renewable energy (Lougsami, 2019).

A global regulatory framework pushing toward further policies, promoting renewables across different states and jurisdictions, similarly to policies being used to promote renewables at the domestic level, would ensure an energy shift through proper energy dissemination across borders (REN21, 2008). It would also play an important role in enhancing the growth in the use of renewables within the power sector globally. The international regulatory framework applicable to renewables should contain provisions related to energy transfer (Bradbrook, 1996). Indeed, the transfer of renewables across borders for satisfying various needs is key to ensure that it replaces the existing energy sources, as numerous countries do not have the capacity to either produce or generate sufficient renewable energy.

4. Energy Trade

Following the comparative analysis of ideal and more realistic scenarios in production and transfer phases, as well as their implications for creating a regulatory framework on a more global scale, it is also necessary to focus on the next stage of energy utilization: energy trade.

Energy trade is a vague term; therefore, we intend to distinguish between the trade with (i) renewable energy *per se* – markets with power (electricity), and (ii) the trade with various products crucial for renewable energy utilization.

The primary output of renewables – electricity – is energy itself in the form of electrons, which needs to be utilized in a timely manner; relatively close to the source of production, due to transmission losses with long distances (IEC, 2007). Furthermore, it has limited possibilities of storage, while other energy carriers can be widely stored and utilized according to demand, with minimal losses and efficiency problems during trade.

We have two primary aims in this section, some of which have already been initially set up. The first aims at outlining ideal and realistic scenarios more in detail, as the actual functioning of the electricity markets and their concentration and interaction between market participants. With this relation, the main question is firstly: what is the desirable level of competition on the market ensuring energy security via renewables, and secondly: how can a globally centralized regulatory system contribute to the maintenance of fair market conditions, while overcoming the everlasting problem with access to energy for affordable prices. Last, but not least, the second focal point in relation to energy trade, is the market with various products necessary for renewable energy utilization. These products are also closely related to environmental protection, fighting and mitigating climate change. It is not far-fetched to argue that the environmental goods related to renewable energy production, transfer, and eventually consumption are one of the largest product groups capable of contributing to sustainable development and fulfilling its main long-term goals set by the United Nations (UNEP, 2014).

4.1 Trade with Energy *Per Se*

A. *The Fairytale*

Subsequent to the notion of covering the global energy demand via renewables, the problems with intermittency of electric power cannot be overlooked, not even in an idealistic scenario. The biggest intermittency related problems affecting the power grid in the form of potential overloads and various congestions, result from the fluctuation of supply due to differing production capabilities, primarily in the case of solar and wind energy.

For normal grid functioning without overloads, the power supply and demand need to be balanced mainly during peak hours of solar and wind energy generation to maintain grid stability both regarding frequency and voltage. During these peak hours of supply, the frequency on the grid can skyrocket, causing complete failure and permanent damage. While during peaking demand, the grid frequency decreases resulting in wide-range blackouts depending on grid coverage (Swiss Grid, 2020). A balance on the grid can be achieved ideally via (i) making generation more flexible with easier output regulation in case of overloads, and also in case of energy shortage, (ii) supporting solar and wind energy generation with energy from other (fossil) sources, and (iii) via applying energy efficiency measures during consumption.

Solving intermittency issues require naturally additional investments and coordinated efforts from all the market participants – suppliers, consumers, but also system operators and regulators. These conditions, combined with high-level grid interconnections among various country clusters and regions under the aegis of a global regulatory framework, undoubtedly result in more efficient market functioning.

How does this more fluent market functioning come through, compared to a more realistic scenario? First of all, in trade with electricity, prediction is inevitable and can influence whether all the produced renewable energy is sold on the market and bought by consumers. Securing high-level allocation of transmission capacities on the market firstly takes place in a day-ahead bidding process, where the market participants (sellers, buyers) trade ahead, bidding for particular amounts of capacity for particular timeslots in the future. In a very simplified way, this is where supply meets demand even before the electricity is actually produced, with the participants making commitments to sell/ buy particular amounts at a given time the following

day. Of course, such bidding needs to go hand-in-hand with the real-time flows on the grid to maintain its stability and to be able to cover demand at any given moment. Therefore, the trade is moved to the real-time market, where the day-ahead commitments need to be met (EC, 2020) (ISO-NE, 2020) (ENTSO-E, 2020) (Nord Pool, 2020). Considering these conditions, the ideal trade on the power markets would fulfill the following conditions:

- Interconnected grids via a coupled market on a supranational level allowing electricity to be transmitted anywhere in the world in a short period of time.
- Maximized utilization of produced electricity with no losses of energy due to inaccuracies and erratic market dynamics.
- Minimal or no deviations from the day-ahead bids on the real-time market in order to lower the necessity of maintaining reserved capacities. The high amounts of reserved capacities for balancing, upheld by the system operators, can lower tradable amounts and overall grid capacity. In this regard, smart grids are able to better monitor, control and automatize electricity flow could ensure such limited deviations, due to higher flexibility and adaptiveness to changes on the grid itself. (IEA, 2019)
- No price volatility on the market, and free price formation mechanisms need to go hand-in-hand with high competitiveness of market participants. This would lead to consumer welfare, efficient (low cost / high output) production, as well as constant innovation and investments into research and development.

The fairytale nature of these conditions is a given, and their main requirements can be narrowed down to three main blocks: coupling, investments, and technological development. These building blocks bring us right to the second main aspect of trade with energy: competition on the market.

Energy market liberalization, with multiplying market participants and market integration, although still not global, has initially emerged as a principle during the second half of the 20th century, and the process itself started in Europe in the 1990s. The main idea was to break the incumbency of certain energy companies with large state ownerships, in order to secure a market with low entry barriers, free price formation, and mainly to unbundle vertically integrated groups of undertakings being present as producers, suppliers and system operators too, able to easily foreclose new entrants and incumbents from essential infrastructure. (DG IP, 2017) (IEA, 2001)

Imagining an energy market with a high number of market participants, competing on the merits of energy supply and its prices for consumers, could secure long-term affordable energy. Furthermore, a competitive energy market can minimize costs of investments into infrastructure, and technological innovation could be encouraged due to economies of scale (cost reduction via generating higher amounts of renewable energy, extending production capacities and using more efficient technologies) (Energy Policy, 2019). The above scenario shows an indirect proportionality between the level of competition and the level of prices on the energy market – ideally the former being as high as possible, for the latter to be the lowest possible.

B. The Reality

Unfortunately, in reality the markets, where renewable energy is traded, are functioning slightly differently than outlined above, not only when it comes to competition. From a technical perspective, it is mainly due to the lack of wide-scale interconnections between grids, these being far behind a global level, and also the status of technological development.

The cross-border coupling of energy markets between countries, systematically taking place in Europe in order to create an Energy Union, has been partially carried out in the past five years. The latest status update of the European Commission underlines the achievements in the field of connecting isolated regions to the internal grid, and involving them in the trade with electricity (EC, 2019). Similar efforts are taking place also in Africa and Asia. The East African Community is putting in significant efforts to build transmission lines connecting the Uganda-Rwanda and the Kenya-Uganda interconnections, as well as upgrading the Burundi, Democratic Republic of Congo and Rwanda interconnections, which are key to boost the power

markets in the region (Mabea and Okoli, 2019). In Asia, the process of connecting the isolated Japanese grid to the rest of the mainland is ongoing, which would allow international trade and also increase the working efficiency of supranational grids, resulting in higher capacity allocation and security of supply (less outages and higher economic efficiency) (AIGCSG, 2017). Last, but not least, China recently also proposed setting up energy interconnections, which will also ensure power flow across the mainland of the Asian continent (Li, 2019). These results underline a bottom-up approach coordinated internationally, via multilateral negotiations involving foreign investments into infrastructure, as well as appropriate capacity building. Such a bottom-up approach is also considerable when it comes to the global regulatory framework overarching trade of renewables.

The functioning of the power markets, although lagging behind the ideal scenario, equally has significant achievements, mainly when it comes to technological development and thanks to coordination and cooperation between these markets. Innovative solutions are being proposed to handle demand monitoring, allowing better adaptation of supply, e.g. via increasing the resolution of market schedules, which can better reflect grid flow in a particular moment in time (*cf.* Philipsen, 2019). These scientific proposals, applicable more efficiently under a global framework, can also eliminate price volatility, which can occur during peak supply, when prices drop due to power overflow, as well as during peak demand, when prices skyrocket, due to the limitations in supply.

In case of competition on power markets, the situation can be called "work in progress". There are still problems with denying third party access to infrastructure, making new market entries difficult, abuse of market power by dominant undertakings, and, in some cases with discriminative pricing. Renewable energy generation has become a subsidized industry, constantly pressing production costs lower and lower, but this puts the producers of conventional energy in a difficult position. Although these incentives were meant to, and partially already managed to support the transition to green energy and fighting climate change, there is still not enough available renewable capacity despite of their economic advantage. The option of large fossil fuel power plants to switch to renewable generation promptly and profitably remains challenging. Due to the homogenous character of electricity, its origin (whether coming from renewables or conventional sources) is not distinguishable for the consumer, therefore the original idea of production subsidization is becoming more and more contra productive, since the costs of renewable generation are constantly moving on a downward slope. This means that the producers of renewables are competitive enough even without state subsidies, while producers of conventional energy are unable to change their production profiles in a swift manner. In the light of this, the aim of subsidization should gradually shift from supporting large-scale solar and wind energy production to supporting self-sufficient small-scale generation, and to helping transmission-capacity building, since getting generated renewables to consumers is becoming more challenging than generation itself (Standaert, 2019). Whether phasing out renewable energy subsidies would be beneficial is notwithstanding still an ongoing debate, with arguments pro and con both having their *raison d'etre* (Nicolini and Tavoni, 2017) (Özdemir et al., 2019) (Yang et al., 2019) (Maloney, 2018).

4.2 Trade with Various Products Necessary for Renewable Energy Utilization

A. The Fairytale

Another crossroad on the way of arguing for a global regulatory system regarding renewable energy is related to the so-called "environmental goods", including products necessary for renewable energy utilization. Naturally, the term has a wider scope than just solar panels and wind turbines, but the border between goods in the "normal" sense and goods "good for the environment" is still very blurry, and has been since the beginning of the 1970s (UN, 1972).

In an ideal scenario a holistic list of products would exist for complete liberalization of trade with these, decreasing their costs via not levying any tariffs or putting any additional financial barriers on their imports by the domestic state. This would result in a global triple-win on the field of (i) fighting climate change, (ii) fostering transition to renewable energy and also (iii) eliminating the gap between developed and developing (least-developed) countries caused by trade intensity differences.

Established environmental technologies (Class A) and environmentally preferable products (Class B) are two existing categories of environmental goods distinguished based on their position in the production chain, Class A products being mainly components, while in Class B there are mostly goods for final consumption (Iturregui and Dutschke, 2005) (Hamwey, 2005) (Howse and Van Bork, 2006). In case of renewables, the primary emphasis should be put mainly on all the components of cleaner technologies (Kennett, 2001). However, only certain clean technologies would fall into this category of environmental goods, even though all of them are indispensable parts of making more energy efficient environmentally preferable products (e.g. household appliances). The main idea of the idealistic scenario is to create a list of established environmental technologies (parts and components) necessary for renewable energy generation and liberalize their trade worldwide.

Trade with such products would decrease the costs of renewable energy generation further, even as a potential alternative to government subsidies. However, ideally there should not be a large tilt towards certain products, which are on the top of the export list of developed countries only, because this would slow down the overall development progress of countries with weaker economies, based more on raw materials, especially if they are not able to extend adding domestic value to these raw materials via manufacturing. A certain imbalance would be acceptable only at the beginning in case of developing and least-developed countries. This way they could catch up with the rest of the world, but it should neither lead to monopolization via cheap imports, putting emerging economies in a further advantage (e.g. China, India), while undermining domestic production anywhere (*cf.* Zhang, 2018).

In the light of the above, lifting tariffs from environmentally beneficial products necessary for renewable energy generation, should go with technology transfer and know-how sharing, for the countries with low production potentials to get started. Indeed, as visible from this idealistic scenario, plenty of compromises are needed mainly from the side of developed countries. In order to achieve such a level of coordination and worldwide consensus, international regulation on a global scale is inevitable.

B. The Reality

One of the attempts to establish an international framework for trade liberalization of environmental goods took place under the umbrella of the World Trade Organization (WTO) between 2001 and 2015, while moving more and more out of the focus of the negotiating WTO members since 2016.

It does not come as a surprise that the main problem was the inability to come up with a unified definition of these goods and creating a list of them, acceptable for all the parties of the negotiations. Such lists already exist, but mostly only for clusters of countries and not for a global use – e.g., created by the OECD and the Asia-Pacific Economic Cooperation (Steenbilk, 2005). The problems, which should be non-existent in an idealistic scenario, still remain a reality, including the discrepancy between the trade interests of developed, developing (emerging), and least-developed states. During the negotiations, practically all the participants presented their export / import product lists, and were lobbying for the inclusion of as many items as possible among environmental goods for free trade. Developed countries also had concerns with changing the approach toward technology transfer, not willing to provide these via investments to countries lacking basic governance structures, rule of law regimes, and volatile overall political environments, being afraid of intellectual property infringements. In the light of all this, liberalization of trade with environmental goods slowly faded (Wu, 2014). As a result, the liberalization efforts continue to remain in the sphere of Regional Trade Agreements (RTAs) and creating free-trade zones on a smaller scale (WTO, 2020).

These RTAs have an expanded scope of environmental objectives, which also affect the trade with renewable energy-related technology and components. However, these provisions within such RTAs do not go into much specifics about any product lists or related tariffs: they only establish a commitment of the parties to promote environmental objectives including sustainable development goals during their trade. Nonetheless, such provisions can form a frame within which the states can lift tariffs from particular goods for the sake of compliance (Yamaguchi, 2020). Furthermore, concluding an agreement under

the regime of the WTO by itself might not even be enough to change the current pace of ecological degradation (Hu et al., 2020).

5. Conclusions

Dissecting the stages of renewable energy utilization through an idealistic and realistic filter makes it obvious that for fairytales to become reality, a closer and wider cooperation between countries and between their stakeholders is an absolute must. The problems described in relation to production, transfer, and trade with renewables generally all stem in isolation, different national interests, protectionism and putting national benefits ahead of supranational ones. A global regulatory framework based on consensus, compromises, and mutual scrutiny could mean a solution to all of these difficulties.

Wide-scale renewable energy production covering extensive global demand largely stands on accurately evaluating capacity potential of regions, based primarily on geographical criteria. Through such evaluation various countries could get precise data on what the maximum amount of renewable energy output to rely on. According to such data, the appropriate energy mix could be created, tailored on a particular country in order to maximize the global gains from energy sources, which are basically endless. These assessments of energy potential are currently being made on a national basis, but a more centralized global framework could make them more efficient, creating larger data pools and processing them along a single methodology. Naturally, geography is just one of the aspects when it comes to utilizing all the renewable resources a region has at its disposal. Available technology and attracting sufficient investments to build necessary infrastructure are equally important. Nevertheless, past experience already shows that the coordination of different initiatives (e.g. grant schemes), injecting finances into renewable energy and sustainability related projects work quite well, even on a supranational level. The European Union's support of neighboring developing countries, as well as the development projects of the World Bank and other supranational financial institutions serve as good examples. International programs are more efficiently capable of identifying needs and provide the required support via coordinated efforts, also considering particularities of different renewable energy markets. (IRENA, 2012) (*cf.* Donastorg et al., 2017)

Energy transfer and accessible infrastructure to obtain the renewable electricity to the most remote parts of the world is also intertwined with global efforts. Cross-border cooperation interconnecting regional infrastructure, as a bottom-up approach, is practically the key building block of a global framework. Reaching worldwide coverage of renewable energy transferring systems being the ultimate goal, also requires control mechanisms able to guarantee wide access to all, on equal conditions. This leads directly to the issues with the markets trading renewable energy and the goal of their coupling, including grid interconnections. Such a concept is already being widely advocated by Non-Governmental Organizations (NGOs), arguing also for the acceleration of universal access to renewable energy on a global scale. The Global Energy Interconnection Development and Cooperation Organization (GEIDCO) is one of these NGOs considering interconnections under a global umbrella crucial for reaching the goals of the Paris Agreement (UNFCCC, 2018). Not to mention the benefits of larger markets allowing trade in larger volumes, making economies of scale even more relevant, as well as possibilities also for the smallest residential prosumers to find their buyers.

As we have reflected on throughout the article, problems with the renewable energy markets do not stop at solving the difficulties with their interconnection under the aegis of a global regulatory framework. It is also crucial to create rules ensuring sufficient competition and free price forming on these markets. Fragmentation of these rules in various regions could negate the positive effect of connected grids, making compliance costly, leading to imbalances increasing price volatility. Globally harmonized rules and their enforcement could eliminate these shortcomings.

Last but not least, the example of the environmental goods, and the attempt to liberalize their trade, also underlines the importance of an extensive support between countries on different levels of economic development. The failed efforts of the negotiations under the WTO do not mean that the idea was unfeasible. It just requires a similar bottom-up approach as market interconnections and regional cooperation in case of energy transfer, expanding with development.

Notwithstanding, the necessity and feasibility of the global regulatory framework emphasized via the above reasoning is meaningless without political will, commitment from national leaders, policymakers and other stakeholders to closely collaborate, share ideas and provide mutual support. Climate change will not stop, energy transition should not stop, and with one minute to midnight showing on the clock of ecological degradation, seeking for solutions to provide green energy to everyone cannot stop either.

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Corporate Social Responsibility and Sustainable Entrepreneurship

Entrepreneurship, plastics and the Circular Economy: What does an incubator's cohort tell?

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Abstract

As the policy actions from the first European circular economy package are being implemented, the concept is subject to a massive boost in the scientific and the business community. Hence, a new generation of organizational models and approaches to circularity has become visible in recent years. The implementation of circularity affects several levels, from material flows to corporate strategies and finally society as such. Furthermore, it includes established companies, start-ups and bottom up initiatives, as well as a variety of sectors and stakeholders, as also outlined in the focal areas in the CEP. Understanding circularity approaches and inherent sustainability implications on a systemic level is crucial to determine organizational (in this study: businesses and initiatives) strategies for an effective CE. While there is a research stream on business model innovation for CE, ex-post evaluation of circular strategies on a high level is yet largely missing. The aim of this study is to contribute to an improved understanding of sustainability implications of circular strategies, deepen the knowledge on circular transitions, and ultimately the functioning of a CE. Therefore, this study draws on a set of 25 projects executed by start-ups, initiatives, and NGOs tackling the plastic problem from a circularity perspective. The projects were selected from a social accelerator platform in Berlin/Germany. A concurrent mixed method approach including action research was chosen for the analysis: First, self-descriptions, written by the initiatives are content analysed and systematically evaluated, including operational levels and foci of the projects. Based on this, sustainability implications are derived and categorized, using the principles of the Framework for Strategic Sustainable Development. Second, the research team was involved as experts to consult the initiatives under investigation and assess the projects from a systemic and sustainability perspective. Finally, project descriptions were analysed using a topic modelling approach to cluster and analyse the main approaches of the project sample. Results suggest diverse approaches to tackling the plastic problem, ranging from materials-based solutions to platforms and reductionist approaches. Also, a wide range of social inclusion into circularity approaches (during production, but also addressing consumers) was observed amongst the projects, thereby addressing a clearly underrepresented area of European CE. At the same time, the level of systemic understanding of sustainability implications varied. This can lead to negative consequences especially when major trade-offs are overlooked. The study shows that approaches to circularity can be diverse, even within a specific focal area, and that every focal area (also a very materials-based one) can include social aspects to a high degree. Also, as opposed to established companies, the analysed start-ups and young initiatives show a higher degree of freedom when choosing strategies, explaining the diversity within the projects. Regarding sustainability implications, a systems perspective seems useful to qualitatively estimate sustainability implications. However, specific attention needs to be given to potential negative feedbacks and time lags, that in the worst case could offset the positive intended sustainability contribution. Here, a strategic and holistic inclusion of sustainability principles, such as the framework for strategic sustainable development or the UN SDGs, are encouraged.

Keywords: bottom-up initiatives; social innovation; circular economy; framework for strategic sustainable development; plastics

1. Introduction

For the last years, the idea of a circular economy (CE) has shaped socio-economic discussions on European level (European Commission, 2015, 2020). The CE, which is supposed to keep resources in the anthropogenic production loop is on a political level envisioned to create a new economic system, which enables growth and creates jobs while it protects the environment (ibid.). At the same time, from a scientific point of view, the relationship between CE and sustainability is not

as clear (Geissdoerfer et al., 2017; Merli et al., 2018). Hence, understanding circularity approaches and inherent sustainability implications on a systemic level is crucial to determine organizational (in this study: businesses and initiatives) strategies for an effective CE.

As in any economy, businesses and other organizations (such as NGOs) play a decisive role when shaping circular systems of production and consumption, and so do their business models (Bocken et al., 2016; Hopkinson et al., 2020; Lewandowski, 2016). Companies need to adapt their business models and envision a new way of making business and including stakeholders. Thereby, both established organizations as well as young initiatives and start-ups need to come up with innovative solutions to shape this transition Hence, a new generation of organizational models and approaches to circularity has become visible in recent years (Henry et al., 2019)that has revealed the implementation of circularity can affect several layers, from material flows to corporate and other organizational strategies and finally society as such (Hobson & Lynch, 2016; Korhonen, Nuur, et al., 2018), which would result in restructuring the socio-technical regime (and hence, the system in place) (Geels & Schot, 2007). While there is a research stream on business model innovation for CE, ex-post evaluation of circular strategies on a high level is yet largely missing in the literature (Diaz Lopez et al., 2019; Kirchherr & Santen, 2019). This study aims at understanding bottom-up approaches (=in this study niche innovations) for the circular transition from a sustainability perspective, thereby taking the Framework for Strategic Sustainable Development (FSSD) (Broman & Robèrt, 2017) as a reference for holistic approaches towards sustainability. To do so, this study draws on a set of 25 projects (start-ups, initiatives, NGOs) tackling the plastic sector from a circularity and social innovation perspective, drawn from a social accelerator platform in Berlin/Germany. The following research questions thereby were guiding the process:

1) How do bottom-up initiatives in the plastic sector cover sustainability principles?
2) On which level do they operate, and what is their focus?
3) What are the main topics, the initiative aim to tackle?

The remainder of the paper is structured as follows: the next section provides an overview over the methodical approach. Section three subsequently first presents the theoretical background on the FSSD and CE, followed by a display of the results of the analysis. This section is complemented by a discussion. The conclusion finally highlights some central aspects of the study and provides insights on limitations and an outlook.

2. Methods

2.1. Research background and data collection

The “Act on Plastic”[1] challenge was initiated by “Project together”[2], a social accelerator platform aiming to enable bottom-up projects to rapidly prototype and coordinately scale their ideas. “Act on Plastic” consisted of an on-line competition launched in October 2019 with the purpose to recruit start-ups, initiatives, and NGOs aiming at sparking systemic changes in the global plastics landscape, and the subsequent SoulIncubator programme. The means by which the projects would pursue this goal had to be based on at least one the following CE enablers: a) Solutions to reduce the use of plastic in everyday life (“Reduce”); b) Use plastic as a resource (“Recycle”); c) Redesign existing plastic solutions to make them more sustainable (“Redesign”) and d) Making plastic a central issue to the general public (“React”). Successful appliactions would then become part of the SoulIncubator programme (composed of Phases I and II), which would provide increasingly intensive mentoring resources over 12 months in order to mature, consolidate and maximize the impact of incipient ventures. Communication campaigns were launched using the “Project together” website, Twitter, Instagram, LinkedIn and Facebook channels. 110 initiatives were included in the Phase I of the SoulIncubator according to the degree they fulfilled systemic change required by the organisers of “Act on plastic”. During this phase, several consultation calls with subsequent

[1] https://projecttogether.org/actonplastic/

[2] https://projecttogether.org

assessment rounds were conducted over the course of six months to the cohort and subsequent datasets were generated (Table 1) on behalf of "Project together".

Table 1: Datasets generated in Phase I

Focus	Number of datasets	Evaluator	Focus	Reference for evaluation
Self-description	1	Initiative's founder	Mission statement	Self-reflection
Systemic sustainability impact	2 (II Sessions)	Sustainability Academic/Consultant	Systems change impact	"Act on plastic" System Change Guideline (Appendix)
Economic impact	1	Business Academic/Consultant	Economic viability	Feedback questionnaire
Coaching progress	1	Coach	Effectiveness of initiative deployment	Feedback questionnaire

2.2. Research design and data analysis.

The research approach used for this study was based on a concurrent mixed method design (Teddlie & Tashakkori, 2006), including qualitative content analysis, topic modelling, and action research. The Action Research approach is characterised by consecutive rounds of action and research in order to obtain understanding of the phenomena studied while gradually inducing change to the element under investigation (Blessing & Chakrabarti, 2009, p. 273) . In this case, co-authors of this paper were firstly involved as experts in systems change impact and secondly, in the analysis of the datasets generated during Phase I (Table 1). Thus, from November 2019 until February 2020 systems change expertise was provided to 10 initiatives in two rounds of videoconference calls of 90 minutes of duration each. The goal of the first call was to jointly sketch baseline impacts of "as-is" initiatives and giving directions to initiative founders to broaden their scope and aim for wider systemic change through a set of questions (Guide for Authors 1, Appendix). The goal of the second call was to revisit the points addressed in the first call and evaluate how systemic change was incorporated (Guide for Authors 2, Appendix). Co-authors received all datasets from Phase I (Table 1). After data quality check, 25 initiatives were selected for qualitative content analysis (Mayring, 2015) to deductively dissect their contribution to sustainability against the different levels of the Framework for Strategic Sustainable Development (FSSD). Furthermore, to add analytical depth, initiatives were categorized according to their operational levels (which could be (i) material, (ii) process, (iii) strategy, or (iv) system), as well as their operational focus (which was divided into (i) production and supply, (ii) consumers, (iii) end of life). The sample consisted of different projects (NGOs, start ups, initiatives) and varying maturities (some projects were already founded, some in the ideation phase). Due to consistency and completeness reasons, two datasets (self-description and systemic sustainability impact) were eligible for analysis. The analysis of entries was divided into three researchers, who effectuated 3 different categorisations regarding a) levels (; b) focus and c) contribution to FSSD principles regarding social and environmental systems ("positive", "negative", or "neutral"). Thereby, a rather narrow focus (focusing on direct impacts and on the data sets without including external sources) for the evaluation of the projects was agreed upon, to increase consistency in the use of system boundaries (see also section 3.5). Furthermore, for the social principles (as described in section 3.1), the perceived contribution of a project regarding its target group and cultural environment (rather than e.g. employees) was assessed, since no information on internal workforce was available. A fourth researcher subsequently conducted a consistency check across all entries. Correlations where identified between levels, focus, and contribution to social and environmental systems. Finally, the aggregation of data and qualitative observations were conducted in a brainstorming session where all four researchers participated.

In addition to the qualitative assessment previously discussed, a correlated topic modeling (CTM) algorithm was run across the datasets in order to capture possibly hidden semantic structures (Blei, 2012). Using the CTM, these semantic structures could be grouped into different topics that were furthermore ranked according to their prevalence in the dataset. The CTM was fitted using the R package "topicmodels" (Grün & Hornik, 2011) and using the project self-descriptions as input. As 23 of the descriptions were German, the remaining two were translated from English to German.

3. Results and Discussion

3.1. Theoretical frameworks

This work aims at elucidating the intricate connections between the CE and sustainable development in the context of global plastics flows. CE is defined as a means to "decouple wealth and welfare creation from resource consumption" (Stahel, 2019, p. 14). Definitions of a CE come together with a set of value-retention options (Rs) that depict the actionable strategies allowing organisations to meet CE goals. The most comprehensive set of Rs are included in the model proposed by Reike et al. (2018), which consist of: Refuse, Reduce, Resell/Reuse, Repair, Refurbish, Remanufacture, Re-purpose, Recycle materials, Recover energy and Re-mine. The acknowledged multi-level nature of the CE considers that these strategies can be enforced by different bodies operating at different levels of socio-technical systems: a) the micro-level, referring to companies and products; b) the meso-level, referring to industrial parks and neighbourhoods; c) the macro-level, referring to wider regions and countries (Ghisellini et al., 2016). In our research, a CE framework of value-retention options has been used to categorise initiatives according to their respective underlying enabler that allow them to potentially contribute to a greater sustainability in the global system of plastic flows, thereby considering the roles of innovation and stakeholders involved (Potting et al., 2017; Reike et al., 2018).

Sustainable development is widely acknowledged as a means to ensure that "humanity meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Commission, 1987, p. 54). This entails a transition from a baseline, business-as-usual scenario, characterised by the deliberate exploitation of natural and social resources in favour of profitability to a more balanced interplay between the economic, social and environmental pillars of socio-technical systems. The main multi-level perspective (MLP) on socio-technical transitions was put forward by Geels (2002) and studies the interaction of developments at three different analytical levels: niches (locus for radical innovations), socio-technical regimes (locus of established practices and associated rules that stabilize existing systems), and an exogenous socio-technical landscape (Geels, 2011; for a visual representation of the different levels, see Figure 2 in that paper). MLP models allow to envision the dynamics the sample population (bottom-up initiatives, rather associated with niche innovations) could undergo towards a different socio technical system state, and to what extent this would change the respective regime level (and what sustainability implications this would have). The accommodation of bottom-up initiatives, according to the proposed model can take place in four different ways: a) Transformation, in which experiences from niche initiatives are accommodated by mainstream regime actors; b) Reconfiguration, due to landscapes exerting pressure on regimes driving the further development of niche initiatives; c) Technological substitution, in which the niche initiatives gain momentum (i.e. through investment of resources) and replace mainstream regime actors with or without the intervention of favourable landscape conditions; d) De-alignment and Realignment, when regimes are disintegrated due to landscape pressures and multiple niche innovations take advantage of the space and consolidate in a new regime (Geels, 2011) .

The instrument used in this research to dissect the multi-level dimension addressed by the sample of bottom-up initiatives is based on the Framework for Strategic Sustainable Development (FSSD) proposed by Broman and Robèrt (2017). The FSSD considers 5 different levels of contribution to sustainability: a) the System level, including principles for the functioning of the global environmental and social systems; b) the Vision level, which has to be aligned with basic sustainability principles; c) Strategic guidelines, which need to allow to approach the principle-framed vision strategically; d) Actions, which include the set of actionable priorities the specific organization has included in the strategic plan and e) Tools, including methods, tools and other forms of support that are often required for decision making, monitoring, and disclosures of actions. Based on the invertion of mechanisms which destroy environmental and social systems, the FSSD identifies 8 sustainability principles that serve as guidance for strategic sustainable development. These principles include:

- Concentrations of substances extracted from Earth's crust: Nature is not subject to a systematic increase of the concentration of lithospheric substances.
- Concentrations of substances produced by society: Nature is not subject to a systematic increase of the concentration of societally produced molecules.

- Degradation of physical means: Nature ist not subject to a systematic increase of degradation by physical means. This includes, among others, aspects of biological productivity (i.e. freshwater, soils, biodiversity) and that resilience should not be systematically deteriorated by physical manipulation.
- Health: People are not systematically exposed to conditions that undermine possibilities to avoid physical, mental and emotional injuries and illness.
- Influence: People are not systematically hindered from participating in shaping the social systems they are part of.
- Competence: People are not systematically hindered from learning and developing competence, individually and together.
- Impartiality: People are not subject to partial treatment systematically (i.e. by discrimination or unfair selection for job opportunities)
- Meaning-making: People are not systematically hindered from creating individual meaning and co-creating common meaning

With regards to project assessment, no further evaluation criteria were defined for the environmental principles, as they are clearly structured and 'measurable' (e.g. if a project substantially increases the presence of plastic in society). For the social principles, on the other hand, assessment criteria were set. The chosen criteria can be seen in Table 2.

Table 2: Qualitative evaluation criteria for social principles

Social Principle	*Criteria*
Health	- Minimising the presence of hazardous substances in the target group - Direct inclusion of health aspects into project descriptions (focus of project content)
Influence	- Giving people voices - Allowing to express or bundle opinions to address companies or policymakers
Competence	- Projects with educational aspects - Transparency and information sharing
Impartiality	- Addressing discriminatory issues or societal inequalities (for the target group rather than employees)
Meaning-making	- Aspects on empowerment or enabling co-creation (through e.g. gatherings, workshops, etc.) (strong relation to influence)

3.2. Topic model

To get an overview of the most important topics among the initiatives, a correlated topic modelling of the self-descriptions of the initiatives was performed. Thereby, the five most important topics of the projects were identified and each topic was represented by the five keywords dominating the respective topic in the self-description of the initiatives. The results of the topic model are presented in Figure 1 (note, that the keywords are in german due to the german project descriptions, as described in chapter 2.2). It can be seen that, unsurprisingly, most of the topics were formed around the topic of plastics. For three out of five topics, "Plastik" was the most important contributor, while for the fourth topic, "Mikroplastik" was the second most important contributor. The last topic was rather blurry in terms of materials, and instead formed as a visionary theme centered around local projects and actions. Apart from that, the word "Produkt" appeared in three of the topics, indicating a product-centric view of the initiatives (which does not exclude the incorporation of the system the product is placed in). Thereby, the first two topics were found to be rather most commonly centered on products ("Produkt" emerges in both of the topics, as well as "Löffel"), but while topic 2 was rather coined by a broader view, including the community as well as business, topic 3 was more coined by terms referring to unpacked products or the use phase. Topics 4 and 1, on the other hand share a focus on water-related words, which can be seen as a bottom-up answer to high (social) media coverage with regards to water and ocean pollution from plastics. While topic 4 also included terms related to zero waste activities, topic 1 was rather characterised by a political dimension. In general, it can be seen that the initiatives focused on consumer-

related plastic issues, that at the same time represent the highest share of plastic production in the EU (packaging accounts for around 40% of the plastics produced, while 22% is produced for consumer & household goods) (PlasticsEurope, 2019), while the topics around awareness (visible through terms such as academy or community) represented rather indirect approaches towards acting on plastic.

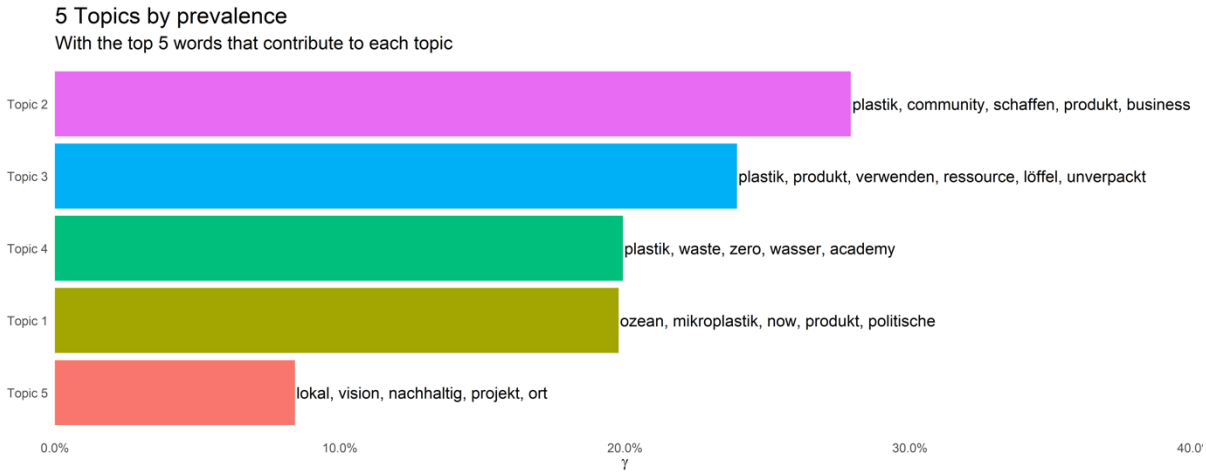

Figure 1: Top 5 topics by prevalence as addressed by the initiatives

3.3. Evaluation results

Altogether, the research team evaluated 25 projects regarding their focus, their level of operation, and their contribution to the sustainability principles as mentioned in chapter 3.1. Figure 2a shows, that 10 of the projects were evaluated as operating on a systemic level, while 9 were considered to operate on a material level, followed by 4 projects on a strategy and 2 on a process level, respectively. For the project's foci, it was found that 12 projects were considered to have a focus on consumers, followed by 8 projects with an end of life perspective, and 5 projects with a focus on production and supply (see Figure 2b).

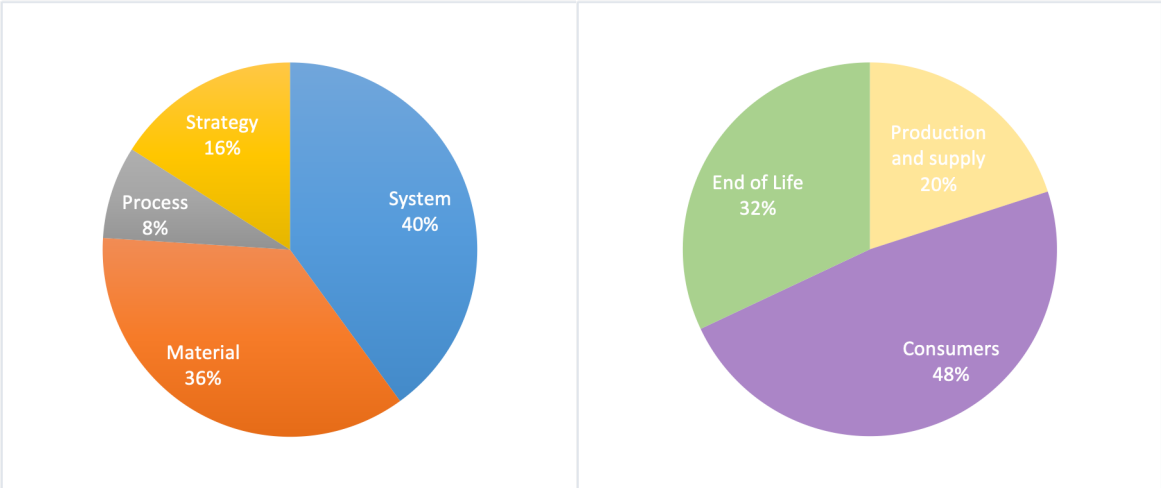

Figure 2: (a) Levels, as evaluated (on the left side), (b) Focus, as evaluated (on the right side)

Regarding contribution of the initiatives to the eight principles of the FSSD, the following picture was found (see Figure 3). The figure shows the absolute assessed number of contributions to the principles as bars, whereby projects could either (i) contribute positively, (ii) contribute negatively, or (iii) be neutral towards the respective principles. Additionally, Figure 3 shows the average values for each contribution (positive, negative, neutral) as horizontal lines across the chart. A focus on two environmental (substances from the earth's crust, concentrations of substances produced by society) and one social

principle (health) was found. Thereby, the positive contribution to health mainly emerged from the assumption, that acting on plastic pollution in the environment would in the end be beneficial for health as well. On the other hand, competence building was prominent in the sample initiatives, while the environmental principle of degradation by physical means, as well as the social principles of influence and meaning-making, and especially on impartiality, were rather out of focus. Thus, in general, a focus on contribution to environmental sustainability principles was observed, without parallel neglection of social aspects. Additionally, for some projects possibly negative outcomes were observed. Thereby, above all the environmental principle of degradation of physical means was found to be subject to possible negative consequences, mainly due to the possibility of shifting the used materials from fossil-based plastic to bio-based alternatives (that may compete with food crops) or paper[3]. Burden-shifting consequently can't be fully excluded. It is possible, that more projects are prone to negative rebound effects, but this part of the assessment proved to be particularly challenging (see also chapter 3.5).

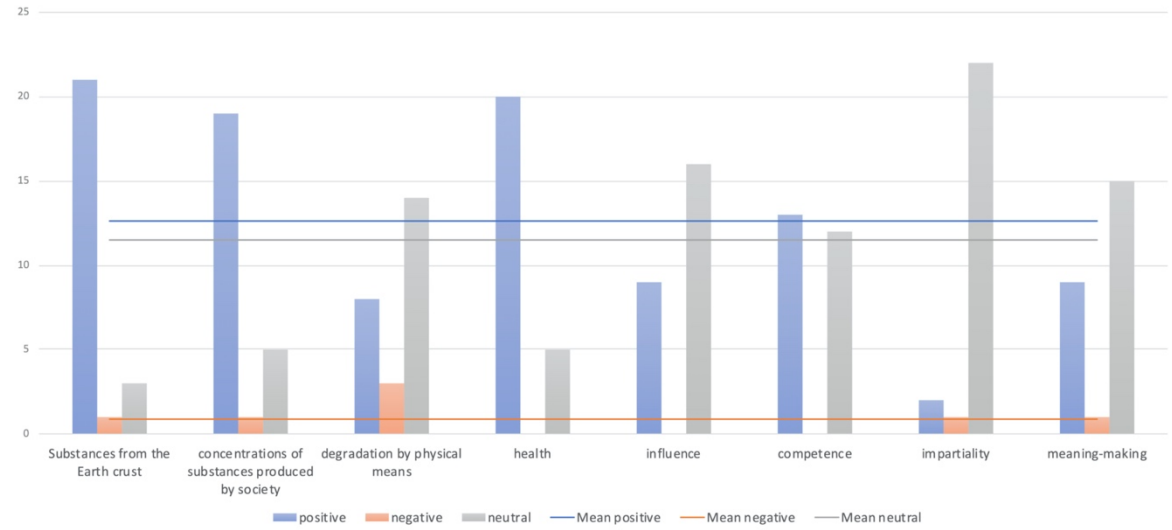

Figure 3: Contribution of the evaluated initiatives to the principles for strategic sustainable development

3.4. Correlations and patterns

We then went on to look for correlations and patterns within the assessed initiatives. The focus thereby was on the relationships between operational level and focus, as well as on operational level and positive contribution to the sustainability principles described in the FSSD.

First, Figure 4 shows the first correlation, between operational level and focus of the initiatives. An interesting aspect is, that numerous projects operating on a material level were perceived to focus on the consumer. This at first looks surprising, but can be explained through a deep-dive into the data: several projects were classified as operating on the material level, since they replaced one material (plastic) with another one (e.g. glass). At the same time, the success of the initiative is highly dependend on consumers, since the new material needs to be returned and brought into the loop to implement deposit schemes.

Apart from that, for projects operating on a systemic level, contribution to all foci was found, while strategic level initiatives were not linked to a production focus, and process level projects solely to an end-of-life focus.

Second, the relations between the operating level and the perceived positive contributions to the FSSD principles are depicted in Figure 5. The inner circle of the figure thereby represents the operational level as evaluated from the research team. The share of the ring thereby does not reflect the absolute number of projects on that level (e.g. 10 on the systemic level), but rather the number of positive ratings towards a specific sustainability principle from projects that were

[3] Here, burden-shifting would depend on the type of paper used

categorized to operate on that level (that is, if a project on the material level was evaluated to contribute positively to two principles, the materials share of the inner circle grows by two). Consequently, the whole rotation of the circle corresponds to the absolute number of positive ratings (=101). First, it can be seen, that the systemic level, while representing around 40% of the projects, is accountable for more than half of the positive ratings (around 53%). On the other hand, the share for all remaining levels was slightly smaller (29% compared to 36% for materials, 12% compared of 16% for strategy, and 7% instead of 8% for processes). Furthermore, it becomes visible that especially the systemic initiatives were believed to contribute positively to the social principles. In fact, they were perceived to have decisively more positive impacts on social compared to environmental principles. The same holds true for processes, but on a smaller scale, while for material and strategic projects, the values show a stronger benefit to environmental compared to social principles.

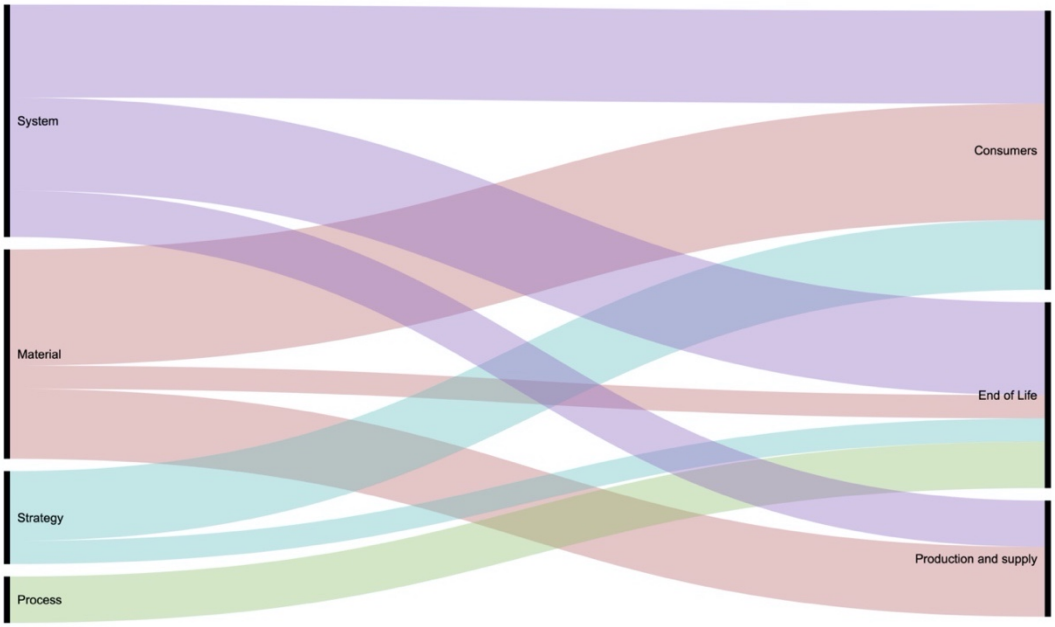

Figure 4: Observed connections between operational levels and focus of the initiatives

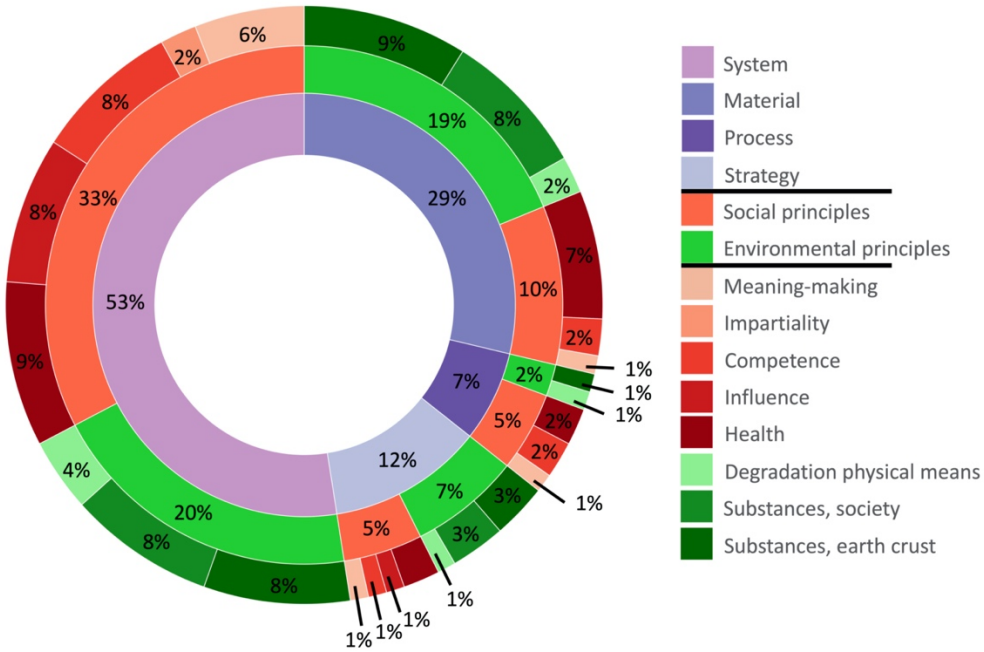

Figure 5: Observed interrelations between the initiatives' focus (inner circle), social or environmental principles (middle circle), and the respective principles (outer circle). Note that each circle individually sums up to 100%.

3.5. Discussion

The forthcoming chapter sets the previously presented results in contrast with other literature on multiple business case studies and contrasts those findings. Furthermore, intangibles and discussion points that arose during the evaluation phase of the projects for "Project together" as well as for this paper, are presented.

Contrasting with other literature

In this study, a high share of projects considered as systemic were identified. This might be (i) because of the high ambitions of young initiatives, including holistic ideals, which might become pragmatized during growth and implementation phases of the projects, or (ii) due to the higher degree of freedom that bottom-up projects have without any incumbent firm behind. Considering a systemic shift as an in-depth intervention which potentially can disrupt the socio-technical regime, this study confirms what has been found by Henry et al. (2019), namely that *"circular start-ups tend to embrace strategies corresponding to higher levels of circularity than those of incumbents"* (p. 1). In parallel, Dijkstra et al. (2020), who analysed 44 business models on sustainable plastic management (including a sample with mainly incumbent firms), find that most of the cases they have analysed rely on the principle of recycling or from making value of waste, but that the startups within the sample showed a more diverse approach, including social benefits such as community involvement and education. This finding is confirmed in the present study, where a high focus on the consumer was observed, as well as a more inclusive consideration of social benefits, even in a largely material-driven sector. Ünal and Shao (2019) concluded from their study on 391 cradle-to-cradle business cases, that projects with a high degree of circularity are likely to include considerations on (i) material health, (ii) material reutilization, (iii) renewable energy, (iv) water stewardship, and (v) social fairness. While in the present study and the one by Ünal and Shao, the foci of the sample is rather different (plastic-related bottom up vs. cradle to cradle in general), this taxonomy could partially be confirmed in the study at hand: "Act on plastic" initiatives were i.e. not found to be concerned on the use of renewable energy (some projects started to include this upon inquiry of the expert), whereas i.e. water stewardship and material reutilization were found to be top priorities in the sample.[4]

Early stage initiatives and uncertainties (eco-design paradox, complexity of systems)

When assessing the initiatives, we were confronted with uncertainties. This was mainly because of two reasons: first, the eco-design paradox (Lindahl & Sundin, 2013). While originally intended to describe the problem of early stage product development with regards to sustainability assessment, the same pattern can be found within the bottom-up initiatives: while the ideas are rather in an early stage (whether founded or not) and hence enjoy higher degrees of freedom when deciding upon respective business models and strategies for improving sustainability outcomes, the same sustainability impacts are not yet clear and highly uncertain. This dichotomy between required sustainability-related data for assessing an initiative, and the potential impact of such an assessment, posed a challenge during evaluating the projects. To address this challenge, the early use of ecodesign methods and tools along the backcasting approach could be helpful, thereby enriching the toolbox of the FSSD. Useful tools thereby could be simplified LCA tools or checklists, such as identified as proposed by Rossi et al. (2016) or through using sector specific tools, as compiled by the round table for ecodesign of plastic packaging (2020)[5]. Second, as was already stated above, numerous initiatives were considered to be systemic or operate on a systemic level. While systemic approaches are generally positively connotated and described as necessary in the literature stream (see i.e. Korhonen, Nuur, et al., 2018) and the approach to embrace the system's complexity is encouraged (Ashoka, 2020), evaluating potential sustainability outcomes of projects becomes more complex the more aspects need to be considered. Thus, designing and assessing systemic approaches reliably on the several levels of effect while including uncertainties, adequate system boundaries, systemic feedback loops and possible time lags requires highly specific expertise from both, the

[4] Ünal and Shao (2019) also use different subcategories to cluster their projects, therefore not sector-specific comparison was possible (the Act on Plastic projects could cover several of the industry memberships as defined by Ünal and Shao, including fashion, health and beauty, materials for product designers, and packaging & paper)

[5] The toolbox can be found here: https://ecodesign-packaging.org/toolbox/; note, that in general there is no one-size-fits-all tool. Depending on the approaches, different tools can be useful, and especially non-materials based initiatives can have difficulties in finding the right tools.

project initiators as well as the evaluators. Within the research team, this challenge was addressed by discussion and question rounds, as well as evaluations from other sustainability experts to guarantee a multi-perspective and multi-layered view on the initiatives. Nevertheless, erroneous evaluations cannot be fully excluded.

While those aspects particularly hampered sustainability assessment of projects, both of them are of particular relevance when trying to understand the implications of scaling up niche innovations that could potentially transform the socio-technical regime. This is because of (i) their contribution to a more sustainable operating level of this regime needs to be evaluated ex ante, and since (ii) a regime change includes a shift of the systemic 'modus operandi'.

Discussion on specific contribution to 8 FSSD principles

Some observations could be derived about the contribution of initiatives to the 8 FSSD environmental and social principles. Two types of initiatives presented conflicting evaluations with the principle "Concentrations of substances extracted from Earth's crust". The first type involved initiatives whose value propositions consisted in substituting single-use plastic solutions for reusable ones. The contribution can be intuitively evaluated as positive, as it consists of a clear means to avoid plastic waste. During the brainstorming session, a possible issue of CE rebound emerged (Zink & Geyer, 2017). It was realised that this condition could only be met depending on the degree of substitution of single-use solutions versus reusable ones to avoid additional environmental burdens. Thus, these types of initiatives should not fall into a generalized positive bias and complement their technical solution with a social approach that allowed for the permanent consolidation of a habit through gamification, behavioural strategies, among others. A second type of conflicting initiatives was characterized by the offering of educational campaigns, consulting services, communication activities. Similarly, these were categorised as positive as awareness on resource-efficiency, sufficiency among others is the stepping stone for initiating action. Nevertheless, many factors internal and external to individuals have been described as impeding action even when subjects have the knowledge on what their normative actions should be. These include behavioural aspects cognitive dissonance (Thøgersen, 2004) and attitude-behavior gaps (Boulstridge & Carrigan, 2000; Young et al., 2010). Against these, it is worth to call for paralleling the knowledge generation with greater implementation of behavioral strategies flowing from disciplines that explore these phenomena, such as marketing, user experience design or behavioral economics (Lehner et al., 2016). External factors such as power asymmetries among actors in supply chains (Hoejmose et al., 2013) or path dependencies on technology development (Korhonen, Honkasalo, et al., 2018), among others, can also hinder action. Thus, consultants, advisors and education providers should take these landscapes in consideration for their implementation plans in order to maximize the positive impact of their generated knowledge onto environmental systems. A second principle, namely "Concentrations of substances produced by society", presented conflicting evaluation against initiatives based on the substitution of an existing material or production processes for alternatives. Unless the baseline and alternative impacts are described, it is bold to assume an alternative is an improvement only because it adheres to a qualitative definition or storyline. This specific conflict can also be referred to the Eco-design paradox previously discussed. Regarding principles of social systems, the issue of unintended consequences also resulted relevant for the principle "Health". This was observed in initiatives that proposed the implementation of plastic waste management infrastructure or take-back systems. While avoiding the leakage of plastic particles in ecosystems has an undoubtedly positive impact on human's health, the implementation of additional collection and reverse logistics infrastructure might entail an increase in CO_2 emissions on-site, and therefore also comes with an environmental cost and the potential of burden-shifting. Depending on the geographical context, formalising such collection systems might also entail the displacement of informal workers from unique source of income. All in all, principle-by-principle analysis revealed possible burden shifts between principles belonging to social and environmental systems, but also among principles within the same system. Resolving these trade-offs calls for interdisciplinary baseline analyses that support value propositions and minimize unintended consequences (Baumgartner & Rauter, 2017; Zimek & Baumgartner, 2017).

Further discussion points

Some additional aspects and questions that were found to be useful to guide future research, emerged during the evaluation of the initiatives. First, as also stated above, various initiatives were found to be prone to the rebound effect of CE (Figge & Thorpe, 2019; Zink & Geyer, 2017). For example, a new company with fashion products could either (i) replace other

(ideally less sustainable) products on the market, or (ii) be an additional offer that increases consumption. An estimation of net sustainability effects is therefore highly dependent from the mechanisms of the rebound effects and – finally – from the total replacement activities carried out. To consistently handle possible negative rebound effects in the assessment, initiatives were consistently assessed in a rather narrow way (that is, not considering the rebound effect), potentially leading to a positive bias in the evaluation. The same was done for potential negative externalities or environmental trade-offs (e.g. when switching from plastics to resource-intensive use of glass packaging) while at the same time the FSSD allowed to uncover those potential trade-offs within the sustainability principles. Second, since various initiatives based their innovativeness on the development of new products, we were confronted with the question if additional consumption choices are in fact a positive contribution towards the social principle of influence, in that they increase the power of consumers to shape consumption patterns and hence contribute to a more impactful transition to a CE. This seems especially relevant considering the perceived central role for the consumer in this transition (Reike et al., 2018). Nevertheless, the consumers' role in a CE lies primarily on action-taking for refuse and reduce activities as well as adaption to new models of consumption, instead of simply shifting consumption from one product to another. Since for this research, a rather narrow assessment approach was chosen, the impact mechanisms of this rating were considered to be not linear enough and at the same time highly subjective. Consequently, for those cases, no positive contribution to influence was assumed.

4. Conclusions

The present study aims at evaluating 25 bottom-up initiatives from a social accelerator platform on plastics with regards to (i) their thematic approach, (ii) their operational levels and foci, and (iii) their sustainability implications. This is particular relevance, since that in times of the change of socio-technical regimes, niche innovations might be able to gain momentum and hence transform the modus operandi of the very regime. To achieve this, an action research approach enriched with quantitative topic modelling was chosen due to the involvement of the research team in consulting the projects during their time in the programme. Limitations of this approach include, that we only carried out a qualitative consistency check. While this check confirmed consistent assessment within the research team, this is of relevance due to the potentially highly subjective assessments especially of the social principles of the sustainability principles of the FSSD. Furthermore, the number of projects is too low for statistical analysis and to generalize results, even though the whole sample was centered around one sector only.

Despite those limitations, results suggest a diverse approach of the projects towards plastics, whereby addressing the political mindset, products and product packaging, as well as water related topics were central. As for sustainability contribution, a slight focus on environmental principles was observed, while also social principles played an important role (thereby addressing an identified gap in CE research). Most of the projects were considered to operate on a systemic level, while consumers were found to be the most important organizational focus. While the sustainability assessment in general shows, that projects have rather positive contributions towards strategic sustainable development. some potential limiting factors were found for (i) for positive assessments of the projects as well as (ii) for the analysis itself. Those factors were mainly centered around potential and unintended rebound effects of the CE, the eco-design paradox, as well as the complexity of systemic sustainability assessment (including setting of system boundaries, time lags, etc.), that are decisive for estimating impacts of niche innovations when scaling up to influence the socio-technical regime. To address this challenge, the early use of eco-design tools is encouraged. Furthermore, the sustainability principles from the FSSD proved useful to specifically uncover the potential to burden-shifting, and backcasting – a method that uses desired future scenarios to determine pathways towards those scenarios - as proposed in the FSSD, could help projects identify those critical issues beforehand and address them in early stages to avoid path dependencies. Lastly, to better understand the chances and pitfalls of circular transition as a way to more sustainable development and hence to guide those transitions as clearly as possible, further research is needed.

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Appendix

Appendix 1 – Guide for Authors 1

1) How satisfied are you with the exchange so far?
2) Is the team able to outline the problem that it wants to address?
3) Please explain your choice briefly
4) Is the team able to explain its own *solution* in a coherent way?
5) Please explain your choice briefly
6) Does the team have enough insights and knowledge about the desired *solution*? Do they understand required technologies well enough to back-up their ideas with facts and scientific evidence?
7) Please explain your choice briefly
8) According to you what is the project's biggest challenge?
9) What would be the ideal next steps from your perspective?
10) Do you think the project can use support in these next steps? If so, please explain briefly.
11) Do you have any serious concerns with this project?
12) Please explain your choice briefly
13) Is this an exceptional project from your perspective?
14) Please explain your choice briefly
15) Is there anything else you would like to tell us about this project?

Appendix 2 – Guide for Authors 2

1) How satisfied are you with the exchange overall?
2) *Importance*: Assuming the project will succeed - How important do you think would benefiting individuals rate the project´s change? Or how important is the project´s contribution for achieving a sustainable planet based on scientific and societal assessment?
3) *Need*: How underserved are the individuals that the project is serving or how urgent is the need to change our planet?
4) *Scale*: How many beneficiaries will be reached by the project in the next 5 years?
5) *Degree of change*: If successful, how big is the anticipated degree of change that the project will create for the affected individuals or our planet?
6) *Duration*: How long will the anticipated change last? How long is the time period for which the individual experiences the outcome change?
7) *Likelihood of change & Risk Assessment*: How probable is it that the project will achieve the intended impact?
8) What environmental impact do the used *materials & resources* cause and how do they affect the overall environmental footprint?
9) Please explain your choice briefly
10) How does the *production* *process* work? Are there any unintended external effects to be expected?
11) Please explain your choice briefly
12) What environmental impact will most likely be generated by the product's *transport* *and* *shipment*? How does this affect the ecological footprint of the project?
13) Please explain your choice briefly
14) Is this product *recyclable*?

    If not applicable, please choose "0 // No response possible"
15) Please explain your choice briefly
16) How would you rate the *overall life cycle assessment* of the innovation based on the conversation you had so far?
17) Please explain your choice briefly
18) Is this project *feasible* from a scientific and technical perspective?
19) Please explain your choice briefly
20) To what extent are the *necessary skills* available in the team to implement the solution?
21) Please explain your choice briefly
22) How new and *innovative* is the project's *solution* compared to relevant competition and next best alternatives?
23) Please explain your choice briefly
24) Based on your impressions, would you recommend this project for the second phase?
25) Please explain your choice briefly
26) Is there anything else that you would like to tell us about this project?

The Innovative Contribution of Multinational Enterprises to the Sustainable Development Goals

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Abstract

The 2030 Agenda recognizes the role of the private sector as drivers of productivity, inclusive economic growth and job creation. It calls on their innovative and creative capabilities to help solve sustainable development challenges. Judging by the positive reactions of companies, for example in sustainability annual reports, this call to help achieve the Sustainable Development Goals seems to resonate. However, the nature, extent and motives of this engagement remain unclear. Has it substance or is it "cheap talk"? Are they mere defensive reactions to stringent environmental regulations, legitimacy issues or stakeholder pressures, or pro-active, strategic investments in unfulfilled sustainable development opportunities? This paper is concerned with the role that large stock listed multinational enterprises (MNEs) play in SDG-related technological innovation. The number of SDG-relevant sustainable patents are assessed for over 1000 MNEs as a proxy for SDG-related innovation and associated with sustainability disclosure, membership in sustainability initiatives, regional and industry membership, company size and sustainability ranking. WE conclude that MNEs play an average role in green innovation, and under-average in unmet needs related innovation. Using a regression model, we conclude that there are strong regional and industry-specific differences, and that there is a clear link with the Global Compact initiative and SDG mentions in sustainability disclosure. It can be concluded that SDG-related contributions from MNEs are less symbolic than could be assumed, though this is more obvious with green innovation than with innovation directed at meeting unmet needs.

Keywords: innovation patents SDGs "unmet needs" "grand challenges"

1. Introduction

The 2030 Agenda is a global plan of action for sustainable development, adopted by the United Nations in September 2015 (United Nations General Assembly, 2015). The Agenda addresses the broad global challenges of climate change, social inequality and environmental degradation, by a global governance framework that contains 17 Sustainable Development Goals (SDGs) with 167 targets. The objectives include ending poverty and hunger, combating inequalities, building peaceful, just and inclusive societies, protecting human rights, promoting gender equality and ensuring the lasting protection of the planet and its natural resources. It expresses its determination to create conditions for sustainable, inclusive and sustained economic growth, shared prosperity and decent work for all (United Nations General Assembly, 2015, p. 3).

The Agenda is not exclusively addressing the governments of the UN member states. It also calls explicitly on the private sector to play its part in realizing the goals. Acknowledging their role in productivity, inclusive economic growth and job creation, the Agenda lodges an appeal to businesses "(…) to apply their creativity and innovation to solving sustainable development challenges" (United Nations General Assembly, 2015, p. 25).

The introduction of the SDGs is a recent phenomenon and the level and nature of corporate involvement with the SDGs has only recently started to attract academic interest. Rosati & Faria (2019) studied the association of SDG mentioning in sustainability reports of both private and public organizations with a number of institutional factors. (Van Zanten & Van Tulder (2018) surveyed how the staff of a group of European and US businesses believed their companies' policies contributed to a set of measurable, business-relevant SDG subjects, irrespective of whether these companies engaged

explicitly with the SDGs, for instance by formal disclosure. They found that companies engaged with SDG subjects that are actionable and relevant in their (value chain) operations that were related to “avoiding harm” more than to “doing good”.

Sustainability reporting explicitly referring to SDGs has become a trend: 29% of companies in the sample with sustainability disclosure mentioned the SDGs at least once. However, a much smaller group treated the SDGs explicitly and substantively. Most disclosure was symbolic, associated with institutional factors, such as country of origin, and membership of corporate sustainability initiatives, such as the Global Compact, the Global Reporting Initiative and Integrated Reporting (Van der Waal & Thijssens, 2019).

This call on the private sector to use creativity and innovation for the SDGs has not been ignored. Over the years, the private sector has shown much sustainable innovation, especially related to cleaner production technology and ecological innovation. The drivers of this development are greater market demand for cleaner products, increasing environmental regulations, cost savings and environmental management systems (Hojnik & Ruzzier, 2016). Innovation and creativity for social sustainability has received far less attention, perhaps because ecological innovation is more related to “avoiding harm” and more directly actionable in production processes and value chains (Van Zanten & Van Tulder, 2018). The socially oriented innovation is more related to “doing good”.

The 2030 Agenda envisions exactly this, that companies help to solve sustainability challenges, not only by doing less harm, but also by making positive contributions to hitherto unmet needs and needs.

As more and more companies start paying attention to the SDGs in their corporate communications and sustainability disclosure, two important questions:

1. To what extent do companies, especially multinational enterprises (MNEs) implement this call for SDG-relevant creativity and innovation in their actual business strategies and research plans?

2. Is this creativity and innovation congruent to the voluntary corporate sustainability disclosure?

This article adds an exploration of the creative and innovative role of MNEs that the 2030 Agenda has in mind, charting the patterns and extent of their contribution and indications of the drivers. This will further inform the development of relevant concepts and theories, as well as be of use to practitioners.

We do this by estimating the SDG-relevant technological innovation activities of the largest, mostly multinational, stock listed companies. We try to associate this activity to the commitment to the SDGs that is presented in corporate sustainability disclosures.

Innovation relates to product and process innovations, as well as business models (Raith & Siebold, 2018; Ritala, Huotari, Bocken, Albareda, & Puumalainen, 2018). In this article, we limit ourselves to technological innovation measurable by means of patent analysis. Patents allow looking behind corporate façades. As legal and technical texts, they have a specific target audience, making them unsuitable for any window dressing. This makes them interesting for our purpose.

Sustainable innovation

Innovation is commonly understood as the introduction of a new good, a new quality of a good, a new method of production, opening a new market, using a new source of raw material, or carrying out of a new organization of an industry (Croitoru, 2012). Many innovations have a technical aspect, but they can also be entirely non-technical and concern services or business models. Developing innovative sustainable business models has already received considerable attention (Bocken, Short, Rana, & Evans, 2014; Boons, Montalvo, Quist, & Wagner, 2013; Ritala et al., 2018; Schaltegger, Lüdeke-Freund, & Hansen, 2016). However, in this study, innovation is limited to technological innovation: product and process innovations that can be protected by patents, which we will use as indicators for innovation.

Sustainable innovation means that innovations do not only create value for the company but offer environmental and/or social benefits. A current definition is: "innovations in which the renewal or improvement of products, services, technological or organizational processes not only delivers an improved economic performance, but also an enhanced environmental and social performance, both in the short and long term have the capacity to generate positive social and environmental impacts" (Bos-Brouwers, 2010).

Already in 2003, Hall and Vredenburg (2003), stated that companies need a strategy that integrates innovation and sustainable development. In addition to creating value as a conventional innovation, sustainable innovation must create additional environmental or social value for stakeholders outside the company, responding to social and environmental pressures and taking into account the interests of future generations.

Sustainable Value and Shared Value

Hart, Milstein, & Caggiano (2003) introduced the Sustainable Value Framework. It is derived from a general shareholder value framework, in which managers of a firm have to manage tensions between the short-term profitability and the need to think of future markets and sources of value creation. The Sustainable Value Framework likewise charts different value creation strategies along the internal and external perspectives of the company and on the short and long-term time dimensions. The short–term strategies are those of pollution prevention as an internal strategy, minimizing waste and harmful emissions, and product stewardship on the external strategy, integrating external stakeholder views and interests into the business. On the long-term side, the internal strategy is that of clean production, developing sustainable competencies for the future, and on the external side, the sustainability vision, aiming to meet unmet needs.

The internal side of the framework is concerned with an organization's internal processes and capabilities. Reducing the costs and risks of pollution, waste and excessive energy and resource consumption, this is typically the dimension that relates to "corporate responsibility", "avoiding harm" and is characteristically measured by pollution emission data (e.g. Cho, Freedman, & Patten, 2012)

A similar development is the "shared value" idea of Porter and Kramer (2011), who seek to reconcile business and society instead of putting them diametrically against each other. They evaluate "corporate social responsibility" (CSR) as inadequate and consider this merely as a reactive activity on the periphery of enterprises intended to avoid creating too much tension with society. They are convinced that the more positive and pro-active concept of "shared value" can bring a new wave of innovation and productivity growth to the global economy.

Innovation for sustainable development is a broad concept. It includes the narrower, frequently employed concepts of green, environmental and ecological innovation, and the narrower concept of social innovation, less frequently used in a technological context, more in a business model or social enterprise context. Silvestre & Ţîrcă (2019) restrict sustainable innovation as innovation that scores highly on both social, environmental and economic aspects. Likewise, Schiederig, Tietze, & Herstatt (2012) explore green innovation and conclude that the concepts of green innovation, environmental innovation and ecological innovation overlap to a great extent, but that sustainable innovation is a wider concept, which includes the three ecology and economy oriented concepts, but also includes social aspects, in line with the Brundtland definition of sustainability (WCED, 1987).

The SDGs of the 2030 Agenda also takes the broad sustainable development perspective as its foundation. The SDGs of course include the green themes, such as avoidance of pollution, cleaner production, clean energy, protection of the natural environment, and so on. In addition, they also include less physics and ecology-oriented and more society focused themes, such as eradicating poverty and hunger, providing good health and welfare for all, the position of disadvantaged groups, and education.

SDG-related innovation

The innovative and creative roles for that the private sector should play to help solving global challenges have not received much research attention yet. Some have enthusiastically called the SDGs "a great gift to business" (Pedersen, 2018). Others are more critical of the role of private enterprise in bringing about development results by pointing at the disconnect between what companies say and do and questioning whether companies can be expected to help solving problems for the creation of which they bear at least partial responsibility (Scheyvens, Banks, & Hughes, 2016). Others opine that companies, particularly multinational enterprises, have a potential to achieve sustainable development, and should not be only part of the problem, as they are sometimes accused of by non-governmental organizations, but also part of the solution (Kolk & van Tulder, 2010).

Walz, Pfaff, Marscheider-Weidemann and Glöser-Chahoud (2017) try to define green innovations that are relevant to the SDGs. They relate the green technological fields of energy efficiency, green energy supply, material efficiency and waste management, and water technologies to relevant SDGs, notably the SDGs "good health and well-being" (3), "clean water and sanitation" (6)", affordable and clean energy" (7), "industry, innovation and infrastructure" (9), "sustainable cities and communities" (11), "responsible consumption and production" (12), "climate action" (13), "life below water" (14) and "life on land" (15). The inclusion of SDG 3 as a "green technology" SDG is contestable, as only one of its fourteen targets relate to green themes. Of course, the SDGs are interlinked, but the point of gravity in SDG 3 and 15 is not on green technology.

The social sustainability component is often neglected in the sustainability-oriented and green innovation projects (Khan, 2016), while it is considered as fundamental for sustainable development. It is much less developed than eco-innovation (green and ecological innovations). It leans more towards social enterprises, and (inclusive) business model innovation (Silvestre & Ţîrcă, 2019). Though social and ecological sustainability are interlinked, many SDGs are principally related to the environment and hence green technologies related to pollution prevention. This concerns more the short-term, internally oriented, "avoiding harm" corporate goals of risk and cost reduction (Hart et al., 2003). Though certainly not unimportant, the appeal of the 2030 Agenda for companies to use their creativity to help solving global problems hints at something transcending this short-term, internally oriented motivation: helping bringing about sustainable development, meeting unmet needs, both ecological and social, in other words "doing good".

Green and blue innovation

As we are interested to find out which role enterprises play in sustainable innovation in the broad sense, we differentiate between "green" innovation – innovation aimed at reducing pollution, emissions and waste and improving energy and material efficiency, in the internal hemisphere of the Sustainable Value Quadrant – and what we will call for practical reasons "blue" innovation1 – innovation aimed at meeting unmet social or ecological sustainable development needs, corresponding to the externally-oriented half of the Sustainable Value Framework. The two types cannot always be strictly separated: preventing water pollution is a green aspect, providing affordable rural potable water infrastructure is a blue aspect, which is only possible if there are unpolluted water sources. Saving water resources by irrigation is a green aspect, providing irrigation to boost agricultural yields is a blue one. Conflicts or tensions between the two aspects exist: providing post-harvest pest control agents reduces food waste (blue) but may increase chemical pollution (green). This shows also how sustainable development goals are interlinked and manifest internal tensions and trade-offs.

The nature and size of the enterprise

It is assumed that large firms have more abundant financial and organizational resources and can benefit from this to shape their competitive advantage (Andries & Stephan, 2019). Large firms are also more visible to regulatory agencies and experience more legitimacy pressure from other stakeholders (Li et al., 2017). We expect large firms to innovate more in general and sustainable technologies, and patent more of such innovations.

[1] Loosely coined after the "blue ocean" strategy concept referring to "untapped market space, demand creation, and opportunity for growth" (W. C. Kim & Mauborgne, 2005), more socially oriented.

Sustainability reporting and the SDGs

The interest of financial and non-financial stakeholders of companies in information about a company's sustainability profile has become important in the past decades. It has given rise to a wide field of research that attempts to unravel determinants of voluntary sustainability or "corporate social responsibility" (CSR) disclosure and to establish links with the sustainability and financial performance. By providing sustainability information, companies try to manage their corporate image in order to maintain legitimacy - the recognition or acceptance of the corporation by relevant groups in society (Ambec & Lanoie, 2008). Divulging such information to stakeholders may also be a signaling act providing relevant information to reduce the information asymmetry between a company and its stakeholders. The question is then how and at what cost companies with good sustainability performance can signal that information credibly to their stakeholders, allowing them to distinguish themselves from less sustainably performing competitors (Connelly, Certo, Ireland, & Reutzel, 2011).

As organizations have many different stakeholders, with many different interests and of differing degrees of salience (Mitchell, Agle, & Wood, 1997), they need to send different messages to different recipients; messages which at times may be at odds with each other. To reflect the often-conflicting values and demands of different stakeholders they may use different sets of talks creating different external facings, or organizational façades. Sometimes the talk may be incongruent with decisions and actions of the company and hence be misleading or hypocritical (Abrahamson & Baumard, 2009). Sustainability reports and other sustainability communications are a part of the talk of organizations. If the incongruence between an organization's talks and actions becomes too obvious, the talk becomes "cheap talk", which is ignored by receivers.

Much research attention has been dedicated to identifying the degree of congruence or between an organization's sustainability talk and the measurement and assessment of its sustainability actions, decisions or performance. Companies may choose different voluntary disclosure strategies in function of their environmental performance. Of companies with high environmental disclosure, those with high performance show strategic environmental leadership, whereas those with low performance only seek legitimization of existing practices (Aragon-Correa, 2016).

The measurement and external appraisal of environmental performance is not without challenges and limited to outcome-based measures and process-based measures, usually measured in pollutant emissions and energy and resource consumptions (Aragon-Correa, 2016). Nevertheless, environmental reporting, as a part of corporate social responsibility reporting, has become more transparent and systematic by the development and voluntary application of standardized, quantified and time-comparable sets of reporting frameworks, such as the Global Reporting Initiative, Integrated Reporting and the Carbon Disclosure Project (Maas, Schaltegger, & Crutzen, 2016). Nonetheless, some publishers of voluntary sustainability feel need to enhance their disclosure credibility by applying external assurance (Sìmnett, Vanstraelen, & Chua, 2009).

An important factor related to SDG-related disclosure is the United Nations Global Compact. This membership organization is the major human rights, labor, environment and anti-corruption interface between the corporate sector and the United Nations and a carrier of SDG awareness. It requires an annual corporate communication on progress towards the Global Compact Principles and actively promotes the members to be aware of and actively support of the SDGs (Van der Waal & Thijssens, 2019). Normative and mimetic mechanisms seem to play a role in the decision of companies to adhere to the Global Compact (Perez-Batres, Miller, & Pisani, 2011), as well as economic and image improvement arguments (Arevalo, Aravind, Ayuso, & Roca, 2013). This may attract the accusation of "bluewashing" (Berliner & Prakash, 2015).

A company's social responsibility performance, actions and decisions are not easy to substantiate. On top of that there are fundamental differences between corporate social responsibility – a managerial approach, corporate sustainability – an approach to guide corporate strategy, and sustainable development - a much wider societal concept (Steurer, Langer, Konrad, & Martinuzzi, 2005). The contribution of corporations to sustainable development is underexposed.

Therefore, the contribution of companies to the SDGs remains difficult to quantify and may often be limited to cheap talk, expressing intentions and intentions aimed at avoiding damage rather than creating sustainable value and meeting unmet social needs (Van Zanten & Van Tulder, 2018). Likewise, the creative and innovative contribution of companies that is relevant to the SDGs remains underexposed. The aim of this study is to look behind the organizational façades of the largest stock listed, mostly multinational, companies by studying their SDG-relevant product and process innovation as laid down in patent applications. This makes it possible to get a picture of the integration of a company's actual sustainability strategy and the sustainability image that the company is trying to create through voluntary disclosure, but from a different perspective. The advantage of patents is that they are not part of cheap talk, because they are technical-legal documents describing technological innovations that are valuable to the company. Applying for and maintaining a patent also requires a considerable investment from a company so that this is not done lightly.

Previous research into the connection between sustainable innovation and sustainability disclosure is scarce. Radu & Francoeur (2017) studied if environmental innovation would drive environmental disclosure. Using green patent data, they concluded that environmental performance and environmental innovation act as substitutes in their relationship with environmental disclosure: high environmental innovation could make up for the lack of environmental performance and in this way strengthen a company's reputation.

Theoretical contribution

From the preceding it becomes clear that SDG-related sustainable innovation of multinational enterprises is still poorly researched. This study helps filling a void by exploring and charting SDG-related innovation, advancing the debate about the sustainable development role of MNEs, by exploring potentially relevant associations and patterns between technological sustainable innovation and sustainability reporting.

Therefore, we advance the following propositions that guide the design of this study:

Proposition 1: large companies will invest more in patentable (sustainable) technological innovation than smaller companies, because of their access to resources and their higher visibility and need for environmental performance. We expect companies with more sustainable innovation to have higher sustainability rankings (in part because sustainable innovation is endogenous to the ranking system).

As an important part of SDG relevant policy relates to themes of eco-innovation, green innovation and eco-efficiency, in other words the more defensive, pollution-abatement side of sustainability, "do no harm" reason, we expect that the environmental sensitivity of an industrial sector and the strictness of environmental regulatory of a country will drive companies to invest more in eco-efficiency innovation (He, Miao, Wong, & Lee, 2018).

Proposition 2: The nature and level of green SDG-related innovation will depend on factors affecting the industrial sector to which the company belongs, such as environmental regulatory stringency of the country or countries of operation, the environmental sensitivity of that sector, or the level of energy and resource intensity;

The nature and level of blue SDG-related innovation will depend on the commercial "unmet needs" opportunities of the industrial sector to which the company belongs in relation to relevant SDG-goals. The green and blue innovations may also overlap.

Proposition 3: Companies that actively communicate their engagement with sustainability, sustainable development or the SDGs see this as a business opportunity that merits SDG relevant investment in green or blue technological process and product innovation.

2. Methods

Research method

We approach the research question by associating SDG related technological innovation of a group of large stock listed international corporations as expressed by patents with voluntary sustainability disclosure and engagement in sustainability initiatives, controlling for a number of company and country variables, such as size, industry sector, sustainability ranking and country group.

Sample

The companies in the sample are those of the Forbes Global 2000 list, ordered according to GICS sub industry, for the year 2017. These companies are the world top-2000 companies in terms of market capitalization. They are not all multinational enterprises, in particular Financials may operate regionally (a separate class in the GICS). For this reason and the reason that these sectors are technology-driven the GICS sectors 30 (Consumer Staples), 40 (Financials) and 60 (Real Estate) are excluded (only 3 fintech companies in Financials own patents). In this way, 1178 companies were retained and grouped into four country groups: USA, Europe, Japan/Korea/Taiwan (JKT) and Other countries.

Sustainability related patents

Patent information and patent counts are frequently used to measure innovation in general (Pianta & Archibugi, 1996) and green innovation in particular. It has limitations in that not all technological innovations are patented, and not all patented innovations lead to marketable products or process implementations (Abbas, Zhang, & Khan, 2014).

Patent documents have a title, keywords, an abstract, description and technical claims and they are always classified according to the technical field of the invention using the International Patent Classification (IPC) or similar. To identify relevant green patents the OECD has developed a list of environmental technology related IPC codes (Haščič & Migotto, 2015), while the World Intellectual Property Organization (WIPO) has developed a different inventory of green patent classification codes. These classification sets have been used to study the influence of regulatory policies and innovation networks on green innovation (Fabrizi, Guarini, & Meliciani, 2018), the effect of corporate governance on green innovation (Amore & Bennedsen, 2016), and the relation between environmental innovation and environmental disclosure (Radu & Francoeur, 2017). However, such patents have not been marked “green” by patent examiners evaluating each individual patent. Instead, some IPC codes have marked as “green” by the assemblers of the inventory because they potentially contain environmentally relevant technology. The WIPO Green codes therefore include bias. For this reason a keyword search in induvial patents is preferred (Walz et al., 2017).

A keyword search also allows to asses the “blue”, unmet, positive social and ecological needs innovations to cover the whole broad range of SDGs. There is no IPC-based inventory for such technologies. Therefore, we developed a thesaurus of SDG innovation related keywords and use this as an effective strategy for patent content analysis (see also Xie & Miyazaki, 2013). The thesaurus is based goals and targets descriptions in the 2030 Agenda and the Global indicator framework for the Sustainable Development Goals (United Nations, 2017). Every single SDG target has been scored as predominantly green or blue, provided they have a connection with technical innovation. A list of 160 keywords resulted a screen for a full text search in patent descriptions. Keywords were chosen carefully to avoid type I (missing relevant patents) or type II errors (including irrelevant patents) (Xie & Miyazaki, 2013). Each keyword was tested on random patents to exclude as much as possible type II errors. Relevant words are often found in the standard “background of the invention” part of the patent description where the technical problem or reason for the invention is described. A sustainability challenge or opportunity can be a reason for the invention.

The keywords are listed in appendix A.

We used the European Patent Database (https://data.epo.org/expert-services/index.html). Of the triadic patent databases, this is the most international database with a wide subject range (J. Kim & Lee, 2015). It contains only European Patents. Non-European companies that are active in Europe, which many MNEs are, need to file with the European Patent Office. We counted European patent applications from 2007 to the reference year 2017, in order to have sufficiently significant counts.

A potential source of bias is that multinational companies may own patents in name of foreign subsidiaries with a different name, (e.g. General Motors, owning European patents through its Opel subsidiary). When this was suspected, subsidiaries have been included.

Table 2a shows the aggregate patent counts in the sample by country group. JKT companies have the highest average number of European Patent applications, indicating the importance of the European market for these companies. US companies have a markedly lower average number of European patent applications, which implies that for some US companies the European market is not relevant.

This bias is softened by normalizing the patent scores based on the regional average scores according to:

$$Normalized\ Patent\ Count = int(\frac{Patent\ count}{regional\ average\ Patent\ Count} * 1000).$$

In this way, normalized Green/Blue and total EP patent counts are computed. The factor 1000 was introduced for the purpose of scaling.

Alternatively, we computed a Sustainable Patent Ratio for each company in the sample having patents:

$$Sustainable\ Patent\ Ratio\ (pG/pB) = \frac{Sustainable\ Patent\ Count}{Total\ Patent\ Count}$$

The Patent Ratio present the data in a relative way, filtering out the size and absolute count effect that is retained in the Normalized Patent Count.

Dependent variable

The dependent variables are the Normalized Green and Blue Patent Counts (GPC/BPC) as defined above calculated from patent counts (with application dates from 2007-2017) showing one or more of the SDG related keywords in the patent description. Additionally, we use the fraction of sustainable patents of total patents to evaluate the relative importance of sustainable innovation per company.

Independent variables

Sustainability attributes. Sustainability reporting attributes are recorded as the dichotomous report variable (if there is a sustainability or integrated report), if so if reporting guidelines such as GRI or <IR> and assurance are used, and if the company is a member of the Global Compact. The environmental performance ranking is derived from the RobecoSAM sustainability yearbook rankings (RobecoSam, 2018). All dependent and independent variables are presented in Table 1a. A deeper discussion of the independent variables is given in (Van der Waal & Thijssens, 2019). Table 1b lists the descriptive statistics of the variables.

The financial information is taken from the Forbes Global 2000 list.

TABLE 1a
Variables of the regression models

Group	Dependent variables	Data type	Description
SUSTAINABILITY INNOVATION	GP	count	number of SDG relevant green (eco-efficiency, environment) patents per company
	BP	count	number of SDG relevant blue (unmet needs) patents per company
	WIPO	count	number of WIPO Green IPC inventory patents per company
	NGC/NBC	count	normalized Green / Blue patent count (number or patents divided by regional average).
	pG/pB	fraction	fraction Green/Blue sustainable patents of total EP patents
Group	Independent variables	Data type	Description
COMPANY	log market value	continuous	logarithm of the market value
	log assets	continuous	logarithm of net assets value
	EP	count	number of European Patent Applications 2007-2017
	NPC	Count	normalized EP Patent count (number or patents divided by regional average).
SUSTAINABILITY DISCLOSURE	report	binary	dummy variable for publishing sustainability or integrated report
	GRI	binary	dummy variable for applying Global Reporting International standard
	IR	binary	dummy variable for integrated report
	assurance	binary	dummy variable for application of external assurance in report
	SDG	binary	dummy variable for mentioning SDGs in report
MEMBER	Global Compact	binary	dummy variable for UN Global Compact membership
	ranking	ordinal	environmental/social/governance rating (ESG) based on RobecoSAM; Gold=4, Silver=3, Bronze=2, yearbook listing=1, no listing =0
COUNTRY	country group	categorical	country of origin of the company
INDUSTRY	sector	categorical	sector GICS (level 1 – *sector*, level 2 *industry group* or level 4 *subindustry*) of the company

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TABLE 1b Descriptive statistics

stats	EP	GP	BP	WIPO	EPI	NGC	NBC	pG	pB
number	1165	1165	1165	1049	1165	1165	1165	747	747
mean	740.54	36.37	26.90	43.88	1013.60	45.51	34.86	0.06	0.04
median	10.00	0.00	0.00	0.00	20.00	0.00	0.00	0.02	0.01
minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
maximum	34962.00	1797.00	1764.00	5525.00	117685.00	2847.00	3071.00	0.75	0.80
skewness	7.13	7.75	8.31	12.77	17.07	8.14	11.04	3.31	3.83
kurtosis	72.88	75.78	101.50	223.04	414.46	93.18	184.55	18.10	21.11

stats	lgmv	lgas	report	GRI4	IR	Assurance	SDG	Global Compact	Ranking
number	1168	1168	1168	749	749	749	749	1168	1168
mean	10.18	10.26	0.64	0.56	0.07	0.32	0.43	0.31	0.44
median	10.13	10.22	1.00	1.00	0.00	0.00	0.00	0.00	0.00
minimum	8.70	8.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00
maximum	11.88	11.97	1.00	1.00	1.00	1.00	1.00	4.00	4.00
skewness	0.40	0.35	-0.59	-0.25	3.47	0.78	0.30	0.83	2.44
kurtosis	3.84	3.36	1.35	1.06	13.05	1.62	1.09	1.68	7.88

Statistical model

To explore the patterns in green and blue SDG related sustainability-oriented innovation, we used a generalized general model (GLM) with of the negative binomial family with a logarithmic link function for the normalized count data and a fractional logit model for the sustainable patent ratios (pG/pB), taking the form:

SDG Green/Blue EP count or pG/pB = f{Number of EPs + Sustainability Disclosure + Ranking + Global Compact Membership + Region + Industry Group + Size + constant} .

Model 1 includes all the companies in the sample, whereas Model 2 zooms in on those companies in the sample having a sustainability or integrated report. This allows to study the association with different attributes of sustainability reporting.

3. Results and Discussion

Regional differences

The numbers of European patent applications filed by companies in the sample in the studied time frame is presented in Table 2a. It shows that JKT companies file on average more European patent applications than European companies, which shows that the European export market is very important for the East Asian technology sector. This region also has the largest proportion of green patents. In contrast, US and Other companies file fewer European patent applications. These companies may invest less in technology or feel less need to protect their intellectual property in the European jurisdictions.

TABLE 2a
Composition of the sample: European Patent counts and percentages of the sample and wider universe

counts	total EP	Green Patents	Blue Patents	WIPO Green Patents
total 2007-2017 universe	2,333,309	125,254	158,038	128,861
Forbes Global 2000 enterprises	793,388	42,279	31,325	46,045

percentages	total EP	Green EPs	Blue EPs	WIPO Green EPs
total 2007-2017 universe	100.0%	5.4%	6.8%	5.5%
Forbes Global 2000 enterprises	34.0%	33.8%	19.8%	35.7%

European and East-Asian (JKT) companies are more likely to publish a sustainability report, are more likely to use the Global Reporting Initiative (GRI) guideline, external assurance and SDG mentioning than US or Other companies. Likewise, Global Compact membership is strongest in Europe, less so East-Asia and low in the USA (see Van der Waal & Thijssens, 2019).

Proposition 1: the role of firm size or the innovative contribution of large enterprises

Table 2a furthermore shows the importance of the Global 2000 companies in the total patent universe. They cover more than a third of all European patents. They cover a similar proportion of green patents, meaning they are average contributors to green innovation, in relative terms. On blue innovation, they show a considerably lower proportion, meaning that they play a significantly less important role in innovating for unmet sustainable needs. This is an interesting finding implying that smaller companies play a more important role in socially oriented, blue innovation, and must not be overlooked in solving SDG-related grand challenges.

Proposition 2: Nature and level of SDG-related innovation

Innovation per SDG

Table 2c describes how green and blue patents are distributed over the SDGs. Green patents are related to green SDGs, especially Goals 6-9 and 11-15. Salient keywords are concepts are wind energy, renewable and global warming.

The blue innovation is especially related to Goals 2 and 3 and 15 (which has also green targets). The most salient Goal 2 concept is obesity (part of the "triple burden of malnutrition"- undernourishment, micronutrient deficiency and obesity (Pinstrup-Anderson, 2007). The most poignant Goal 3 concept is cancer, which is a target 3.4 element, with other major diseases. Epidemics such as AIDS, tuberculosis, malaria and neglected tropical diseases are other keywords that are the object of many blue patents.

TABLE 2c
Composition of the sample broken down per country group.

Country Groups		European Patent Applications				Sustainability report					
country group	# companies	average # EP	% green patents	% blue patents	% WIPO patents	% reports	% GRI4	% IIRC	% assurance	% SDG	% Global Compact
USA	352	631	4.1%	3.5%	4.0%	56.3%	30.7%	0.3%	5.7%	14.5%	13.4%
Europe	257	1168	3.3%	3.9%	6.3%	82.9%	49.4%	8.2%	35.0%	42.4%	59.1%
JKT	222	1425	6.9%	3.4%	6.9%	70.7%	37.1%	7.2%	33.3%	44.6%	36.5%
Other	350	70	4.3%	2.9%	4.3%	53.1%	30.6%	3.4%	16.0%	17.1%	23.1%
total	1181	731	4.9%	3.6%	5.9%	63.8%	35.9%	4.2%	20.3%	27.0%	30.6%

SDG-related innovation per industry group.

The average number of patents differs per industry group. Some industries depend more heavily on self-developed technological innovation of which they need to protect the intellectual property. Table 2d shows how in absolute terms different industry groups contribute to general technological innovation and to green and blue sustainable innovation. It is eye-catching that the Capital Goods group is much more technology driven than the Energy and Materials groups, though the latter have a higher proportion of green technology, which can be expected for environmentally sensitive industries. The Commercial & Professional Services sector is extremely technology intensive. This is less intuitive but driven by the presence of technology-heavy document processing companies in this group. Transportation is a user of technology, whereas the Automobile sector develops technology. The Consumer Durables group includes manufacturers of electronic equipment and household appliances. Here green technology seems to be very important too. Household & Personal Care is also technology driven and scores high on green and blue technology. The Technology and Semiconductor groups are unsurprisingly very technology intensive but show less sustainability related innovation. The Utilities sector is a user of technology rather than a developer, but if it develops, it focuses much attention to green innovation.

Whereas green innovation has been studied extensively, blue innovation relating to unmet sustainability needs is largely uncharted territory. Table 2d shows how the Food, Beverage & Tobacco, Healthcare and Pharmaceutical, Biotech & Life Sciences score high, as well, to a lesser extent Materials and Utilities. Materials includes the Diversified Chemicals sector, which includes companies producing plant protection products and fertilizers.

TABLE 2d
Composition of the sample broken down per industry group.

		average number of patents								
Industry Group	number of companies	total	GP	BP	% Green Patents	% Blue Patents	number of companies	Sustainability report	Global Compact	SDG mention
Energy	97	163	12	3	7.3%	1.9%	97	63.4%	31.2%	20.4%
Materials	147	572	50	27	8.7%	4.7%	147	65.2%	38.6%	33.1%
Capital Goods	181	1167	59	18	5.1%	1.5%	181	62.5%	30.1%	25.0%
Commercial & Professional Services	9	2891	67	42	2.3%	1.5%	9	66.7%	44.4%	44.4%
Transportation	74	12	0	0	3.7%	1.6%	74	68.0%	29.7%	26.7%
Automobiles & Components	100	1738	77	18	4.4%	1.0%	100	65.0%	31.1%	34.0%
Consumer Durables & Apparel	85	1511	94	48	6.2%	3.1%	86	57.0%	23.5%	24.4%
Food, Beverage & Tobacco	78	91	5	8	5.7%	8.5%	78	64.1%	33.3%	32.1%

Household & Personal Products	32	1146	64	48	5.5%	4.2%	32	65.6%	40.6%	34.4%
Health Care Equipment	40	612	19	40	3.1%	6.6%	40	57.5%	12.5%	17.5%
Pharmaceuticals, Biotechnology & Life Sciences	60	673	11	181	1.7%	26.9%	60	68.3%	31.7%	26.7%
Software & Services	50	501	12	7	2.4%	1.3%	50	50.0%	28.0%	20.0%
Technology Hardware	27	1704	43	37	2.5%	2.2%	27	66.7%	29.6%	29.6%
Semiconductors & Semiconductor Equipment	27	2983	77	40	2.6%	1.3%	27	85.2%	33.3%	25.9%
Telecommunication Services	54	202	5	5	2.7%	2.4%	55	70.9%	41.8%	43.6%
Utilities	108	11	2	1	18.3%	5.1%	108	67.6%	25.0%	17.6%
Total	1181	731	36	27	4.9%	3.6%	1997	58.3%	26.2%	23.0%

Table 3 shows the regression model. The EP Patent variable is small but significant. A higher score of sustainable patents is of course somehow related to the score of general patents.

TABLE 3
GLM regression result of normalized Green and Blue sustainable innovation.
(negative binomial family, log link function, robust estimation)

	Model 1				Model 2			
	Normalized Green Count		Normalized Blue Count		Normalized Green Count		Normalized Blue Count	
Normalized EP Patent Count	0.00	***	0.00	***	0.00	***	0.00	***
Report	0.22		0.22					
GRI4					-0.29	*	-0.17	
IR					0.07		-0.06	
Assurance					0.26		0.21	
SDG					0.62	***	0.25	
Global Compact	0.91	***	0.89	***	0.61	***	0.65	***
Ranking	0.05		0.00		0.06		0.02	
Region								
USA	0.00		0.00		0.00		0.00	
EUR	0.00		0.12		-0.15		0.12	
JKT	1.16	***	1.26	***	0.79	***	1.18	***
OTHER	-0.41	**	0.11		-0.94	***	-0.30	
GICS4 Industry Group								
Energy								
Oil & Gas Drilling	0.00		0.00					
Integrated Oil & Gas	1.04	**	-0.21					
Materials								
Diversified Chemicals	1.95	***	1.15	**				
Specialty Chemicals	2.46	***	1.00	**				
Construction Materials	1.32	**	-0.46					
Metal & Glass Containers	1.82	*	0.85					
Aluminum	-1.04		-2.23	**				
Diversified Metals & Mining	0.58		-1.06					
Steel	1.33	**	-0.59					
Forest Products	-17.91	***	-17.39	***				
Paper Products	1.59	***	0.34					

Capital Goods				
Aerospace & Defense	0.82		0.12	
Construction & Engineering	0.03		-0.99	*
Heavy Electrical Equipment.	1.38	*	-0.58	
Industrial Conglomerates	0.22		-0.96	
Construction Machinery	1.90	***	0.26	
Industrial Machinery	1.78	***	-0.03	
Trading Companies & Distributors	-0.25		-0.41	
Environmental & Facilitities	-18.25	***	-18.07	***
Commercial & Professional Services				
Office Services & Supplies	0.77		-0.08	
Security & Alarm Services	-19.19	***	-18.66	***
Transportation				
Air Freight & Logistics	-0.94		-1.74	**
Airlines	-18.49	***	-17.91	***
Marine	-2.31	***	-3.98	***
Railroads	-3.63	***	-4.31	***
Trucking	-18.64	***	-18.05	***
Automobiles & Components				
Auto Parts & Equipment	1.05	**	0.00	
Automobile Manufacturers	1.11	**	-1.06	**
Consumer Durables & Apparel				
Consumer Electronics	0.55		0.59	
Home Furnishings	1.01		-18.02	***
Household Appliances	4.14	***	1.75	***
Leisure Products	-0.33		-1.41	*
Apparel, Accessories & Luxury Gods	0.19		-0.06	
Footwear	-17.98	***	-17.77	***
Retailing				
Internet & Direct Marketing	-0.21		-1.02	
Specialty Stores	-17.80	***	-16.95	***
Food, Beverage & Tobacco				
Brewers	-0.80		-0.46	
Packaged Foods & Meats	-0.48		-0.26	
Tobacco	0.51		0.03	
Household & Personal Products				
Personal Products	1.57	***	0.79	
Health Care Equipment & Services				
Health Care Equipment	1.82	***	2.16	***
Health Care Services	-18.04	***	1.52	
Managed Health Care	-18.37	***	-3.42	***
Health Care Technology	1.49	***	1.01	*
Pharmaceuticals, Biotechnology & Life Sciences				
Biotechnology	1.43	**	3.54	***
Pharmaceuticals	0.17		2.83	***
Software & Services				
Internet Software & Services	0.74		-0.75	

Data Processing & Outsourcing	0.32		-0.50			
Technology Hardware & Equipment						
Communications Equipment	1.82	***	0.86			
Technology Hardware, Storage & Peripherals	-0.10		0.16			
Semiconductors & Semiconductor Equipment						
Semiconductors	1.05	*	-0.82			
Telecommunication Services						
Integrated Telecommunications	0.24		0.17			
Utilities						
Electric Utilities	-1.26	**	-2.43	***		
Gas Utilities	-1.89	***	-3.07	***		
Water Utilities	-0.36		-0.59			
log Market Value	0.53	*	1.20	***		
log Assets	0.75	***	0.09			
constant	-12.44	***	-12.52	***		
number of observations	1178		1178		750	750
log likelihood	-3538		-3030		-2482	-2142
deviance	2918		2493		1714	1478
residual degrees of freedom	1114		1114		687	687

significance levels: *** p<0.01, ** p<0.05, * p<0.1

The reporting variables will be discussed in the next section.

There are marked regional differences. Due to the normalization, no difference between the USA and Europe is visible. However, the East-Asian JKT group is especially and significantly more active with green and blue innovation, which is a remarkable outcome. Japan has a high regulatory pressure, though not higher than West-European countries, according to the OECD data, but many products developed here are not intended primarily for the home market, but for export and need to conform to export market demands.

The regression Model 1 confirms the relatively important of green innovation contributions of environmentally sensitive subindustries such as Chemicals and Machinery. Service industries score significantly lower, which may be logical but also gives food for thought. Airlines and Trucking companies for instance have large environmental footprints and could benefit much from self-developed sustainable technical innovation. They are not innovation intensive, but when they innovate technologically, they do so less on sustainable subjects, it appears. The same holds for the Utilities industries. The Automobile industry contributes as well, but perhaps sufficient in view of the large footprint of their products and the dieselgate scandal (Held et al., 2018).

Communications and Semiconductors also stand out, as sectors where energy efficiency, e.g. in data centers, is increasingly important.

On the blue innovation side, the Chemicals industries have relatively high contributions, which can be ascribed to plant protection products and other agrochemicals, connected to SDG 2 “Zero Hunger”. Perhaps unsurprisingly, the largest blue innovators are the Health Care Equipment/Technology, Biotechnology and Pharmaceuticals subindustries. They innovate strongly towards SDG 3 “Good Health and Wellbeing”, by developing diagnostics and treatment technologies, as well as medicines against major diseases, including tropical diseases.

Some industries stand out for large negative signs. These are sectors with low patent counts anyway, showing low technology intensity. They are less likely to show sustainable technological innovation.

The results of the analysis of the SDG innovation of the subindustries shows also the tensions that exist in and between the different sustainable development goals. While improving food security is an important goal, chemical companies producing agrochemicals are also criticized for having a negative impact on SDGs 14 Life on Land and SDG 15 Life Below water.

Another critical note is that Pharmaceutical and Biotech companies may make important contributions to SDG3, their contributions are not universal. Their products are often only affordable for Western consumers in countries with well-funded public health systems. As Table 3 shows, cancer and other diseases associated primarily with Western lifestyles, have the highest patent scores, whereas (neglected) tropical diseases have lower scores as these diseases have a more limited commercial potential.

Turning to the relative importance of sustainable innovation in different industry sectors – so the percentage of sustainable patents of a company rather than the absolute number, Table 5 shows a pattern similar to Table 4, showing the cores for green innovation relative to the Energy sector and for blue innovation relative to the Commercial & Professional Services sector.

TABLE 5
GLM regression result of relative Green and Blue sustainable innovation at GICS 2 level.

	Model 1			
Fractional logit	Green Patent fraction (pG)		Blue Patent fraction (pB)	
Report	-0,07		-0,06	
GRI4				
IR				
Assurance				
SDG				
Global Compact	0,09		0,35	***
Ranking	-0,01		0,01	
Region				
USA	0,00		0,00	
EUR	0,01		0,03	
JKT	0,73	***	1,08	***
OTHER	0,00		-0,13	
GICS2 Industry Group				
Energy	0,00		2,33	***
Materials	-0,48		1,50	
Capital Goods	-0,92	***	1,18	***
Commercial & Professional Services	-2,41		0,00	
Transportation	-2,01	***	0,15	***
Automobiles & Components	-1,17	***	0,55	***
Consumer Durables & Apparel	-0,96	***	0,97	***
Retailing	-2,85	***	0,02	***
Food, Beverage & Tobacco	-1,34	***	2,06	
Household & Personal Products	-1,09	***	1,53	**
Health Care Equipment & Services	-1,42	***	2,27	
Pharmaceuticals, Biotechnology & Life Sciences	-2,20	***	3,82	***

Software & Services	-1,03	**	0,56	***
Technology Hardware & Equipment	-2,11		0,97	
Semiconductors & Semiconductor Equipment	-1,81	***	-0,34	***
Telecommunication Services	-2,05	***	1,14	**
Utilities	-0,14		2,09	
log Market Value	-0,20		0,40	*
log Assets	0,47	**	-0,59	***
constant	-5,03	***	-3,17	**
number of observations	747		747	
log pseudolikelihood	-149		-110	
residual degrees of freedom	24		24,00	
pseudo r2	0,07		0,16	

significance levels: *** p<0.01, ** p<0.05, * p<0.1

For green innovation, all sectors score lower than the Energy sector. It is remarkable that environmentally sensitive sectors, such as Transport and Automobiles, lag behind in terms of relative importance of green innovation compared to the Energy sector. The same can be said of the Semiconductor sector, where energy consumption of devices becomes an ever more important issue. For technology-using and less environmentally sensitive sectors, it is understandable that green innovation plays a less important role.

The Pharmaceutical sector takes the lead in blue innovation, also in relative terms, and this can easily be explained by the nature of the business. However, also the Energy sector contributes to blue innovation especially because of contributions to the provision of green and affordable energy. The Food sector scores also high, by providing good and nutritious food, and offering light products to counteract obesity, which was shown in Table 2b to be an important keyword in SDG3.

Proposition 3: Sustainable innovation and sustainability reporting.

Model 1 in Table 4 indicates that there is no association between higher sustainable innovation and sustainability reporting. The voluntary disclosure practice as an externally oriented corporate activity seems to be disconnected from the internally oriented innovation strategy.

However, when companies do publish a sustainability report, Model 2 elucidates the association with some attributes of sustainability reporting.

Global Compact membership is not a reporting attribute, but companies adhering to it are required to publish an annual Communication of Progress, which can be in the form of a sustainability report. It is fairly strongly positively associated to higher sustainable innovation. This is an interesting feature, as Global Compact membership is sometimes associated with just providing a better image or financial gains to members (Arevalo et al., 2013; Coulmont & Berthelot, 2015), also dubbed “bluewashing” (Berliner & Prakash, 2015).

Of the other reporting attributes, only GRI4 guideline application seems to be relevant, surprisingly with a negative association (though at low significance). Integrated reporting does not seem to be relevant, at least not in the diverse multinational sample under investigation here. This is remarkable, because integrated reporting pretends to improve the integration and congruence of shareholder and non-financial stakeholder information and in this way break down organizational façades (Perego, Kennedy, & Whiteman, 2016). Neither external assurance, nor sustainability ranking seem to be connected to sustainable innovation.

Next to Global Compact membership (which is not dependent on having a formal sustainability or integrated report), mentioning the SDGs in sustainability disclosure is positively associated with sustainability innovation, both green and blue. This is an interesting result and gives the impression that companies mentioning the SDGs may engage more substantially with them, as far as sustainable technical innovation is concerned, than was thought (Van der Waal & Thijssens, 2019). Companies themselves may not even be sufficiently aware of this as SDG relevant innovation is not a topic currently included in reporting guidelines.

4. Conclusions

Multinational companies make important contributions to SDG related technological innovation as measured by their patents. Their strongest contribution is on green innovation, whereas smaller companies play a more important role in blue sustainable innovation, directed at meeting unmet needs.

Companies that are a member of the Global Compact or are mentioning the SDGs in their sustainability reports, are stronger contributors to green and blue innovation. Though the practice of sustainability reporting seems not to be connected to sustainable innovation performance, mentioning the SDGs in a report seems to be more substantial and less symbolic than previously thought. Looking behind the sustainability reporting façade of companies, it seems that sustainable innovation as actions and deeds is important and is often congruent with the sustainability talk in their voluntary sustainability disclosure. However, companies may not always be aware of this and may display their sustainable innovation better in their disclosure.

The study has limitations in that only large stock-listed companies have been considered.

Further study is needed to elucidate the relationship between sustainable innovation and environmental performance, as the DJSI ranking that was used in this study may not reflect the environmental performance component properly, being a broader ESG construct.

The relationship between environmental performance and environmental innovation also needs a more profound analysis, preferably at the country level with companies operating on a national level. With multinational companies, environmental innovation may be often disconnected from the numerous countries of operation with different environmental pressures.

Finally, a more fundamental debate is needed about what society can really expect from multinational enterprises as profit-pursuing, primarily shareholder-value increasing organizations, and how they relate to the roles of governments and other stakeholders. An important part of that debate is about the role of equality and justice in dispensing the fruits of sustainable development. The contribution of multinational enterprises or any enterprise may not only be judged by the contribution it makes to technological sustainable innovation, which is a fairly monolithic, single-aspect issue, but needs to be assessed by a broader societal standard of equitability and justice, especially when the advantages of technology are unequally divided between developed and developing countries. This study shows that pharmaceutical companies provide important contributions to the blue SDGs, but this says nothing bout how their commercial policies help or hinder the advancement of equal and equitable access to such public goods. The tradeoffs between the Goals are also important issues to study more deeply: where one Goals is advanced, another Goal may be endangered, and this is something that is not reflected in the current study of sustainable innovation.

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Appendix A Keyword list

Blue SDG keywords

(urban /5W waste) “green city" OR “green cities" “sustainable cities" “sustainable housing" “sustainable transport" sustainable /1W building* "public transport" “traffic accidents" OR “traffic safety" natural /1W disaster* “tsunami" "food loss" “food waste" “post-harvest" "fish stocks" “overfishing" (flora /5W fauna) “freshwater ecosystems" (soil /1W clean*) (invasive /3W species) “wetlands" "afforestation" “reforestation" “sustainable forestry" "degraded land" “desertification" “drought" “ecological" “ecology" “land degradation" “soil degradation" "biodiversity" "biodiversity" natural /1W habitat* "poaching" "natural ecosystem" “sustainable development" “terrestrial ecosystems" “sustainable development" "bribery" (political /10w vot*) “democracy" "vitamin A deficiency" “hunger" “developing countries" “bottom of the pyramid" “improved nutrition" “food security" “crop protection" "malnutrition" “stunting" “wasting" “obesity" "small farmers" “small producers" “agricultural productivity" “pest control" “plant protection" “post-harvest" "drought" “natural ecosystem" ((dairy OR meat OR horticulture) AND sustainable) (climate AND disaster) “climate change" “soil degradation" "soil quality" "sustainable agriculture" “organic agriculture" "maternal mortality" "neonatal mortality" “children under 5 years" "newborns" neonatal /10W care "Chikungunya" “malaria" “dengue" “communicable diseases" “acquired immune deficiency syndrome" “schistosomiasis" “stunting" “tripanosomiasis" “tropical diseases" “tsetse" “tuberculosis" “water-borne diseases" “hepatitis B" “ebola" “filariasis" "chronic respiratory disease" “cancer" “cardiovascular disease" “diabetes" “mental health" “well-being" "traffic accident" “traffic accidents" “traffic safety" "reproductive health" “adolescent girls" “family planning" "contraceptive" “birth control" "essential medicines" “developing countries" "access to medicines" (water /10W sanitation)

"clean energy" “clean fuel" “poverty" “bottom of the pyramid" “least developed countries" "poverty" “south-east asia" “sub-saharan africa" "poverty" "microfinance" "poverty" "pro-poor" “bottom of the pyramid" "handicapped" "local materials" "life cycle analysis" “natural resources" “sustainable consumption" “sustainable production" "marine resources" “sustainable aquaculture" "access to market" "sustainable oceans" "rural" "access to market" “market access" "drug abuse" “alcohol abuse" "substance abuse" "adolescent girls" "gender equality" "birth control" "contraceptive" “family planning" "water harvesting" (desalination) /5W (water) “wastewater treatment" "sustainable transport" "bilharzia"

Green keywords

natural /1W disaster* “refuse collection" “air quality" exhaust /20W ("particulate matter") "fine particulate" “natural resources" “life cycle analysis" “hazardous waste" "hazardous chemicals" “waste collection" “waste recycling" “waste recycling" ((recycling OR recycled) /50W environment*) plastic /5W recycl* “chemical waste" sewer* “environmental impact" natural /1W disaster* "climate change" “GHG emissions" “global warming" “natural ecosystems" greenhouse /1W gas* "CO2 emission" "Carbon dioxide emission" (coast* OR marine OR aquatic) /5W ecosystem* (ocean /10W conservation) (coast* /5W (conservation OR protection OR ecosystem*)) (ocean /10W acidification) “eutrophication" (environmental OR soil OR air OR water) /1W pollution "hazardous chemicals" “safe drinking water" “wastewater treatment" “efficient water use" water /5W efficien* “irrigation" “water harvesting" “water resources" (efficient /10W (water resources)) desalination /5W water “freshwater ecosystems" “wetlands" “biofuel" “geothermal energy" “geothermal power" “hydropower" “ocean wave energy" “renewable resources" “tidal energy" wind /1W (power OR energy) (solar /1W (power OR energy)) (energy /1W efficien*) “clean energy" “renewable energy" “sustainable energy" “renewable resources" clean* /1W production “clean technology" “environmentally friendly" “carbon neutral" biodegradable /10W environment*

Design for Sustainability

The life cycle approach to compare health and safety performance of products

A new risk assessment methodology applied to an Italian leather company

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Abstract

The tanning industry recovers and transforms animal skins into non-putrescible, hygienic, breathable and resistant products. The use of chemicals in tanning companies represents a relevant risk for health and safety (HS) of workers both for inhalation and adsorption. The risk management model is an opportunity for companies to assure preventive and protective measures to reduce these risks. At the same time, with market perspective, companies are more and more interested to demonstrate the sustainability of management measures to reduce the impacts of products with life cycle (LC) approach. The research aims to define an innovative methodology to assess the HS risks related the processing of leather products made by an Italian company; the methodology is tested to compare HS performances of two leather products realized for the automotive sector. Originality of the research concerns the adoption of LC perspective in assessing HS issues related the products. The research starts with in-depth analysis of processes, in order to define the goal and scope of LC risk assessment, and to identify all substances and mixtures involved in LC phases of products and their dangerousness, working conditions and potential exposures. The research continues through the quantification of HS risks, through the adoption of systematic risk assessment methodology applied to the processing phases, concerning retanning, dyeing, fattening and finishing operations. Finally, the HS performances' evaluation of leather products guides to identify during LC the activities characterized by highest HS risks. The results highlight the LC phases of tanning processing that are most critical for HS of workers, with direct and repeated handling of dangerous chemicals. The results also demonstrate what is the leather product characterized by higher HS risk index. The methodology implemented in the case study supports a systematic inventory of substances' dangerousness, an ad-hoc analysis of LC phases and LC processes, a consistent evaluation of risks associated to each product and each activity. The implications both for practitioners and scientists derived by research are underlined in conclusions. For companies, the HS performance assessment of products supports a critical review of adequacy of measures adopted to prevent and protect workers' risk exposure. For scientific community, the LC approach, born to quantify the environmental hotspots associated to products, can be adopted also to assess the HS performance of products and to compare different products in a risk management perspective. New research perspectives can be identified, concerning the integration of environmental and HS assessments at product level, to support sustainable considerations by managers and markets.

Keywords: Health and safety risks, Life cycle approach, Risk assessment, Leather products.

1. Introduction

The issue of environmental sustainability is of great interest today and the international community encourages companies to adopt cleaner production systems and technologies (UNEP, 2011). The market seems to reward environmentally responsible organizations, and many companies around the world are increasingly interested in environmental issues, introducing them as strategic variables in their businesses (Mazzi, 2020/a). However, over the years, many environmental management tools have shown an important limit, that is the reduction of environmental impacts of an organization or a process by allocating them at other times, upstream or downstream of the supply chain (O'Rourke, 2014). An emerging interest in market concerns the green supply chain management, that explores various types of supply chain relationships and governance encouraging a sustainable management of suppliers and distributors (Tseng et al., 2019). With life cycle (LC) perspective, it is possible to consider the totality of problems, including the evaluation of the product's entire LC, with long-term time horizon and multidimensional view (Hoekstra and Wiedmann, 2014). Through the LC approach relevant innovations in designing, producing and using products and services become achievable, and benefits to several stakeholders along the product supply chain are obtained (Mazzi, 2020/b).

During the years LC approach has evolved, multiplying methodologies and practices (Hellweg and Milà i Canals, 2014). LC is not just a methodology of analysis: it's a philosophy, a way of observing and reflecting, which leads to effective solutions for overall improvement of the sustainability of products, processes and systems. Since the sustainability of a product is also linked to dangerousness of substances, materials and processes included in its LC, it would be interesting to apply the LC approach to assess the health and safety (HS) performances of products (Giannakis and Papadopoulos, 2016). From this overview, a first area of investigation emerges: to apply LC approach to understand and reduce the HS risks associated with dangerous products and processes.

Attention to the dangerousness of products, processes and plants has progressively and continuously grown since the 1970s, mainly thanks to the efforts of industrialized countries, primarily in Europe, to establish the *minimum* safety requirements for producers and users (Lave, 1987; Mikulčić et al., 2017). In order to answer to the pressure of consumers and suppliers, as well as legal obligations, an increasing number of companies around the world are paying attention to HS concerns and adopting modern management systems for evaluating and reducing the risks associated to industrial processes and products (Porter and Kramer, 2011; Coca et al., 2019). To support the growing needs for sustainable management in many sectors around the world, in recent years standards and guidelines supporting sustainable management have gradually multiplied (Toniolo et al., 2019). Risk assessment (RA) represents the main relevant requirement in modern sustainable management models: it supports companies in conducting the analysis and evaluation of potential risks and opportunities related to external and internal issues that can have relevance in terms of environmental impacts, HS hazards, quality of products and processes, customer satisfaction, market success, and so on (ISO, 2018). RA allows organizations to predict danger factors that can affect the success of their activities and therefore allows to plan a sustainable and durable business (Ruíz-Frutos et al., 2019).

Although RA is applicable to any kind of risks and can be a reference both strategically and operationally, companies often adopt it only to manage risks associated with plant or structural aspects and sometimes to optimize processes (see, as example: Gul and Ak, 2018; Zeleňáková et al., 2020; Zwetsloot et al., 2020). Instead, there is a lack of literature on RA applications for optimizing the LC of products. A second area of investigation is highlighted by these premises: RA could be useful to identify and manage the critical issues related the LC of products, focusing on risks associated to HS in working conditions, related to materials, components, machineries and plants.

From this overview, the following key elements emerge in the adoption of LC approach and RA methodology in sustainable management:

- LC approach allows to assess sustainability of alternatives, with a comprehensive point of view, including all relevant phases of design, production, use and end-of-life of products;
- RA methodology allows systematic identification and objective evaluation of critical issues concerning HS of workers associated to each phase of production process;
- The integration between LC approach and RA methodology could identify more relevant HS risks associated to the LC of products and consequently could achieve a more comprehensive and consistent performance of products, in terms of preferability and feasibility;

To fill the literature gaps and following emerging opportunities, a research was conducted with the aim of developing a new methodology of RA for evaluating the HS risks associated with LC of products. The expected results were dual: first, the purpose was to integrate LC approach and RA for sustainable management of risks associated to products; secondly the expectation was to test the validity of the new risk assessment methodology to compare sustainability performance of products in a case study.

The paper's contents are organized as follows. An overview of literature experiences concerning integration between LC and RA is reported in section 2, followed by explanation of the new LC-RA methodology designed for this research. In section 3 the case study is presented, through description of the Italian company, its production processes and the leather products

selected to test the LC-RA methodology. Results obtained by the case study are presented and discussed in section 4 and conclusive propositions are reported in section 5.

2. Methods

2.1 How to integrate LC approach and RA methodology

Both LC approach and RA methods are well-known scientific methodologies which can provide support in decision making process, but they have very different backgrounds.

The focus of LC is at product level: it analyses the whole LC of system or product and covers a broad range of impacts for which it attempts to perform a quantitative assessment (Mazzi, 2020/b). The international community gives a fundamental role to the LC approach for the construction of a sustainable future (UN, 2002), and several initiatives have been developed to favor the dissemination of LC practices all over the world and in particular to emerging economies (Wolf et al., 2006).

The methodology that supports the application of LC approach is the life cycle assessment (LCA): it is a tool used for assessing the potential environmental impacts of a product, process or activity during its whole life, through the quantification of resource use – in terms of energy, raw materials, water – and emissions in the environmental compartments – such as air, water and soil – with a global approach (Guineè et al., 2011). To conduct an LCA study practitioners around the worlds are supported by two international standards: ISO 14040 (ISO, 2006a) and ISO 14044 (ISO, 2006b), respectively containing general principles and specific requirements for an LCA. An LCA study includes four steps, related to each other through an iterative procedure: goal and scope, inventory, impact assessment and interpretation. Four features of the LCA make it a complete and robust tool to support companies and market in sustainability commitments: it takes a life cycle perspective, covers a broad range of environmental issues, is quantitative and science-based (Bjørn et al., 2018). In the last two decades, government initiatives supporting the LC approach have multiplied and scientific literature has exploded (Hellweg and Milà i Canals, 2014; Toniolo et al., 2019); nowadays the panorama of experiences concerning LCA is enormously rich and interdisciplinary (Mazzi, 2020/b).

The occupational HS and the environmental protection can be ensured by several RA technics, that help to identify hazards and quantify related risks, verify effectiveness of risk control measures, and provide actions to reduce them. International regulations and guidelines and the need for health prevention have led to considerable progress in the promotion of health and prevention of safety risks in the workplace (Lotti, 1993). In the last decade, in high-level risks industries, the concept of operational risk management has been defined as the process of dealing with the risk associated with any type of operations, which includes risk assessment, risk decision making, and implementation of effective risk controls (Alonso, 2012). To support companies in adopting a RA perspective, in the last decade, international standards have been published, like ISO 31000 (ISO, 2018) and ISO 31010 (ISO/IEC, 2009), that contain requirements and guidelines to implement the risk management with continuous improvement perspective, applicable to all industrial sectors.

RA methodology determines the potential impact of a chemical or physical agent on the ecosystem and human health, with reference to local level and allows the decision makers to select the management options characterized by an acceptable level of risk (EC, 2003). Risk is a function of three elements: danger, probability and damage: identifying and quantifying them allows you to assess the risk (ISO, 2009). RA is the preliminary phase of risk management: through the identification, quantification and evaluation of risks related activities, plants, or conditions, RA offers the basis for the risk treatment, which then allow the organization to reduce probability and/or damage of risks over time (ISO, 2018).

The integration between LCA and RA is recognized as an important research field within the LCA community (de Haes et al., 2004) and many studies have provided an analysis of their main features and common elements (Olsen et al., 2001, Tiruta-Barna et al., 2007). The main similarities and differences among the two approaches have been widely outlined, and advantages and disadvantages of a combined approach have been discussed (Owens, 1997; de Haes et al., 2006; Askham et al., 2013).

During the last decade, several attempts to integrate LCA and RA have been explored by scientists. The sectors most interested in integrating solutions refer to chemicals and waste management (see also Nishioka et al., 2002; Carpenter et al., 2007, Mazzi et al., 2013; Askham et al., 2013). From literature analysis, four possibilities have been identified to integrate LCA and RA (see also Sonneman et al., 2003; Flemström et al., 2004; Scipioni et al, 2010):

A. LCA and RA can be developed independently and final results are compared in a final discussion step;
B. RA can be applied as a subset of LCA, to support the inventory and/or impact assessment of LCA;
C. LCA can be applied as a subset of RA, to support the risk identification and/or evaluation of RA;
D. LCA and RA can be implemented in a complementary way, through integration of risk and impact assessment related to product or process in each step of RA/LCA methodology.

Although several solutions are possible, the combination between LCA and RA remains difficult, due to the following:

- Different scope of analysis: LCA concerns a product and includes all its LC phases, while RA concerns materials, substances, machineries, and working conditions involved in each process;
- Different aspects evaluated: LCA quantifies environmental impacts on ecosystems due to consumption of resources and production of waste and emissions, while RA quantifies the probability of occurrence of adverse events and related severity of HS effects.

These features, although differentiating LCA and RA, also represent great potential for their integration. In this research a new method of integration was designed, which allows to enhance the particularities of LCA and RA, enriching each other by virtue of their integration. The type of integration developed in this research is the fourth (D); the expected result was to understand what LC phases of a product determine higher HS risks for workers.

2.2 The research methodology: life cycle risk assessment

The new methodology conceived to integrate the LCA and the RA, named “life cycle risk assessment” (LC-RA), intends to combine each step of LCA and RA, in order to quantify the risks associated to each LC phase of production/transformation. Figure 1 represents the designed LC-RA methodology, that includes four main steps:

- Step 1: goal and scope of LC-RA, to define the product’s LC phases included and the HS characteristics considered (as processes, activities, substances, materials, machineries, plants, environmental conditions, emergency situations);
- Step 2: LC-R identification, to identify the HS hazards connected to the product through LC inventory of potential risks related raw materials and manufacturing processes;
- Step 3: LC-R analysis, to quantify the HS risks associated with the product through RA of effects as effects to HS of workers;
- Step 4: LC-R performance evaluation, as conclusive LC-RA step, through interpretation of LC-R analysis results and considerations about the HS performance of each LC phase of the product.

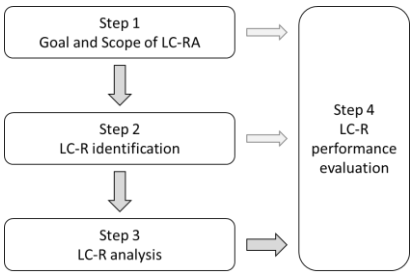

***Figure 1**. The LC-RA methodology designed to conduct the research.*

3. Case study

3.1 Presentation of the company, products and production process

The context in which the research was conducted is an Italian company leader in tanning industry. The company produces more than 9.000 leather products per day, mainly intended for the automotive sector where they are used to cover panels, seats, headrests, steering wheels and dashboards. 90% of the company's production is exported to car manufacturers all over the world. The processing activities take place in four production sites, all located in northern Italy, and involve around 640 employees.

The tanning process has the purpose of recovering and transforming the rotting skin of animals, as by-product for the food industry, into a rot-proof, hygienic, breathable and resistant product. After skinning, the hides are treated to block the development and proliferation of bacteria, and to obtain a new raw material ready to be shipped to tanneries.

The industrial processing can be divided into four LC phases, that include several LC phases and activities with chemical and/or mechanical risks associated, carried out through internal or outsourced processes. Table 1 summarizes them.

Table 1. *The leather processing described through the LC approach.*

LC phase	LC stage	Chemical or mechanical process	Contents (what is it for)	Internal or outsourced process
1. Preliminary and tanning phase	Raw material supply	Mechanical	To select raw hides with quality characteristics linked to the origin of the animal	Internal
	Liming and fleshing	Chemical and mechanical	To restore the leather to its original swollen and turgid state, removing dirt and salt, hair and top hair layer, and mechanically fleshing the leather	Outsourced
	Splitting	Mechanical	To even out and reduce all leather thickness, by splitting it in two parts: the upper one called grain, the lower one called split	Outsourced
	Tanning	Chemical	To prevent the leather from rotting ensuring it cannot be altered by external agents, with different tanning agents to obtain tanned leather with different properties	Outsourced
	Samming	Mechanical	To remove excess water and make them more even in terms of moisture (58% to 62% depends on the season) and thickness	Outsourced
2. Retanning, dyeing and fattening phase	Selection	Mechanical	To classify leathers on the base of number and type of natural or man-caused defects	Internal
	Shaving	Mechanical	To achieve even thickness all over their surface and remove imperfections caused by fleshing and splitting	Internal
	Retanning	Chemical	To give leather physical-mechanical properties (mechanical strength, fullness, softness, elasticity, yielding and lightness)	Internal
	Dyeing	Chemical	To confer leather all the desired quality (colour, brightness or dullness)	Internal
	Fattening	Chemical	To ensure that physical-mechanical characteristics of leather are maintained over time	Internal
	Drying	Chemical	To reduce the amount of moisture in leathers reaching hygroscopic equilibrium (14-18%)	Outsourced
3. Dry machining phase	Staking	Mechanical	To soften leather all over its surface	Internal
	Milling	Mechanical	To check the temperature and humidity values inside the product and to change the degree of softness of leathers	Internal
	Frosting	Mechanical	To remove subcutaneous residues on the flesh side and to give a writing effect (nabuk) on the opposite side	Internal
4. Finishing phase	Finishing	Chemical and mechanical	To confer to the surface of the finished leathers a series of features that enhance its aesthetically, in terms of handle and mechanical/chemical properties	Internal
	Embossing	Mechanical	To confer a particular grain to the leather, depending on the desired article	Internal
	Measurement	Mechanical	To determine precise measures of each product, individually identified using multiple-stamping	Internal
	Cutting	Mechanical	To cut products to their final dimension as panels or to customize them to reproduce the shape of a specific object	Internal

The tanning process can be made with various substances. The most common tanning procedures are: chrome tanning, named "Wet Blues", from which the characteristic bluish hides are obtained, and vegetable tannins tanning, named "Wet White", from which the whitish hides are obtained. In this research, in order to test the LC-RA method, two top final products of company were chosen, with excellent quality characteristics and sold to luxury automotive market:

- Product A, realized with Wet Blues leather, made from chrome tanning procedure;
- Product B, realized with Wet White leather, made from vegetable tanning procedure.

To guarantee the equivalence of the compared products, the LC-RA was applied to quantify the risks associated to production of one square meter of finished product in black color.

3.2 How to apply LC-RA methodology to the case study: from theory to practice

Each step of LC-RA methodology presented in figure 1 was applied considering the following factors.

- Step 1: Goal and scope of LC-RA was defined by observation of the product's LC during operations related to manufacturing, transformation, transport, storage. All the relevant phases were included in the scope, coherently with the goal of RA: information about activities, substances, materials, plants, machineries, are to be considered in this step.
- Step 2: LC-R identification was based on the inventory of chemicals, substances and mixture, their identities and hazard characteristics, handling and use conditions, storage methods. To do this, regulated labelling of substances (EC, 2008) and real conditions observed directly on the field were considered.
- Step 3: LC-R analysis included chemical risk associated with each processing phase. To do this, an algorithm that considers the intrinsic hazard of substances and the exposure to hazard was elaborated; inhalation and skin contact were included to estimate the exposure level. Sub-section 3.3 describes the formulas of the LC-R analysis algorithm.
- Step 4: LC-R performance evaluation was obtained by comparison of LC-R analysis results with an evaluation criteria matrix defined a priori, in order to identify activities and processes in LC phases that are more critical for HS of workers. Sub-section 3.4 explains the LC-R evaluation matrix adopted to do this.

3.3 LC-R analysis algorithm

The risk associated to the LC of products has been derived from a series of correlated formulas, outlined in figure 2. The risk associated to each LC phase was a combination of risks associated to processes related to this phase; in turn, the risk associated to each process depended on risks related to all activities performed during it. The risk index associated to each activity depended on risks related to substances and mixtures used in the activity, that were functions of both hazard of substances/mixtures and workers' exposure by inhalation and/or skin contact.

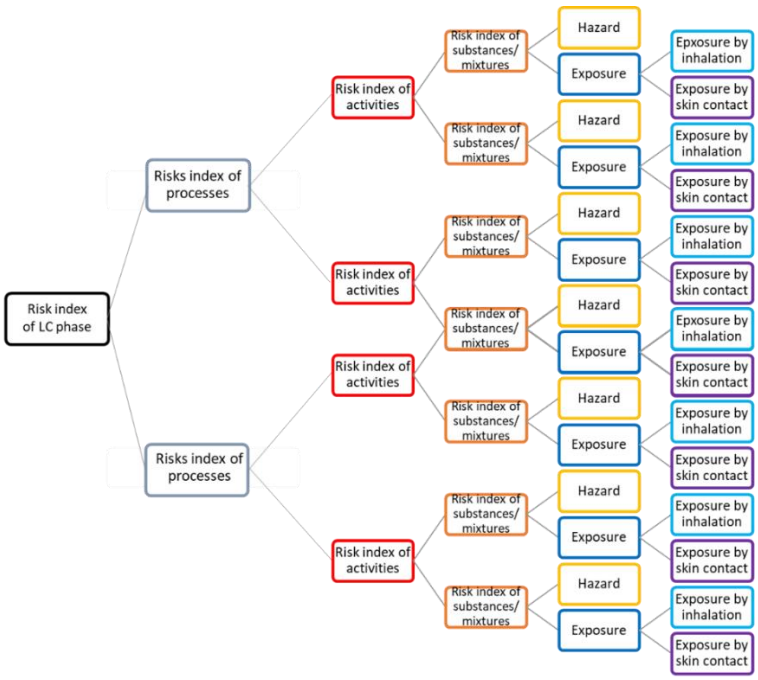

***Figure 2**. Elements making up risk index in step 3 LC-R analysis.*

The risk index associated to each LC phase ($R_{LC\ phase}$) was obtained by the sum of risk indexes associated with processes component the LC phase, as reported in formula F.1.

$$R_{LC\ phase} = \sum R_{processes} \quad \text{F.1}$$

In turn, the risk index associated to each process ($R_{process}$) was obtained by the sum of risk indexes associated with activities included in the process, as reported in formula F.2.

$$R_{process} = \sum R_{activities} \quad \text{F.2}$$

The risk index associated to each activity ($R_{activity}$) was obtained by the sum of risk indexes associated with substances and mixtures used in the activity, as reported in formula F.3.

$$R_{activity} = \sum R_{substance/mixture} \quad \text{F.3}$$

The risk index associated to each substance/mixture ($R_{substance/mixture}$) was estimated through the formula F.4 (adapted by Regione Toscana et al., 2018):

$$R_{substance/mixture} = H \times E \quad \text{F.4}$$

In F.4, H is the hazard index associated to substances/mixtures: it is estimated through the regulatory criteria (EC, 2003).

In F.4, E is the exposure index, calculated through the formula F.5:

$$E = \sqrt{{E_{inal}}^2 + {E_{skin}}^2} \quad \text{F.5}$$

In F.5, E_{inal} and E_{skin} correspond respectively to the exposure index by inhalation and by skin contact.

In turn, to estimate the value of E_{inal} and E_{skin} both following factors were considered (EC, 2008):

- Hazard factors: acute toxicity, skin corrosion or irritation, serious eye damage or eye irritation, respiratory or skin sensitization, specific target organ toxicity, and dangers for aquatic environment;
- Exposure factors (EC, 2008): chemical-physical characteristics, quantities and concentration in use, conditions and procedures of use, possibility of dispersion, protective measures adopted, exposure time, and distance from source.

Through a linked system of scoring matrices (in line with Regione Toscana et al., 2018), objective and repeatable values of E_{inal} and E_{skin} were associated to all possible combinations of the above factors.

3.4 LC-R evaluation matrix

Results obtained by risk quantification (through the formula F.4) were compared with the risk evaluation matrix (elaborated in line with Regione Toscana et al., 2018) in which five levels of relevance were defined: irrelevant, negligible, uncertain, high, and serious. Figure 3 summarizes the contents of the risk evaluation matrix.

Then, a comprehensive evaluation of risks related all substances/mixtures referred to activities was conducted, in order to identify the non-negligible ones. The overall assessment of risk associated with each LC phase made it possible to obtain the LC-R performance evaluation of a product, identifying what are the relevant risks and to which processing phases they refer to. Through this approach, the comparison of LC-R performance of different products was also conducted, checking at each LC phase the product with worse LC-R performance.

R = H x E	Level or evaluation	Comments
0,1 ≤ R < 15	Irrilevant risk	No action shold be taken
15 ≤ R < 21	Non-negligible risk	Risk treatment can be improved
21 ≤ R < 41	Medium risk	Adequate prevention and protection measures must be guaranteed
41 ≤ R < 81	High risk	Urgent reduction measures must be taken
R ≥ 81	**Serious risk**	**Immediate drastic risk reduction measures must be taken**

***Figure 3**. LC-R evaluation matrix.*

4. Results and discussion

4.1 Goal, scope and inventory of LC-RA

In line with the LC-RA methodology in figure 1, first the goal of LC-RA study was formulated, as the comparison of LC-RA performances of products A and B, by considering the RA associated to the activities that use chemical substances and mixtures and carried out internally in the company factories.

The functional unit of LC-RA for both A and B products was 1 m^2 of final product available to the market. Coherently with the goal and functional unit, in the LC-R inventory and analysis the total amount of processed chemicals, expressed in Kg, compared to the total surface of leather, expressed in m^2, were calculated for each LC phase and LC phase . Then, the results of LC-R quantification were expressed in kg/m^2.

The scope of LC-RA was defined as follows:

- processes carried out internally in the company factories were included in the boundaries, while processes outsourced were excluded from the analysis;
- chemical processes were considered in LC-R inventory, analysis and evaluation, while mechanical processes were neglected because they were meaningless with respect to the LC-RA methodology adopted.

Figure 4 represents the LC phases of the products (already described in table 1) and highlights the LC processes included in the LC-RA study (black boxes) and the LC processes with chemical risks relevance (bold boxes). Summing up, within the study the products A and B were compared by quantifying the risks associated with substances/mixtures used in the LC processes in bold black boxes in figure 4.

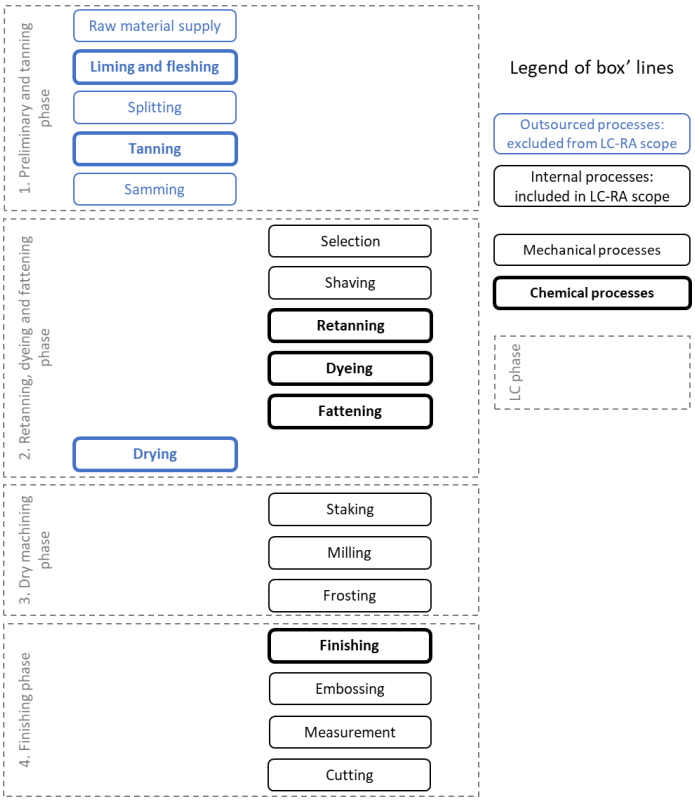

***Figure 4**. System boundaries of LC-RA, highlighting LC processes included in (and excluded from) the study.*

In LC-R identification, for each process included in the LC-RA scope, the inventory of HS risks was conducted, by the identification of substances and mixtures used and considering the information about hazard classification (EC, 2008). From the analysis information contained in the recipes of leather articles and from the observation of LC processes, a list of substances and mixtures was obtained, and the weight and concentration of each component were estimated. Dangerousness associated with each substance and mixture was estimated on the base of characteristics, quantity and concentration, for both A and B products. Moreover, information about operative conditions of each LC activity were registered through direct observation; for example, procedures for use, handling and storage of substances/mixtures by workers were registered, in order to estimate the risk exposure factor related the activities in which substances/mixtures were used.

From LC-R inventory, overall, 6 substances and 34 mixtures were identified in the LC of product A, while 1 substance and 50 mixtures in the LC of product B. Among the activities in LC phases, some substances and mixtures are the same in both products A and B, even if in different quantities and conditions; however, several are different.

4.3 Results of LC-R analysis and evaluation

Information collected in LC-R inventory were utilized to calculate the risk indexes related each substance/mixture and each activity, through formulas explained in section 3.3; then, the risks evaluation associated to each activity were obtained through the application of the LC-R evaluation matrix in figure 3. In order to evaluate the LC-R related to each LC phase and LC process of products A and B, the activities with a risk index greater than 15 ($R_{activity} > 15$) were considered, therefore all situations classified as “Non-negligible risk index” (yellow level in figure 3), “Medium risk index” (orange level), “High risks index” (red level), and “Serious risks index” (amaranth level) were included.

Overall results obtained by LC-R evaluation of products A and B are summarized in table 2. The dangerous substances used in the processing of product B are more numerous than those of the product A. Moreover, the risks associated to substances/mixtures in the LC of product B are more relevant than those in the LC of product A.

***Table 2**. Results of LC-Risk evaluation for products A and B.*

		Product A		**Product B**	
N. of activities with substances/mixtures	N. of $R_{substances/mixtures}$ quantified	**277**	*100%*	**379**	*100%*
N. of activities with "Irrelevant risk index" (green level)	N. of $R_{substances/mixtures} < 15$	244	*88,1%*	315	*83,1%*
N. of activities with non irrelevant risk index (yellow, orange red and amaranth levels)	N. of $R_{substances/mixtures} \geq 15$	33	*11,9%*	64	*16,9%*
N. of activities with "Non-negligible risk index" (yellow level)	N. of $15 \leq R_{substances/mixtures} < 21$	30	*10,8%*	39	*10,3%*
N. of activities with "Medium risk index" (orange level)	N. of $21 \leq R_{substances/mixtures} < 41$	3	*1,1%*	25	*6,6%*
N. of activities with "High risk index" and "Serious risk index" (red and amaranth levels)	N. of $R_{substances/mixtures} \geq 41$	0	*0%*	0	*0%*

The evaluation of risks index associated to each LC phases of products gave the results shown in figure 5, that demonstrate the following:

- the finishing phase include the largest number of activities with non-negligible risk index (yellow) for both products;
- in retanning, dyeing and fattening phase, product A has more situations with non-negligible risk (yellow level), however product has more activities with medium level (orange);
- in the LC of product B there is a higher number of activities with both non-negligible (yellow) and medium (orange) risk index.

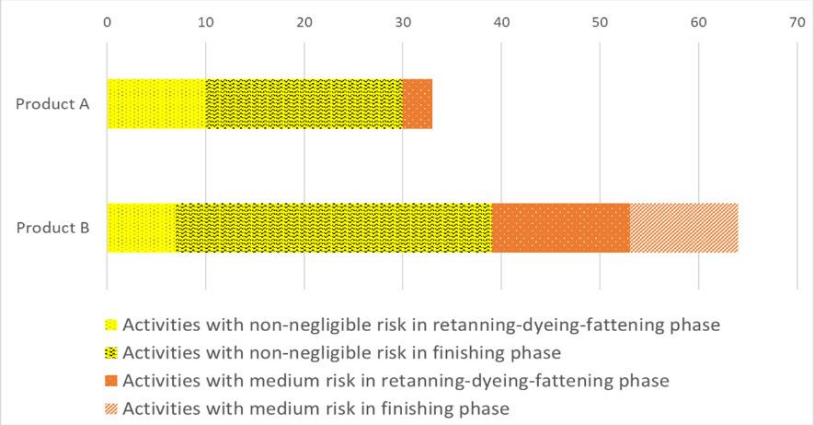

***Figure 5**. Number of activities with HS risks in LC phases of products A and B.*

By comparing the LC-RA of products A and B it is possible also to note the activities with higher risk index: figures 6 and 7 reports a summary of these results, showing for each process the number of activities with respectively non-negligible risk index ($15 \leq R < 21$, yellow) and medium risk index ($21 \leq R < 41$, orange).

The more critical activities are in the finishing phase, for both the two products: loading of pirovan, mixing, filtering and mixture preparation expose workers to major risk situations. This is due to the following concurrent factors: number of dangerous mixtures used in these operations, their quantities and concentrations, manual operations adopted, and danger of production waste and residues.

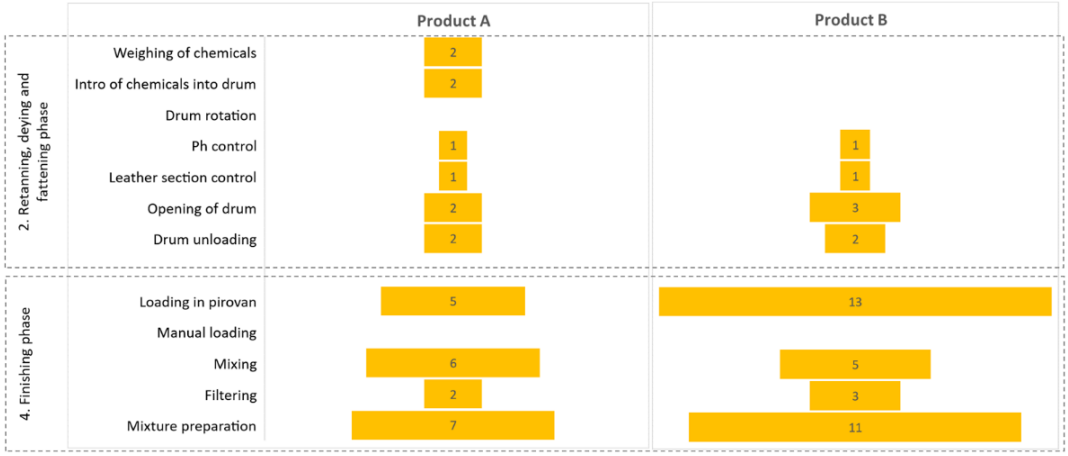

***Figure 6**. N. of activities with non-negligible risk index ($15 \leq R < 21$) in LC processes & phases of A and B products.*

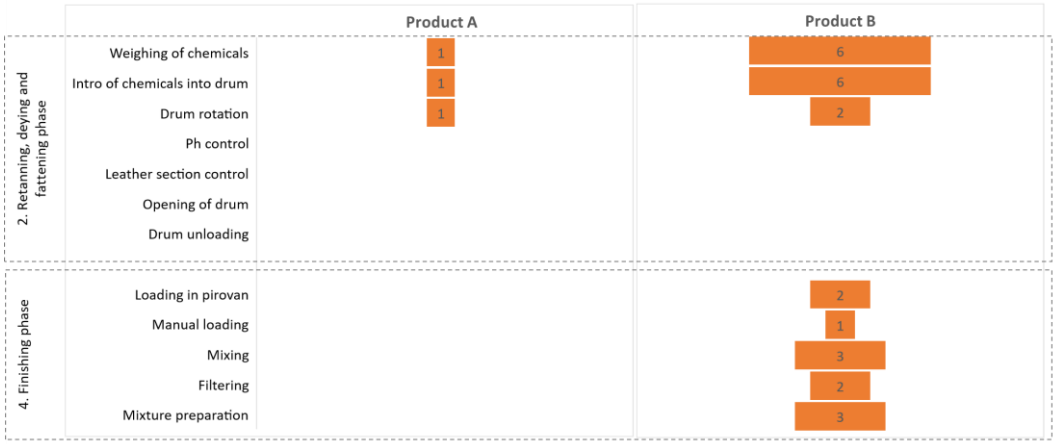

***Figure 7**. N. of activities with medium risk index ($21 \leq R < 41$) in LC processes & phases of A and B products.*

Thanks to the LC-RA results, the company was able to define ad-hoc actions to be taken to improve the HS conditions of processes and therefore also the HS performance of its products. In order to reduce the risks identified, internal protocols and guidelines to respect best practices in storage and handling substances and mixtures were defined. Information and awareness of workers about the correct and systematic use of individual and collective protection devices were organized. At the same time, a more frequent health monitoring of workers involved in risky activities was also organized. Moreover, in-depth procedures for managing emergencies relating to the most dangerous activities were developed. Finally, HS performance of products were discussed by company with its customers to promote greater collaboration in the supply chain in the future, in favor of less dangerous processes.

Concluding the discussion of research results, the case study conducted demonstrated the following strengths:

- The LC-RA methodology was functional for comparing different products, therefore it allowed the company to evaluate which products entail greater HS risks;
- The results obtained from the LC-R evaluation supported the review of risk treatment measures, to reduce the risks associated with production processes;

- The results of LC-RA were used to share with all the staff the risks associated with each processing phase and activity, in order to improve the knowledge and consciousness of safe behavior;
- The LC-RA methodology was useful for the company to verify the profitability of its products based on the hidden costs concerning the reduction of HS risks along the LC of production;
- The information about the sustainability of products, obtained by the LC-RA, was communicated to customers, in a collaborative supply chain perspective.

The main limitations of the results, depending from the assumptions of the research, are the following:

- The LC-RA methodology applied considered only chemical risks evaluation, while the mechanical processes were not considered;
- The scope of LC-RA study included only the processes carried out by the company within its factories, while the processes outsourced by company to other suppliers were not considered.

5. Conclusions

The research made it possible to develop and test a new methodology that integrates RA into the LC approach. The LC-RA methodology, applied to an Italian company, led to the identification, quantification and evaluation of HS risks related the LC of two leather products through the identification, analysis and evaluation of HS risks associated to each LC phase and process and activity.

The expected results established at the beginning of the study were fully achieved. The integration of LC approach and RA methodology was possible, thanks to design of a methodology that adopted the LCA framework and used appropriate RA algorithms. The experimental application of the LC-RA methodology to two products of the same company allowed to verify the effective usability for comparing products and processes. Through the case study carried out in this research, the LC approach was useful for systematically identifying all hazard sources and calculating the risks associated with each LC phase of the products; at the same time, the risks assessment related to each LC phase was useful in understanding the relevance of activities and processes in terms of workers HS.

Following lessons learned from the research can guide practitioners in integrating LC approach and RA methods:

- The adoption of LC approach in risk evaluation is convenient, because it allows to more precisely understand the dangerousness of activities during the processing phases; consequently, the company can adopt more effective risk reduction measures because they refer specifically to each risky situation identified;
- The RA is a useful tool to compare products in terms of HS performances, because it allows the company to identify the products that determine greater risks for workers' HS, which in turn favor company's commitment to reduce them;
- The proposed methodology allows to obtain complex and articulated evaluation through simple steps and with easily available information, thus allowing a systematic use with a continuous improvement perspective.

Other research perspectives can be underlined for scientists:

- To overcome the limits of this experience, the LC-RA methodology must be integrated by methods of RA referred to mechanical risks; moreover, the boundaries of LC-RA study should be expanded to include all processes with HS risks for workers;
- In order to strengthen the validity of the LC-RA methodology, next research perspectives include the testing of this methodology in other industrial sectors, with more complex products and more dangerous processes;
- A further area of research development concerns the use of LC-RA methodology to inform customers, consumers and market about the preferability of some products over others, based on HS performance. this would allow less dangerous products to obtain greater visibility, in favor of a more sustainable production and a more aware market.

List of acronyms and abbreviations

E: exposure index

E_{inal}: exposure by inhalation index

E_{skin}: exposure by skin contact index

H: hazard

HS: health and safety

LC: life cycle

LCA: li cycle assessment

RA: risk assessment

$R_{activity}$: Risk index of activity

$R_{process}$: Risk index of process

$R_{LCphase}$: Risk index of LC phase

$R_{LCstage}$: Risk index of LC stage

$R_{substance/mixture}$: Risk index of substance or mixture

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Circular Economy - Part 1

Analysis of industrial waste management regulation to drive resource management in a circular economy: a case study in Spain

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Abstract

Waste generation is outpacing the rate of materials recovered and recycled. So, a problem is generated when materials that should be cycled back to industrial production follows a linear approach wherein energy and resources are being exhausted. To ease the environmental burdens created by poorly management of waste, countries have conceived policies to deal with waste. Nevertheless, it is not enough to handle waste, but most importantly is to create other applications for this waste to be used as a resource for other industrial activities. Thus, an approach such as industrial symbiosis (IS) has been around for more than 20 years to solve this issue, still, implementing this approach at a country level is hard to achieve. The European Commission (EC) under its 'green deal' foresees IS as a vehicle to achieve a better resource efficiency in which a high quality secondary raw materials market is guaranteed to reduce waste. Hence, an enhanced waste policy is endorsed to support waste prevention though the implementation of IS. In that sense, the efficacy of policies for the waste management sector plays a crucial role to integrate a linear waste management to a more comprehensive approach for resource management. Thereby, studies are needed to highlight how waste management policies might assist authorities in analyzing the materials with better chances of being recovered and potentially be used in other ways, therefore, paving the way for enabling the emergence of IS by increasing resource efficiency. Thereby, this paper explores the efficacy of a specific policy enforced as a measure to enhance waste reduction in ten industrial areas located in the Basque Country (Spain) for a period of five years. The findings of this study show that an increasingly strict waste management policy improves collection of waste, especially in three waste streams. These findings highlight the opportunities to shift from a mere waste management regulation approach to a resource management strategy.

Keywords: circular economy, industrial symbiosis, resource management, waste management, policies.

1. Introduction

Waste generation is increasing dramatically worldwide due to among others, economic growth, overpopulation and overconsumption (Karak, Bhagat, & Bhattacharyya, 2012). This creates a problem of billions of tons in waste generated annually around the world, thus, converting it into a serious issue in both developed and developing countries (Kothari, Kumar, Panwar, & Tyagi, 2014). In developing countries an inappropriate waste management system due to a lack of funding for waste treatment, inadequate land for disposal and weak policies and regulations are causing environmental hazards (Mohee et

al., 2015). In addition to the environmental problems such as methane emissions, bad odors and leachates associated with poorly waste management practices (Moumen, Azizi, Chekroun, & Baghour, 2016), the large physical area required for the landfilling waste is often a problem. Highly populated areas in Europe and Asia have regulated against waste landfilling because of lack of space and land competition with agriculture (Moh & Manaf, 2014).

Although, there is not a forthright solution for best waste management practices; cities, regions and countries have established different strategies to deal with this issue. Very often these strategies for managing waste has been focused on legislations, plans and programs. Policymakers focus on designing strategies to reduce landfilled waste include taxes, regulations and policies and thereby in some cases encouraging waste recovery in different ways (Schreck & Wagner, 2017). For instance, the European Parliament issued the waste hierarchy as a strategy for handling waste. The Directive 2008/98/EC of the European Parliament (2008) presents a waste management hierarchy framework that aims to diminish the unwanted outcomes of waste generation. The waste hierarchy states that waste prevention is the prevailing option for waste management followed by reusing, recycling and recovering as the preferable options and it is highly considered as a framework that does not support landfilling in any of its state members. By doing so, state members are obliged to set higher targets for recycling rates and waste recovery (Aguilar-Hernandez et al., 2019).

The European Union since then has developed directives to set increasingly rigorous objectives in which resource efficiency plays a key role in achieving an optimal waste management (European Commission, 2017). However, as the consumption of raw materials keep rising so does the waste generation and with it the valorization of waste remains insignificant (Circle Economy, 2019; Shahbazi, Wiktorsson, Kurdve, Jönsson, & Bjelkemyr, 2016). As a result, the European Commission released an improved waste policy in support of waste prevention in which the decoupling of waste generation from economic growth will be supported with measures that guarantees a high quality market for secondary materials (European Commission, 2020). The aim as stated in previous communications (European Commission, 2015) is to support the shift to a secondary material market aligned with circular economy (CE) strategies to engage all stakeholders in order to incentivize resource efficiency (European Commission, 2017; Fletcher & Dunk, 2018). These measures shift from the current waste management approach to a circular integrated waste management system (Cobo, Dominguez-Ramos, & Irabien, 2018) whereby no material is wasted or underused under a CE (Ghisellini, Cialani, & Ulgiati, 2016; Prieto-Sandoval, Jaca, & Ormazabal, 2018).

CE is acknowledged as a concept for cycling back materials in a constantly closed-loop system (Ghisellini et al., 2016; Pitt & Heinemeyer, 2015; Prieto-Sandoval et al., 2018). Therefore, current linear waste management will be improved by shifting toward an approach of better resource utilization whereby waste generation is decoupled from economic growth (Kirchherr, Reike, & Hekkert, 2017). One of the strategies to achieve this CE is called industrial symbiosis (IS) which is described as a system wherein different companies collaborate to gain competitive advantage by linking exchanges of resources through collaboration in a context in which the waste of a company becomes the resource for another company (Chertow, 2000, 2007). By doing so, IS supports the transition from a linear to a CE model by closing loops and thus, eliminating reliance on virgin materials (Abreu & Ceglia, 2018; Nasir, Genovese, Acquaye, Koh, & Yamoah, 2017; Saavedra, Iritani, Pavan, & Ometto, 2018).

Nonetheless, this task would require for policymakers to seek for effective waste policy that includes considering waste-as-a-resource business model (Schreck & Wagner, 2017). So that, approaches for waste management policy must determine which material to recycle and identifying which stakeholders to target in order to use waste and byproducts as high-quality resources (Anshassi, Laux, & Townsend, 2019). Therefore, policy actions plays a central role in stimulating this IS in practice to avoid wastefulness (Jiao & Boons, 2014). Despite the theoretical value of IS contributing to a better resource management, this approach seems to be underexplored in terms of practical applications (Aid, Eklund, Anderberg, & Baas, 2017; Domenech,

Bleischwitz, Doranova, Panayotopoulos, & Roman, 2019). Even though, different attempts to stimulate IS in practice consists in the application of adequate policy measures (Fraccascia, Giannoccaro, & Albino, 2017).

Thus, the objective of this research was to analyze how regulations enforced to enhance waste policy might result in an input for a better understanding of materials that might stand a better probability of potentially be handled in other ways, thereby, elevating the role of resource efficiency that could enable the emergence of IS. The study at hand analyzed the information compiled by a municipal waste management organization for five years in ten industrial areas located in the Basque Country (Spain). The paper is structured as follows; section two discusses the methods used in this study, section three showcases the results obtained from data of the municipal waste management organization and discusses the results obtained when there is a change of legislation, and section four concludes with the main insights found in the analysis of waste generation in this region.

2. Methods

Our objective is to analyze the efficacy of a specific policy aimed to increasingly set strict waste management regulation in the collection of waste streams in different industrial parks (IPs). IPs was selected to evaluate the efficacy of this policy as these sites must be given a particular importance because they could be used to implement IS due to geographical proximity among different companies to uptake a waste-to-resource exchanges (Chertow & Ehrenfeld, 2012; Ghisellini et al., 2016). Likewise, IPs in Europe host diversity of companies that could create multiple opportunities across value chains involved in multiple industrial activities to foster IS networks (Domenech et al., 2019).

Therefore, the case study method is used in this study as it allows the investigation of a phenomenon within a real context (Freitas & Magrini, 2017). In this case, it allows to study the effects of a policy in IPs to observe changes in the object of analysis. In order to ensure a methodological consistency of the case study method, a three-stage research was proposed as exemplified in Figure 1. With that aim, our study analyzed the effect of regulation on waste generation in IPs in 10 different locations in the Basque Country region in Spain, through data recorded by the waste management organization at the moment of waste collection. Quantitative data of waste generation was compiled to analyze changes over time due to regulation issued to enhance waste management. The ten locations studied in this research were selected as they are part of a region wherein, they are oversight by the same regional authorities and therefore any regulation issued by the authorities are applied to them equally. This study's approach was used as it offers a more detailed view of the subject to explore a problem and gather information about it to build the hypothesis (Yin, 2015).

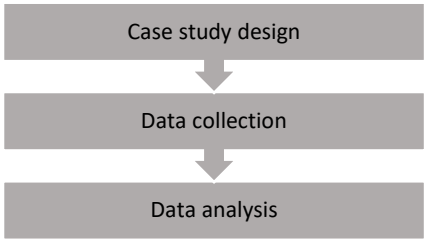

Figure 1 *Research method*

The analysis focused primarily on waste stream collection and separation after three changes in waste management regulation were enforced over a period of five years. The data for this study were collected by primary sources using a SQL database. A large number of data between 2014 and 2018 were collected (waste types and amounts, generation flows, ways and frequency of collection, number of waste producers, etc.). Finally, quantitative data was analyzed through a spreadsheet program to process the data to make them useful (Saunders, Lewis, & Thornhill). Quantitative analysis techniques such as graphs, charts

and basic statistics were used to describe and examine relationships and trends between policy implementation and changes in waste management.

3. Results and Discussion

Some city councils of the Basque Country region (Spain) have issued their own regulation on waste, among which is the San Marcos community association, (Figure 2), with the aim of preventing the generation of waste and improving the efficiency of its management. The association serves to approximately 315.000 inhabitants and 2000 companies in industrial parks, mostly small and medium sized enterprises. Within this area of service, the San Marcos community association has changed the rates applicable to waste management, in order to adjust to the costs that this management generates and, on the other hand, to enhance waste separation. In this way, the proper management of all potentially recyclable or recoverable waste is guaranteed, avoiding its landfilling. Furthermore, it allows the detection of inadequate management of other types of waste, such as hazardous waste, which can be corrected.

Figure 2 *San Marcos community association, in the Basque Country region*

Under this area and circumstances, the aim of our study is to analyze the evolution of the management of waste of industrial source associated with the community of San Marcos (10 locations), in the period between 2014 and 2018. This seeks to identify the effect that changes in regulation, specifically related to a waste management tax policy are determinant of its influence on generation, classification and collection of waste from this community. In order to improve waste management, two changes have been made in the policy regarding collection rates, which are detailed as indicated below (Table 1). These changes in the rates associated with waste collection are expected to have improved the efficiency of waste management itself, through two factors that must be analyzed: a) improvement of waste separation, thus, improving the quality of the residue and b) an increased collection efficiency, (e.g. increasing the collection ratio per trip).

Table 1 *Main changes on regulation*

Issue date of regulation	**Main changes**
Feburary 22nd-2013	Start of analysis
March 11th - 2016	• **Bio-waste:** start charging for this concept • **Non-compostable organic:** rates increase • **Bulky and others:** rates increase

June 19th - 2017	• **Bio-waste:** new concepts appear subject to tax, compared to the previous regulation • **Organic:** a new concept appears subject to taxation

The San Marcos community association manage the waste from the municipalities, through collection, separation and treatment of waste. The community also provides the data of the different industrial areas for this study. This research focuses on waste collection in industrial areas, grouped by municipalities or IPs, which from now on we will call them locations. Waste data collected contains besides billing information, places and companies visited, the characteristics of the containers, etc. In addition, an estimation of the used filling capacity of the container before collection is recorded, which is referred as "filling level", with 1 being a low-filled, 10 being full-filled. This last information is of particular interest because, as it means that when filling levels are higher, companies manage their collections better, resulting in greater system efficiency, so that, in the creation of a reliable waste as a resource model, a secondary material market could be sustained over time (Schreck & Wagner, 2017).

As mentioned before, this study has focused on three waste streams, as they are considered to be of most interest since biowaste and non-compostable organic, hereinafter organic, are the ones that have undergone variations in terms of regulation, and inert due to its evaluation in volume and because it is a fraction with a high environmental impact (not recoverable). As can be seen in Figure 3, these three fractions over the time-span period studied represent a significant amount in terms of the number of operations carried out with the waste streams managed in the Commonwealth. It is noteworthy that the amount associated with "Other" represents different waste streams that at the moment are of no interest for this study. However, this stream has increased significantly in the last two years, which perhaps should be taken into account for future analyzes. This data could be relevant for companies in the scenario wherein the waste management sector would participate in expanding its role toward a facilitator for managing resources (Aid et al., 2017) or as a supplier of high-quality waste in an IS (Prosman & Wæhrens, 2019).

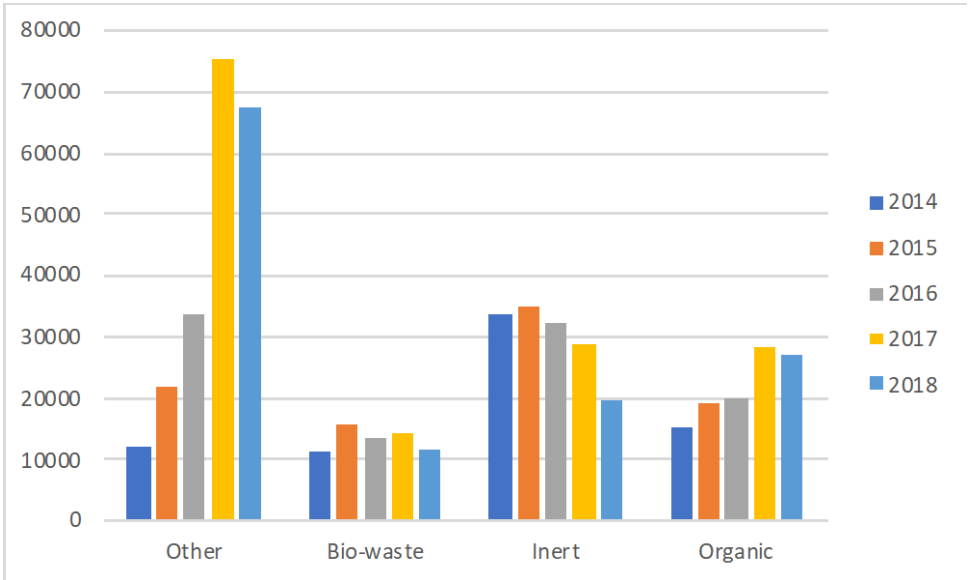

Figure 3 *Number of collections for different waste streams*

Below is a graph showing the evolution of the number of times a waste stream has been collected corresponding to the three fractions studied (bio-waste, inert, organic), carried out during the years of the study (2014-2018) in each of the 10 locations. As can be seen, the different locations present similar trends as a whole. Although, neither a characterization of each waste stream has been done nor an assessment of its quality, the fact that waste streams in the different locations analyzed are being collected constantly throughout the years offers an opportunity for integrating material management into waste policy planning. The findings in this study showed that every location are reporting their individual waste generated, this could be used to more accurately observe how waste management can create synergies boosted by geographical proximity (Figure 2) (Freitas & Magrini, 2017). So that, a better target for specific materials in the waste stream for recovery could be set in place (Cobo et al., 2018).

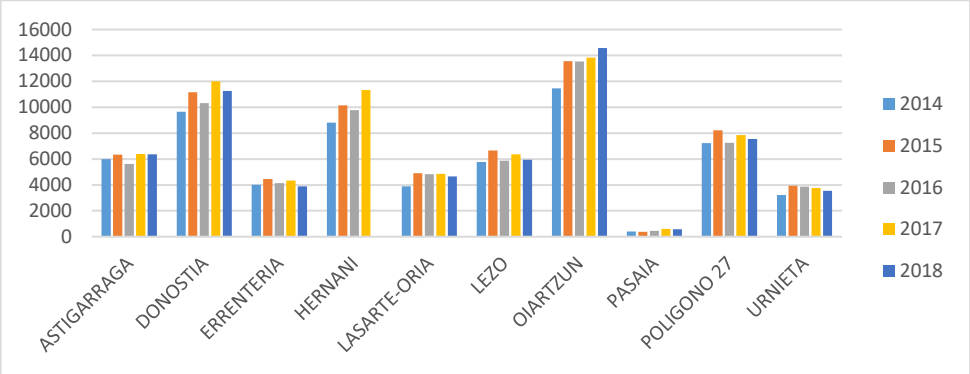

Figure 4 *Waste stream collected in locations*

Moreover, it is believed that companies in order to reduce the costs associated with waste management (taxes per number of waste collections) have caused a reduction in the frequency of waste collection, which would imply a greater volume of filled containers per collection. To observe this trend, the number of collections for each type of waste per year and location, for each level of filling (grouped into sections of scale) has been analyzed in a comprehensive manner, as shown in Table 2.

Table 2 *Year-on-year variation of waste collection with a low-filled level (0-3)*

	2014/2015	2015/2016	2016/2017	2017/2018
Bio-waste	-3,0%	-3,9%	0,1%	-8,1%
Inert	-4,9%	1,3%	2,0%	1,5%
Organic	-4,8%	-0,3%	2,1%	-2,2%

To observe the efficacy of the regulations implemented under a waste management policy, an analysis of the evolution of number of actions per year and level of completion was investigated. The filling levels have been grouped into four levels: low-filled (0-3), medium-filled (4-6), high-filled (7-10) and the rest consisting of several containers with different filled levels, which are valued with a single figure (> 10). As observed in a year-on-year variation of filled-level containers for waste collection, there is tendency downward, especially for the low-filled levels. To check this data, Table 2 presents the interannual variation, for the level (0-3) for the three fractions of interest. In this table, the negative values have been colored, to highlight the cases that this downward trend has been met. As seen in the previous table, a reduction in the percentage of collections with a level (0-3) is observed, which would indicate an improvement in high-filled containers and, therefore, improves waste management (Fletcher & Dunk, 2018).

4. Conclusions

Waste management enforced through a regulatory scheme towards the achievement of targets set by the European Union is crucial to harness resource efficiency opportunities. This sort of policies is crucial to realize in practice the implementation of IS wherein waste of one industry may become a resource to another value-added production process, thereby enhancing resource efficiency. The findings of this study show that an increasingly strict waste management policy improves separate collection of waste, especially in three waste streams.

Originally organic waste stream which was more relevant for the policy-makers due to its environmental impact and the prevalence for a high rate of recovery to composting had been subject of variations in collection rates under this policy. Although not as representative as organic waste stream in terms of target for collection of waste, other waste streams (e.g. inert) collected seems to follow similar patterns that suggest this could be an approach to enforce in subsequent regulation schemes. These open up opportunities for other materials to be recovered and, therefore, drive waste management regulation into a resource management approach. Hence, it is important to achieve a more integrated waste management to provide solutions for a circular economy.

This study was limited by a narrow timeframe of 5 years in only one region which leaves our argument limited to a single regulation scheme set in place. Nevertheless, our study shows that proper regulation set in place with the participation of the waste management sector may increase opportunities for certain types of waste to be recovered. Thus, an internal market for high quality secondary raw materials could be set in place in a circular economy model in Europe if it is enabled by the implementation of different strategies such as industrial symbiosis.

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Circular Business models and the challenges for recovering value from used lithium-ion batteries

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Abstract

Business models for the Circular Economy, or Circular Business Models (CBMs), is a growing field of research applied in various industries with the incentive to close the loops of materials and energy through maintaining the value of goods throughout the lifetime. Global trends, such as electrification of the transport sector and increased consumption of energy from renewable sources, have led to rapid growth in the number of high capacity lithium-ion batteries (LIBs) in use. As the use of LIBs increase, sustainable lifetime management (including end-of-life) is needed to avoid potential harm to our health and the environment and to ensure effective resource efficiency. Some literature exists regarding this topic; however, it is primarily focusing on technical and economic issues with recycling and reuse of batteries rather than circular business models. The purpose of this study is to explore CBMs for spent LIBs, critically assess their potential, barriers, drivers, and necessary stakeholders to enable a second life of LIBs. The Delphi panel method is applied, communicating with LIB experts from various disciplines to identify and rank appropriate CBMs. The Delphi panel structure covers the following categories: ecological impressions of LIBs; CBMs; drivers for recovering LIBs; barriers; and stakeholders. According to the experts, the highest ranked CBM is resource recovery of discarded materials followed by product life extension. Findings furthermore reveal that the most important driver is national and international regulation and policies, and the most critical barrier is financial closely followed by lack of technical standards. There are several opportunities for further research on the topic, including empirical, and examine value creation in CBMs for LIBs.

Keywords: Circular business Models, Lithium Ion Batteries, Electric Vehicles, Energy storage, Circular Economy

1. Introduction

As global society moves towards increased sustainability, governments, institutions, firms, and consumers need to join forces to achieve meaningful targets such as the Sustainable Development Goals (SDGs). UN SDG Eleven is about the development of "Sustainable cities and communities" (United Nations, 2015a); working towards this goal represents an opportunity for implementing circular economy (CE) and transitioning towards low carbon societies with zero waste and pollution.

In line with the transition to low carbon societies, renewable energy production is expected to increase. At the same time, electrification of the transport sector will lead to the production and consumption of high capacity batteries in increasingly larger volumes (Winslow et al., 2018; Zhang et al., 2018). Utilizing batteries, such as the lithium-ion battery (LIB), can potentially aid in reducing emissions both now and in the future (Gaines, 2014).

However, production and lifetime management of LIBs implies various challenges associated with obtaining raw materials, and particularly the lithium which may achieve a future demand of one million tonnes annually in 2050 (Speirs and Contestabile, 2018). Moreover, it is unclear the future prices of lithium and the extraction barriers, and the development of

new technologies for energy storage. Additionally, it can be environmentally hazardous and must be handled responsibly within the frameworks of the CE (Ahmadi et al., 2014; European Commission, 2019; Melin, 2019).To overcome these barriers, companies can work towards a CE at an organizational level by adopting circular business models (CBMs) and implementing circular strategies, such as reuse, as part of the core business activities. A better understanding of CBMs for recycling and reuse of batteries contributes to SDG Eleven through increasing the use of renewable energy sources, battery recycling and waste reduction, and reducing environmental impacts in a lifetime perspective.

To understand the dynamic between electric transportation and circular use of batteries, it is essential to recognize that recent academic literature is focused on economic and technical studies of second life LIBs (Heymans et al., 2014; Martinez-Laserna et al., 2018) rather than CBMs, except a few studies discussing business model barriers, and drivers (Jiao and Evans, 2016; Olsson et al., 2018). Therefore, there is a gap related to the CBM challenges and drivers in the battery sector, which are necessary to make battery reuse and recycling feasible.

This gap has led us to propose the following research questions: What are the existing CBM's and which have the highest potential in the context of LIB lifetime management? What are the main challenges and drivers to create CBMs in the LIB market?

This study's research objective is to fill this gap in literature by carrying out a novel Delphi study to identify the context adapted CBM designs and rank them based on their potential towards the feasible management of used LIBs. Moreover, this study unveils the most important drivers, barriers, and stakeholders to develop CMBs associated with LIB lifetime management.

2. Lithium-ion battery value chain

LIBs are already used for a wide range of services in mobile and stationary applications. Electromobility and electric vehicles (EVs) represent the largest growing sector for LIBs. In 2018, the total global number of full battery electrified EVs was already above 4 million and is estimated to reach a global market share of 20% by 2025 while already accounting for 3% of the European vehicle fleet (Melin, 2018).

A battery pack used in an EV comprises several components such as the casing, electrical components (e.g. battery management system, converters, switches, wires, sensors), and individual battery modules and cells. An average lithium-ion battery pack (by weight) is approximately 40% casing, 15-27% cathode, 3-5% separator, 10-18% anode, and 10-16% electrolyte (Zhang et al., 2018). Spent lithium-ion battery packs have about 1 kg of lithium per 28 kg of mass, which is comparable to the amount of lithium in raw ores while battery recycling has lower environmental impacts than raw material extraction (Dunn et al., 2015; Zhang et al., 2018).

For this study, however, the main interest is the battery cell and how these batteries can be managed for second life and recycling. When an EV battery reaches 70-80% of its initial capacity (Faessler et al., 2019; Keeli and Sharma, 2012), the battery pack is disassembled and processed by a battery handler. The battery handler can either assess if the battery is suitable for reuse applications or if the battery must be sent for recycling. The handling process involves the diagnosis of the battery's state of health (SOH) followed by the sorting for second life or recycling. In case of second life, the batteries get repurposed on battery pack, module or cell level in a new energy storage system. Typical reuse applications are stationary storage applications, which are normally less demanding than mobile applications (Reinhardt et al., 2017). A second use battery can be used until it reaches 60% of its initial capacity until it must finally be sent for recycling (Cicconi et al., 2012). However, the second use of EV batteries does not usually happen and used EV batteries are typically sent directly to end of life treatment leading to low rates of material recovery for use in new cell manufacturing. This system, known as the lithium-ion battery value chain, is shown in the figure below.

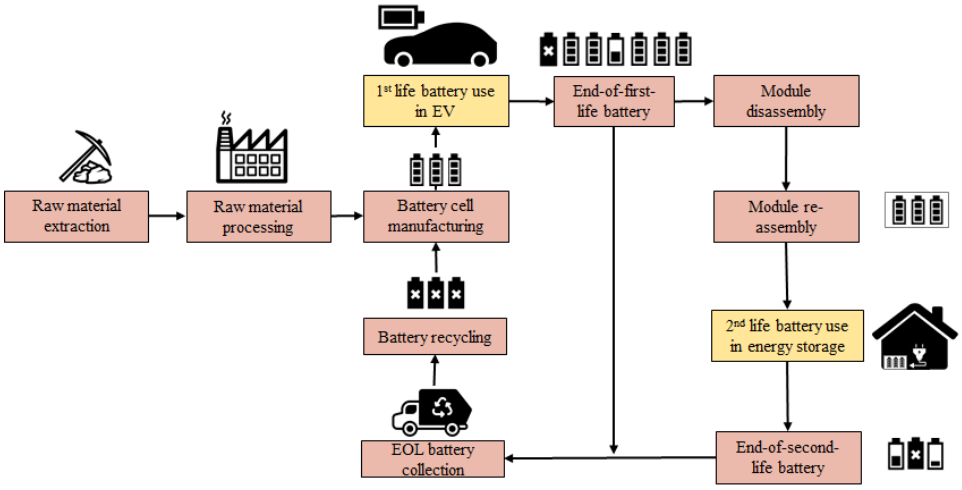

***Figure 1**. Lithium-ion battery value chain. Own elaboration.*

In 2018, recycling firms estimated that 97 000 tonnes of lithium-ion batteries would need to be recycled globally; however, the forecast for 2025 already indicates four times this amount (Melin, 2018). Recycling of LIBs is more challenging compared to other batteries such as Pb-acid, since they have a wider variety of materials in each cell. LIB recycling typically involves the separation of casing and electrical components as well as the decommissioning of the battery pack to modules and/or cells. These fractions are often exported to Asia for further processing (Brandslet, 2019). In general, industrial LIB recycling processes are inefficient because currently not all materials are recovered; only the most valuable materials such as copper, nickel, cobalt are recovered (Ordoñez et al., 2016). The main material recycling methods are pyrometallurgy, hydrometallurgy, and biometallurgy where several environmental issues regarding wastewater, residue, and exhaust gas require further treatment (Zheng et al., 2018). The lack of optimization in recycling processes for battery material recovery due to a lack of standardization efforts and due to the large variety of battery chemistries and producers. Consequently, the current low recycling volumes do not allow for separate and optimized processes for each battery type.

Although lithium itself is not known to be very toxic to humans (Aral and Vecchio-Sadus, 2008), the additional materials in batteries, especially heavy metals such as Ni and Co, are both carcinogenic and mutagenic to humans and animals and exposure and release to the environment should be avoided (Banza et al., 2009; Chagnes and Pospiech, 2013). Material recovery and protection of natural and human life are thus the main incentives for developing circular lithium-ion battery value chains (Pagliaro and Meneguzzo, 2019).

Fortunately, the 2020 EU Circular Economy Action Plan has a stated goal of "boosting the circular potential of all batteries" (Commission, 2020). This plan identifies the importance of evaluating battery value chains from a sustainability and transparency perspective finding ways for closing the loop of materials. Moreover, it opens the door to design CBM for battery reuse, repurposing and finding ways to eliminate waste and pollution in the value chain. It is critical for the European and global battery market to ensure that these issues can be dealt with in both sustainable and economically viable ways to push the battery market towards circularity (Gaines, 2014).

3. Circular business models

The business model concept is discussed with various perspectives and definitions in literature. However, most researchers hold a systemic view focusing on both what the business does and how they do it (Zott et al., 2011). A business model is vital to facilitate the value of products and services and aims to describe the competitive advantage (Chesbrough, 2010). In this sense, many authors have adapted the "business model canvas" designed by Osterwalder and Pigneur (2010) with the following

nine building blocks: customer segments, value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure. In this regard, two additional components should be included to adopt a circular business model canvas: a design for a “take-back" system and adoption of factors that are required to manage the transition to circular practice (Lewandowski, 2016). Nußholz (2017)states that firms should rethink how an organization “creates, delivers, and captures value” throughout the product lifecycle with less environmental impact and within the CE framework. Consequently, the exploration of circular business models for recovering value from lithium-ion batteries needs to identify the potential value even after they are discarded from electric vehicles.

This leads us to the second aspect that needs to be addressed, namely the circular business model taxonomy. Recently, Vermunt et al. (2019) identified four types of circular business models in terms of the 4Rs (reduce, reuse, recycle and recover) framework proposed in the EU Waste Framework Directive (European Commission, 2008; Kirchherr et al., 2018). The four models are 1) product-as-a-service model, 2) product life extension, 3) resource recovery, and 4) circular supplies. Moreover, Vermunt et al. (2019) report that each of the models faces some barriers. The product-as-a-service model, which is focused on leasing or performance models, mainly faces organizational, financial, and market barriers. The product life extension has supply chain and market challenges while the business model for resource recovery faces supply chain, market, and institutional barriers. The business models for circular supplies are mainly threatened by knowledge and technology, supply chain and market barriers. Six major CBM patterns are identified by Lüdeke-Freund et al. (2019): repair and maintenance; reuse and redistribution; refurbishment and remanufacturing; recycling; cascading and repurposing; and organic feedstock. The CBM can promote different types of loops: “closing loops, slowing loops, intensifying loops, narrowing loops and dematerializing loops” (Geissdoerfer et al., 2017). All contribute to the circular economy from an organizational level and such a business model that creates value from waste is identified as a sustainable business model archetype (Bocken et al., 2014). Olsson et al. (2018) proposed two circular business models specifically for spent electric vehicle batteries: refurbishment after the first use, followed by second life in an electric vehicle in another market, and lastly, recycling, or repackaging followed by second life in another application, and recycling. Barriers to facilitate these are categorized as technical, organizational, and cognitive.

Several stakeholders in the battery value chain see the potential of a second life for LIBs. There is, however, a need to fight the current (Jiao and Evans, 2016; Martinez-Laserna et al., 2018; Olsson et al., 2018). Three significant factors encourage businesses to seize these opportunities: battery ownership, inter-industry partnership, and policy support (Jiao and Evans, 2016). By collecting knowledge from several experts using, the Delhi-panel method, this study contributes to a better understanding of the current status, challenges, opportunities, and drivers to move LIBs towards greater circularity.

4. Methods

This study carried out a Delphi panel intending to answer the research questions based on the above described theoretical framework and the Delphi method. The Delphi method is a systematic and iterative process for structuring a group communication process to obtain consensus between experts about a complex problem (Dalkey, 1969; Linstone, Harold A. Turoff, 1975; Okoli and Pawlowski, 2004). The Delphi technique was chosen in this research project for three significant reasons. First, the fast development of this phenomenon implies a high amount of knowledge exchange within the business ecosystems, which requires managerial sources. Second, the academic literature about CBM for LIB end-of-life management is scarce; for example, a combined search in WoS about the topics “circular economy” AND “lithium” AND “business model*” shows only the paper published by Reinhardt et al. (2019). Most of the existing studies apply the interview method (Jiao and Evans, 2016; Olsson et al., 2018). Finally, the Delphi panel method is suitable for research on framework development (Okoli and Pawlowski, 2004), such as, in this case, to identify particular CBMs for the batteries industry.

The Delphi method utilised was enhanced with the opinion and consensus from multiple practitioners, academics, and CBM experts from different European and American countries. The method is characterized by an anonymous and iterative process,

and it provides controlled feedback and a statistical response from the group (Landeta, 1999). Controlled feedback refers to the communication of the group opinions at the beginning of each round. Moreover, a statistical response guarantees the presence of each viewpoint in the result and reduces the pressure toward conformity (Landeta, 1999). This method is preferable to minimise bias and increase the freedom to express opinions because participation is anonymous. The iterations give the experts time to think over the proposed topic by reconsidering their preliminary idea. Other participative methods like interviews and focus groups provide few minutes to answer questions or develop activities. In contrast, the flexible design of the Delphi method allows participants to answer in the comfort of their home or office, with low time pressure. In these conditions, the collection of more abundant data is possible, which leads to a deeper understanding of the questions (Okoli and Pawlowski, 2004).

4.1. Participants and recruitment strategies

To contact and define a broad and diverse group of panel candidates ("stakeholders, […] who are or will be directly affected; experts, […] who have an applicable specialization or relevant experience; and facilitators, […] who have skills in clarifying, organizing, synthesizing, stimulating" Scheele, (1975), the research group developed multiple strategies, such as, search through research communities, professional networks (LinkedIn, ResearchGate), academics authors of LIB management and CBMs, and referrals from expert colleagues. Thus, people with experience in sustainable transportation technologies, lithium and traditional batteries management, CBMs, and smart cities were contacted. The participants' demographic and individual aspects, such as gender balance and cultural diversity were accounted for to ensure heterogeneous perspectives.

Forty-five (45) experts from different companies, consultancy firms, research centres, and universities were invited to participate in this Online Delphi Panel. For carrying out a Delphi study, it is advisable to have between 10 and 18 experts to participate, as in this kind of study, the key factor is to have a dynamic discussion to achieve a consensus, rather than a statistical power (Okoli and Pawlowski, 2004). The rate of acceptance was 47% for the first round, which is 21 participants including men and women from different countries (Colombia, Finland, Italy, Mexico, Norway, Spain, and the USA). About 65% of the participants are 41 years old and older (15), 28 participants hold a master's degree and 11 have doctorate degrees. 20 out of 21 participants confirmed they have more than five years of experience in the field of LIBs and batteries, and 9 have more than 20 years. Nonetheless, only 12 participants finished both rounds.

As soon as the experts confirmed their participation, they were informed about the objective, method, and ethical considerations of the study, and received a LimeSurvey link to answer the Delphi round. The researchers chose the LimeSurvey platform because it gives the option to guarantee anonymized responses, confirms the experts' participation, offers different question formats, and provides automatic reports and data security. At the end of each round, participants received a statistical report that prompts them to rethink their opinions and look for consensus. In this report, each expert's previous answers, and the mean of the group's ranking were provided (Skulmoski et al., 2007). At the end of the process, all participants will receive a report on the activity and a certificate for their participation. Throughout the process, they never know the identity of the other participants.

4.2. Data collection structure and performance

The Delphi was structured into five assessment categories based on the circular business models proposed by Vermount et al. (2019) (Table 1). The first assessment category of the Delphi rounds explored societal preconceptions related to the contribution of LIBs in EVs to reduce transport emissions and the transition to low carbon energy to reduce air pollution. The second section is dedicated to evaluating the potential viability of five CBM proposals, as well as investigating the existence of other business models that allow the recovery of LIBs within the framework of CE. The third section focuses on identifying the drivers that will enhance the recovery

of LIBs and their relevance for this purpose. Panellists were then asked about the importance of hard barriers and soft barriers that can hinder the recovery of LIBs. Finally, the last section evaluated the influence of different stakeholders that can facilitate or impede the development of CBMs in the context of LIBs.

Table 1. *Delphi panel structure*

Assessment category	Description	References
Ecological impressions of lithium-ion batteries	LIBs contribution to the environment: • Decrease global warming from transportation • Sustainable option for energy storage • LIBs reuse for crisis and isolation scenarios	(Speirs and Contestabile, 2018)
Circular Business models	Potential of CBM to extend the use or recover the value from used lithium-ion batteries that have been discarded from EVs: • Product-as-a-service model • Product life extension by durable design, update services, remanufacture • Resource recovery of discarded materials (waste) • Circular supplies by using recyclable or biodegradable materials Current circular practices for LIBs recovery in organizations and firms	(Merli and Preziosi, 2018; Nußholz, 2018; Vermunt et al., 2019)
Drivers for recovering lithium-ion batteries	Assessment and prioritization of drivers that encourage more efficient waste management of lithium-ion batteries: • National and international regulation and policies • Global difficulties in exploiting raw materials • Pollutant risk • Raw material availability • Second-hand material availability • Raw material production costs • Production and recovery technologies • Logistic and infrastructure development • Waste management costs • Potential applications of recycled products • Potential profits from reuse or remanufacturing • Consumer behaviour	(Balbuena and Wang, 2004; EYDE and NCE, 2019; Speirs and Contestabile, 2018)
Barriers for recovering Lithium-ion batteries	Assessment and prioritization of barriers for recovering materials from lithium-ion batteries: • (Soft) Human talent • (Soft) Socio-cultural • (Soft) Market • (Hard) Technology • (Hard) Infrastructure • (Hard) Financial • (Hard) Legislation	(Garcés-Ayerbe et al., 2019; Kirchherr et al., 2018; Prieto-Sandoval et al., 2018b; Rizos et al., 2015; Vermunt et al., 2019)
Stakeholders for recovering Lithium-ion batteries	Assessment and prioritization of stakeholders that may encourage the waste lithium-ion batteries management: • Governments • Institutions • Research centres and universities • Car users and shoppers • Car producers • Public transport companies • Suppliers • Waste managers and recyclers	(Bocken et al., 2014; Del Río et al., 2016; Ellen MacArthur Foundation, 2015)

The importance of these elements was assessed on a Likert scale from 1 to 6, where one is “Not important” and six is “very important”; the par number avoids average answers. Other questions were designed to ask for an extended explanation (especially when their opinions were too distant from the group), which require suggestions to enrich the categories and invite experts to reach a consensus. As the responses were anonymized to protect personal data of participants, it was not possible to contact them via email or telephone to ask for additional explanations. A total of two online Delphi rounds were carried out,

and each round presented information with the overall results and comments by the panellists (names withheld) intending to promote the consensus and at least make a personal reflection about the group answers.

5. Results and discussion

This chapter will present the preliminary results of the Delphi panel study, representing two of three rounds, with 21 experts participating in first round with 12 experts in the second round. The results show the expert opinion regarding CBMs for spent LIBs, the challenges and drivers to move forward, what is needed for closing the loops of materials and energy in LIB value chains, and by debating the opportunities to upscale circular practice. Finally, the study assessed the importance of the stakeholders who may support the LIB waste management improvement within the CE framework.

5.1. Ecological impressions of lithium-ion batteries

The push towards a CE aims to close the loops of materials and energy in biological and technical cycles to avoid the exploitation of raw materials, keeping the value of goods during its life cycle and contributing to sustainable development (Prieto-Sandoval et al., 2018a). As the study concerns business models for CE, the participants were asked to consider the degree of environmental sustainability of lithium-ion batteries from electric vehicles. Table 2 shows the average answer based on responses from all participants, who answered on a Likert scale from 1 (completely disagree) to 6 (completely agree). The authors also added a question related to the global COVID-19 pandemic, about the usefulness of LIBs during crisis and isolation scenarios.

Table 2: *Ecological impression of EVs and LIBs (second round)*

Ecological Impressions	**Average**	**Standard Deviation**
Reuse of lithium-ion batteries is an excellent choice in crisis and isolation scenarios	4.7	1.0
Electric cars are the most feasible choice to decrease global warming from transportation	4.4	0.9
The lithium-ion batteries are the most sustainable option for energy storage	3.9	1.0

Most experts (13) confirmed they mostly agree (12) and completely agree that “Electric cars are the most feasible choice to decrease global warming from transportation”. This finding corroborates the purpose of regions as the European Union, and multiple governments towards the transition from a fleet of fossil energy-based vehicles to the implementation of electric mobility systems with sustainable energy sources (European Commission, 2020). The experts recognize that EV performance helps to reduce air pollution and contributions to global warming. Global warming reduction is a critical goal since COP21 in Paris when more than 175 countries committed to ensuring that global temperatures do not go above 2C from the average since 1850 (United Nations, 2015b). Even one of the participants points out that China’s transition towards an EV fleet will have socio-environmental benefits for 2030 and 2050 (EMF, 2018).

Nonetheless, the questions that are mainly associated with LIBs, present divergent opinions with a high standard deviation. This divergence is attributed to difficulties surrounding LIB waste management and the intensive use of raw materials in LIB

technology. Surprisingly, the participants showed many concerns about behavioural or "soft" solutions such as the importance of public transportation use, reduction in the number of cars produced through smart mobility and shared transport solutions.

Most of the participants agree that "Reuse of lithium batteries is an excellent choice in crisis and isolation scenarios", however have concerns about LIB waste management and recycling, which is not feasible in all countries.

5.2. Circular business models

The main objective of this study is to identify existing and potential CBMs to recover value from spent LIBs. Thus, the participants were asked to assess the potential of four CBMs, and a fifth option added in the second round, the "Hybrid models" based on the research published by Vermunt et al. (2019). Table 3 shows the average ranking. All models are interpreted as average potential.

According to the experts' opinion, the *resource recovery of discarded materials (waste)* is considered to have the highest potential, based on the first and second Delphi panel rounds (Table 3). This also corresponds with earlier observations, which showed that LIBs contain a set of valuable materials that could represent a profitable opportunity by optimizing hydrometallurgical processes for battery materials recovering (Heelan et al., 2016).

Table 3: *CBM potential to extend the use or recover the value from used lithium-ion batteries stemming from electric vehicles (first round).*

CBM	Average	Standard Deviation
Resource recovery of discarded materials (waste)	5.0	0.9
Product life extension by durable design, update services, remanufacture	4.8	1.1
Product-as-a-service model	4.6	1.1
Circular supplies by using recyclable or biodegradable materials	4.3	1.5

Interestingly, in the first round (Table 3) more than half of the participants declared that they know firms and organizations which are developing CBM or technical applications to recover value from LIBs and improve the sustainability of its materials. Nine confirmed that they are familiar with a firm that offers battery performances as a service instead of battery ownership, and 13 participants knew a firm which is providing remanufacturing/reassembly of lithium-ion batteries. Thirteen answered that they are familiar with firms, research centres, or any other organization that improve the material sustainability of LIB components. Interestingly, 13 also confirmed that they know one that reuses LIBs that come from EVs. These results provide evidence about the feasibility of every CBM analysed in this study.

The participants were further asked if any business models are missing, and a few of the participants contributed to the following proposals:

"Vertical integration of LIB production and recycling"

"Cascaded life cycles make sense. But it really depends on the condition of the battery and the second life application"

"A mixed model: Reuse + Reman + Recycle + Disposal"

"Second life as energy storage taken care of by separate business entity, without the "batteries-as-a-service"-model"

"Platform business model with smart cars in the platform"

"2nd use in general"

Consequently, the second round asks for three different combinations of hybrid CBM (Table 4). In this round, more than 80% of participants considered that the best combination is: Reuse + Product life extension (Remanufacture)+ Resource recovery of discarded materials (Recycle) + Waste management.

Table 4: *CBM potential to extend the use or recover the value from used lithium-ion batteries stemming from electric vehicles (second round).*

CBM	Average	Standard Deviation
Hybrid model - Option C: Reuse + Product life extension (Remanufacture)+ Resource recovery of discarded materials (Recycle) + Waste management	4.75	1.8
Resource recovery of discarded materials (waste)	4.7	0.98
Product life extension by durable design, update services, remanufacture	4.7	1.3
Hybrid model - Option A: Vertical integration of LIB production + Resource recovery of discarded materials (Recycle	4.3	1.9
Hybrid model - Option B: Product life extension + product as- a-service model (to ensure the product can be remanufactured after use)	4.1	1.6
Product-as-a-service model	4.1	0.9
Reuse (Immediate resale or reuse of the Li-ion batteries WITHOUT any upgrading process, Ex. Second-hand for energy storage without remanufacturing process)	3.8	1.76
Circular supplies by using recyclable or biodegradable materials, procurement of renewable materials	3.5	1.3

With the aim to confirm the most feasible CBM in the second round, the participants had to rank the CBMs based on their potential to extend the use or recover the value from used lithium-ion batteries that have been discarded from electric vehicles. The ranking confirmed the following priority order:

1. Resource recovery of discarded materials (waste)
2. The hybrid models
3. Product life extension by durable design, update services, remanufacture.
4. Product-as-a-service model
5. Circular supplies by using recyclable or biodegradable materials

Thus, it was confirmed that contrary to expectations and previous work of Vermunt et al. (2019) and product-service system literature, the Product-as-a-service model is one of the least-desired CBM options, according to the experts in this study.

5.3. S Drivers for CBMs of LIBs

To upscale CBMs for LIBs, an assessment category suggested twelve drivers and asked to assess the importance of each on a Likert scale from 1 to 6. Figure 2 shows the average ranking. The overall, national and international regulations and policies are considered the most important driver, followed by potential profits, and then raw material availability.

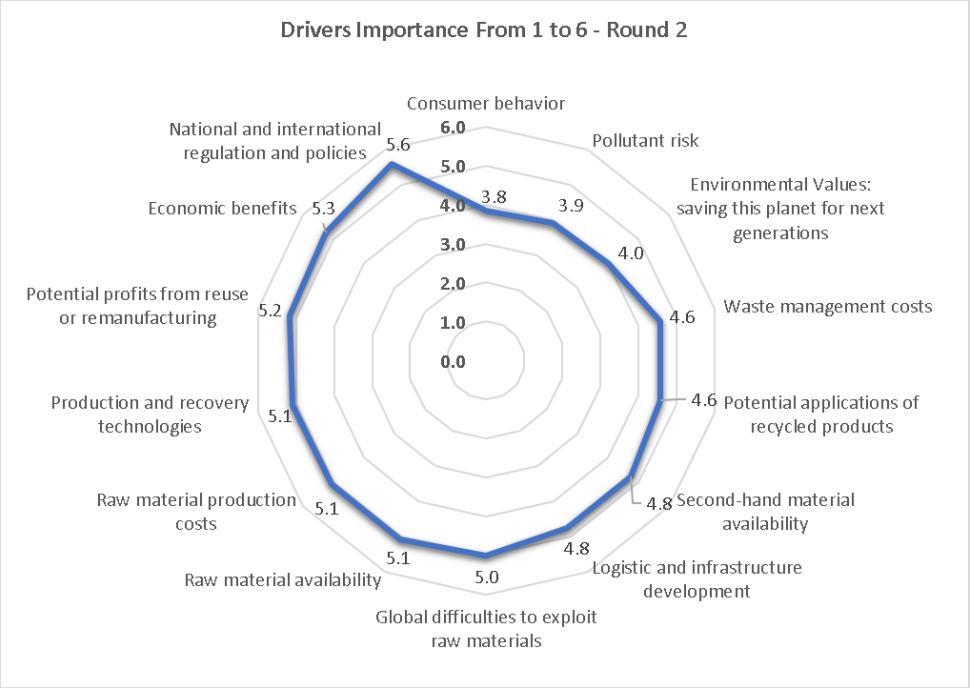

Figure 2: *Drivers' importance for CBMs of LIBs.*

In one of the questions, participants ranked the importance of several drivers relevant for recovering lithium-ion batteries. The answers and standard deviation varied regarding the degree of importance. For example, for pollutant risk where all alternatives except "not important at all" on the Likert scale received votes. One explanation can be the large variety of expert roles in the battery value chain included in this study. Both organizational- and individual values may affect the responses in this question.

There was almost complete consensus that *national and international regulation, and policies* are the most important drivers while *Consumer behaviour* was the least important driver (67%). For *raw material availability*, most agreed about the importance. This implies that the governments and international institutions have the ability to influence the consumers' decision-making process and to pressure firms and institutions to develop eco-innovation by incentives or penalties (Horbach et al., 2013).

The economic driver was proposed by one of the experts in the first round, and it gained prominence in the following round as the second most important driver. Two potential benefits come from the lithium-ion batteries recovery: the materials supply for the growing EV industry, and the mitigation of environmental impacts from lithium extraction. This result is consistent with the Yaksic and Tilton (2009) study, who argue that an increase in lithium carbonate prices from $2 per pound to $7 and $10 per pound of lithium carbonate may enhance the interest of extraction from seawater. Then, an increase in the EV use globally would increase the lithium prices and the interest of recovering materials from used LIBs.

5.4. Barriers for CBMs of LIBs

As acknowledged, there are challenges at different levels which prevent circular practice such as enabling a second life for LIBs. Seven hard and soft barriers were proposed by the authors for the Delphi panel participants to assess the significance of

these on a Likert scale from 1 to 6. Figure 3 shows the average ranking. Thus, overall, financial and legislation are considered to be the most critical challenges to tackle.

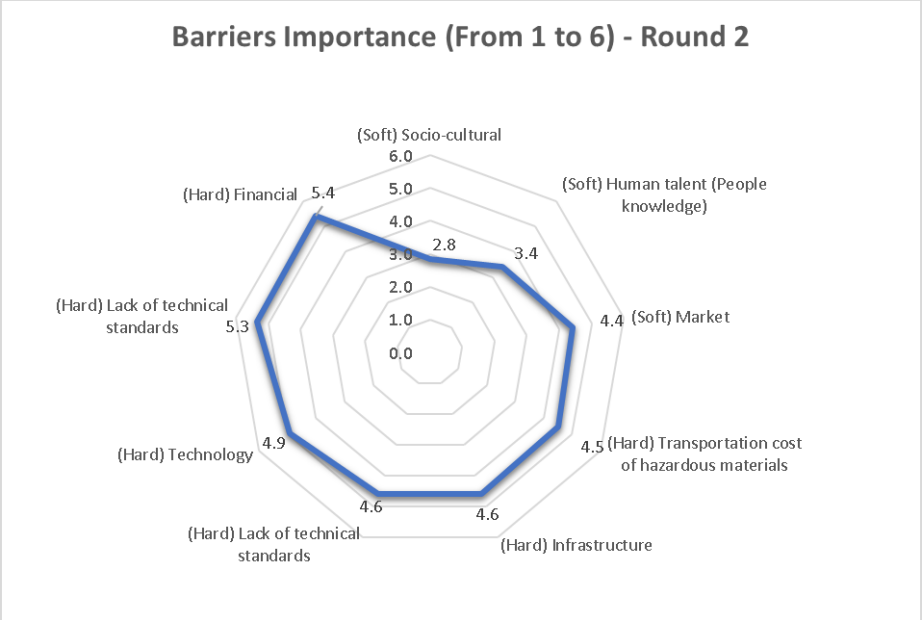

Figure 3: *Barriers for CBMs of LIBs*

The experts gave the highest importance to "hard" barriers, especially legislation, financial (e.g. Incentives, financial viability), and transportation cost of hazardous materials. The experts also expressed that a legal framework would support a transparent and predictable market and would encourage the second life market of LIBs. In contrast, the "soft" barriers got lower scores, especially the Socio-cultural (Experiences + culture) and Human talent (People knowledge).

In addition to the barriers proposed by the researchers, the participants wanted to emphasize the following barriers: Transportation cost of hazardous materials; and lack of a well-defined policy scheme and incentives to develop second-hand battery market.

This result is coherent with previous studies in the field (Matthias Buchert, Doris Schüler, 2009) that highlight a lack of economic incentives to recycle lithium, given its relatively low price. This barrier is closely related to the economic driver (explained above) because an incentive to close the loop in the LIB industry would increase the interest in CBM development.

5.5. Stakeholders for LIB waste management

Several stakeholders need to cooperate to recover value from spent lithium-ion batteries. The next section of the rounds concerned who are the most important stakeholders as ranked on a Likert scale from 1 to 6. Some of the experts suggested the following additional stakeholders: battery cell manufacturers, raw material producers, and renewable energy companies. One of the participants also stressed the importance of individual stakeholders to work together to develop a coherent LIB waste management plan.

Figure 4 shows the average ranking. Overall, governments are considered the most important, followed by car producers, battery cell manufacturers and raw material producers, and waste managers and recyclers. This result is consistent with the previous perception about the high importance of governments towards the LIBs waste management. In other words, the participants charge a high level of responsibility of LIBs management innovation on the governments, the firms (producers of EVs and LIBs), and waste managers who struggle to standardize LIBs recycling activities.

It is consistent with the previous drivers' assessment that car users and shoppers are considered slight important for used LIBs recovery. However, they manage the LIBs for most of the lifetime, and are responsible for final disposal in many countries.

The experts expressed in many ways that people are used to expecting an excellent product with a competitive price, and that consumers are not usually concerned about the destination of end-of-life LIBs and hazardous materials. It is essential to bear in mind the possible bias in this response because no experts work from the consumer or demand side. Most of the experts (18) work from the Academy, research centres and universities, and business, governments and international institutions (UN, UNEP, etc.) (3), NGOs, Foundations, non-profit entities (2), and consultancy firms (1).

One unanticipated finding was that experts consider that Research centres and universities are a highly important stakeholder which might be inconsistent with the low valuation they gave to "Soft barriers."

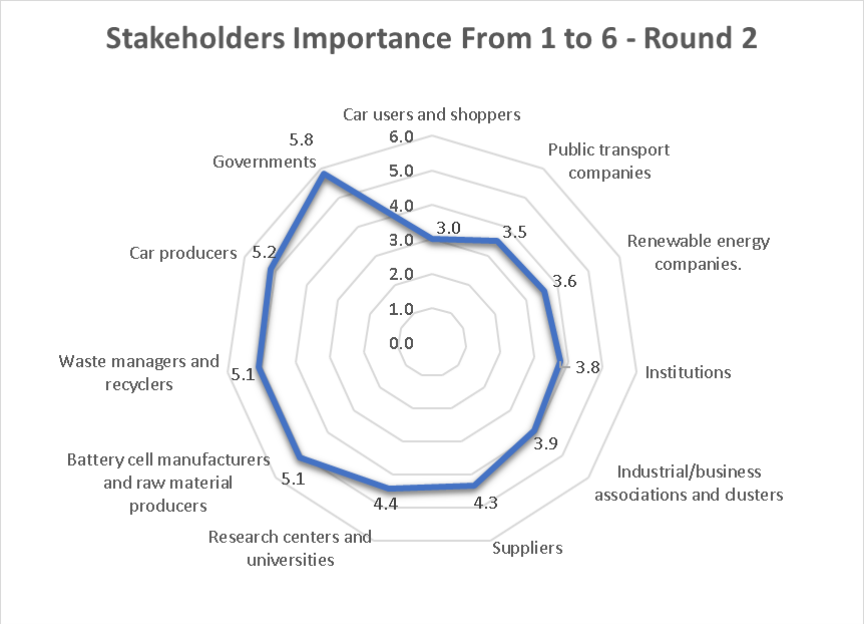

Figure 4: *Stakeholders importance for LIB waste management*

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6. Conclusions

The purpose of this study was to propose a context adapted CBM design and rank CBMs based on their potential towards the feasible lifetime management of spent LIBs. This research unveils the most important drivers, barriers, and stakeholders to develop CBMs associated with LIBs lifetime management. Findings reveal that five CBMs have potential to recover value from LIBs, with most identifying the "resource recovery of discarded materials" (waste), to offer the highest potential of economic opportunities to recover various valuable materials.

Economic benefits match with financial restriction, that's why CBMs are quite important to make it real. In fact, the technical reasons were never commented as a priority, in some way they take for granted that technical barriers and knowledge can be overcome, but the profit model is first.

Findings in this study show that lithium demand and potential price increase may accelerate the interest on applying CBMs to extend the use or recovery of the value from used LIBs from EVs. Thus, if a completely new LIB is cheaper than one made from salvaged materials, the transition to close the loop in LIBs value chain would be hindered by profit incentives.

The relevance of governments and institutions is clearly supported by the experts' opinion in the assessment categories of "drivers", "barriers" and "stakeholders" because they have the power to influence the relations in the market as policymakers. The critical "hard barriers", which may hinder CBM development for LIBs, are related to financial incentives, technology and infrastructure, and technical guidelines. An implication of this is the possibility that policymakers turn their attention to support the hard barriers and contribute to make EV technology more circular.

Unexpectedly, this study discovered that the consumer concerns, and their willingness to push for CBMs for used LIBs, are poorly valued by the experts. Thus, further research could explore the causes of the low relevance of consumer behaviour for the transition towards EVs and their potential motivation to enhance future EV and LIB demand. Future research may also examine value creation and capture in CBMs to upscale the reuse practice of LIBs.

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Circular spaces of alterity: the interplay of mainstream and alternative economic spaces for inclusive circular economy development

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Abstract

The new transformative circular economy paradigm, which emerged to address global challenges such as growing resource scarcity and climate change, has gained momentum among scholars and practitioners in recent years. Currently, circular economy (CE) discourse and practice is greatly focused on techno-managerial and profit-oriented mainstream economic processes whilst significantly overlooking alternative economic practices that generate social value. Very few studies have attempted to conceptualize CE using a diverse economy perspective (Gibson-Graham, 2006) that challenges mainstream representations of global capitalism and reveals the diversity of local economic activities and practices. We propose that a more holistic approach to the CE debate offers the potential to couple ecological premises of CE thinking with mission-driven social enterprises that tackle poverty and inequality, promote communitarian mode of functioning, and address environmental issues.

This contribution presents initial conceptual findings of a research project aiming to explore interrelationships between the mainstream and alternative economic spaces for the CE development. In doing so, it draws upon the literature on alternative economic spaces, diverse economies, social metabolism and social embeddedness; and employs two case studies: 1) *heidenspass* – a social enterprise project, which engages young individuals in reuse and upcycling activities across the wood/interior design, textile and food sectors in the city of Graz, Austria; 2) EMS, Ltd. - a social enterprise in the city of Hull, the UK, which is committed to alleviating food poverty by rescuing food waste. The key research methods included interviews with employees, interactive mapping sessions as well as empirical observations.

The research presents social circular enterprise as an entity entangled in the complex web of social and material relations that span mainstream and alternative economic realms. By examining how social enterprises and their alliances stimulate transposition of resources in a given institutional context, yet across the two economic spheres, the paper explores the meaning of such cross-realm interactions for the development of a more social and inclusive CE. It concludes that understanding complex relationships underpinned by monetary and non-monetary, material and non-material transactions, as well as ever-evolving political, socio-ecological and economic contexts in which social enterprises are embedded, is important when studying transition pathways towards a more sustainable CE.

Keywords: mainstream/alternative binary, social enterprise, circular economy, diverse economies, social embeddedness

Introduction

The global economy is engulfed in the narratives of growth-driven neoliberal capitalism, whose extractive and profit-driven nature is broadly associated with high rates of ecosystem degradation that surpass the Earth's capacity to restore its finite resources (Gibson-Graham, 2006; Rockström et al., 2009; Allen, 2015). The pressing environmental challenges have prompted academia and practitioners to explore new economic models that would challenge linear production models. One of the transformative paradigms that challenges the way businesses operate is the circular economy (CE). The CE has gained momentum among the European Union (EU) policy makers since the introduction of the CE platform and CE Package by the EU in 2014 (European Commission, 2019). Although the definition of the CE is constantly evolving, it generally refers to 'production and consumption of goods through closed loop material flows that internalize environmental externalities linked to virgin resource extraction and the generation of waste (including pollution)' Sauvé et al. (2016, p. 49). This is enabled by

CE practices such as 'long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling' (Geissdoerfer et al., 2017:6).

The development of the CE has received a lot of attention in industrial ecology, business and engineering (Korhonen et al., 2018), and yet such research often overlooks social aspects (Hobson & Lynch, 2016; Murray et al., 2017; Ranta et al., 2018). Currently the research on the CE does not question power relations and mainstream norms, which tend to restrict transformative character of alternative approaches to capitalist production systems and social relations. The present debate on CE also fails to address the root causes of the problems that CE is expected to tackle (Hobson and Lynch, 2016). This has implications for the existing alternative and CE-based solutions, whose development might be constrained by the controversial notions of 'green capitalism and consumerism' (Dauvergne and LeBaron, 2012 in: Hobson 2016). Consequently, there is a growing need to understand how such alternative practices could propel changes in linear economic systems (Schulz et al., 2019).

This paper argues that CE debate could benefit from better understanding of the interrelationships between the mainstream and alternative economic spaces by drawing upon the literature on diverse economies (DEs) (Gibson-Graham, 2006). The DEs concept demonstrates alternative and non-traditional economic activities not as much through the lens of markets and market transactions, but in terms of social desirability of a particular activity. DEs perspective is especially relevant in modern and increasingly environmentally conscious societies where diverse economic initiatives advocate novel ways of producing, distributing and exchanging goods, usually in local circles. More importantly, some of these non-capitalist, everyday economic activities often already embed CE principles such as resource reuse and sharing. An example of an alternative form of organizing, which challenges the dominant neoliberal narratives and may administer circular activities, concerns a social enterprise (SE). SEs emerge to address complex socio-environmental challenges such as ecosystem degradation, social isolation, unemployment, poverty or food insecurity, all of which may be (indirectly) referred to as negative externalities associated with capitalist practices. Contrary to many of the traditional mainstream capitalist firms, SEs reinvest profits back into their social and/or environmental missions rather than distributing them among SE shareholders (Longhurst et al., 2016).

Using a case study approach that concerns two circular SE projects working across the textile, interior design/wood and food sectors, this paper presents a conceptual model emphasizing material flows within a DEs framework and a broader socio-ecological, economic and political contexts, which impact cross-realm transposition of monetary and non-monetary resources and relations. In doing so, it adopts a social metabolism perspective, which acknowledges flows of materials and energy between, and within humans/society, and the biosphere. It also employs the lens of social embeddedness (Grannoveter, 1985) in order to show social relations underpinning material circulation as embedded in the broader economic system. As Hobson (2016) emphasized, there is a need for an approach 'that recognizes the contingent and spatially specific nature of systemic change' (p.94) when exploring CE transitions.

1. Methods

This paper emerges from the international collaborative project on circular economy – CRESTING. One of its sub-projects explores the role of social enterprises in stimulating local CE development in different spatial contexts (Graz, Austria; Hull, UK; and Metropolitan & Valparaíso regions in Chile). This paper focuses on two SE initiatives: *heidenspass* project in the city of Graz (the project is formally executed by an association called Verein Fensterplatz), and EMS, Ltd. in Hull, UK. *Heidenspass* was founded in order to offer entry level employment opportunities to disadvantaged youth. Its activities are executed in seven distinct economic units, namely textile workshop and interior design workshop, two kitchens, offline and online shop, and eatery (adjacent to the shop). The enterprise project employs the following CE practices: 1) upcycling; 2) reusing materials; 3) using vacant spaces; 4) repair. Upcycling concerns creative reusing/ repurposing of materials such as

reclaimed wood or rubber hoses to make furniture. Reusing is manifested in the use of old, second-hand sewing machines and ovens, as well as food surplus from the supermarkets that would otherwise go to the landfill. Given that *heidenspass* premises are rented, the enterprise also maximizes the use of vacant spaces in the city. Besides, the enterprise offers its customers repair services in order to expand the lifespan of their homemade products. Activities offered by EMS, Ltd., on the other hand, revolve around the food sector and concern collections of food donations and food surplus from the supermarkets for sales among disadvantaged people in the local community shop at affordable prices. CE at EMS, Ltd. is hence manifested in the reuse of food products that would be otherwise sent to landfill.

The total of 12 interviews were conducted with 13 members of *heidenspass* staff during one week visit to the organisation in November 2019: CEO, two members from the core team, three key staff members representing the main kitchen and textile department, and seven young employees aged between 16 and 29 year old. One interview was additionally conducted with the member of a core team during the scoping visit in May 2019. The interviews lasted approximately 30-80min and were conducted in person. They were complemented with interactive mapping sessions, which enabled to identify and map flows of inputs and outputs to/from the enterprise, yet across the mainstream and alternative economic spheres. These sessions incorporated the lens of relational reflexivity, which enabled to reflect 'the material arrangements and their social meanings in how collective sense making and action emerges' (Allen, 2015:7-8). Several semi-formal interviews were conducted with EMS, Ltd. - a Cresting project partner organization - in the period between October 2019 and December 2019. They were complemented with empirical observations in the Hull Community Shop and attendance of social events organized by the enterprise (e.g. 10th Anniversary). All the interviews were recorded, transcribed and analysed adopting thematic content analysis approach, which enabled to identify key patterns and themes surrounding the functioning of each project. These patterns and themes enabled the development of a conceptual model featuring circulation of materials and formation of stocks of capital across the mainstream and alternative economic spheres and within the broader contexts (ecological, socio-economic and institutional).

2. Results and Discussion

This paper proposes a broader conceptual model depicting physical resource metabolism across the mainstream/formal (i.e. regulated) and alternative/(semi-)informal (i.e. un-/semi-regulated) economic spheres within a broader ecosystem. Drawing upon the concept of social embeddedness (Granovetter, 1985), it contends that understanding of the socially embedded nature of resource flows in the complex institutional and socio-ecological contexts is important when exploring pathways toward sustainable CE developments. Based on the data derived from the interviews, and inspired by the conceptual model representing physical resource flows within the formal economic spaces developed by Laurenti et al. (2018), the Economic Iceberg by Gibson-Graham (2006), and representation of social metabolism by Haas et al. (2005), the Figure 1 depicts inflows and outflows of physical resources (inputs and outputs) across the mainstream and alternative realms.

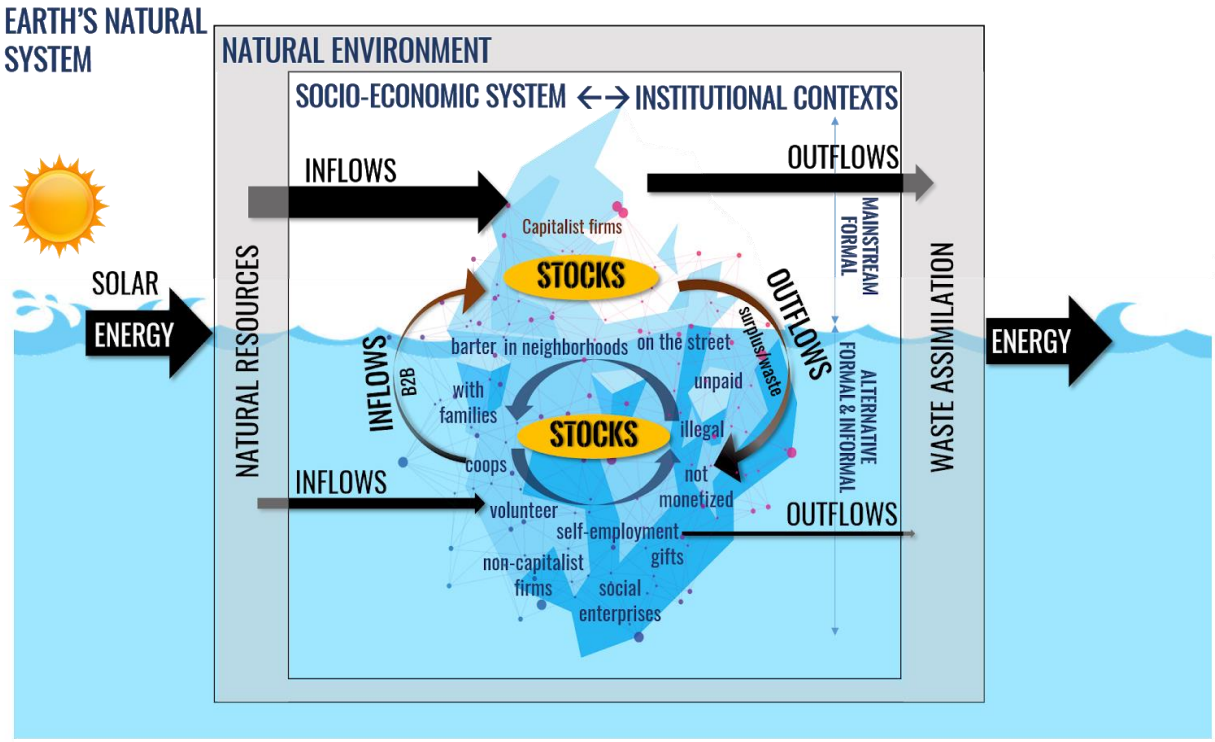

***Figure 1**. Physical resource flows across the mainstream and alternative economic spheres*

The core of the model – the Economic Iceberg diagram - unravels the diversity of alternative economic forms and ways by which people produce, exchange and distribute goods and services outside the dominant capitalist paradigm, namely profit-driven capitalist firms/international corporations. These alternative forms may range from consumer/worker cooperatives, bartering or any voluntary work in non-profits to social enterprises such as *heidenspass* project or EMS, Ltd. Even though alternative economic spaces are positioned in the submerged part of the iceberg, the multitude of such forms and their existence prior to the encroachment of capitalism challenge the idea of viewing alternative economic activities and spaces as marginal, subjugated phenomena or subsystems of the capitalist system (Gritzas & Kavoulakos, 2016).

Following the social metabolism perspective, the iceberg is subject to inflows of resources from the natural environment, including life-sustaining energy flows ('energy arrows'), which permeate the entire ecosystem, including human agents (Foster, 2000). The formed 'stocks' in each economic realm refer to stocks of accumulated capital (i.e. social, natural, human, built and manufactured, financial), which sustain both mainstream and 'submerged' alternative economic activities. These stocks denote intrinsic, rather than purely instrumental, value of economic activities, and vary across downstream and upstream spheres in terms of their functional value and material composition. For example, the 'mainstream stocks' are largely built around the market's profit logic, which is incompatible with the need to protect the natural environment and tends to perpetuate (over)production of substantially useless goods. This is because in capitalism, the use value is only a means to exchange value and profit (Löwy, 2015). Such capitalistic logic tends to inhibit generosity, reciprocity and a sense of inclusion, which cannot be satisfied through monetary, market-based transactions. While both mainstream (capitalist) and downstream (alternative) forms of economic activity can help to satisfy authentic human needs such as the need for food, clothing, shelter and education, it is the downstream/bottom-up economic spaces that are typically targeted at the disadvantaged local subjects by promoting inclusivity and solidarity, and fostering a sense of community belonging, rather than augmenting social stratification (Lenski, 1984). For example, many of the *heidenspass* employees (human capital stock) are constituted by young immigrants seeking (low entry) employment and inclusive social integration opportunities, which may be much more difficult to access in the mainstream economic spaces. Apart from finding employment and building relations underpinned by the principle of

solidarity, these young individuals can additionally boost at *heidenspass* not only their organizational, cooking, woodworking or motor skills, but also creative thinking and environmental awareness whilst transitioning into adulthood and mainstream forms of employment. Similarly, EMS, Ltd. helps to meet authentic human needs, i.e. the need for food, among those who would otherwise not afford food products in the mainstream supermarkets. In doing so, the enterprise helps to alleviate food poverty in deprived parts of the city.

The curved arrows above the stocks in the alternative economic realm represent a multitude of inherently circular activities such as reuse, repair, refurbishment, rental, remanufacture, sharing services, recycling, and recovery of resources, which help to create positive closed loops. Such notions of circularity are manifested in the context of *heidenspass* and EMS, Ltd. where material resources are being recirculated through upcycling and reuse. The absence of curved arrows in the mainstream economic sphere indicates the need for more reconfigurations within the capitalist structures, where economic practices remain rather linear when compared to those in the alternative economic realm (Hobson & Lynch, 2016). As Laurenti et al. (2018:4) stated, the CE concept in its current form 'lacks a necessary strong link to and acceptance by formal economists and lacks embedding the material system in the formal economy'. However, while this implies that CE is more broadly conceived within the informal rather than the formal economic sector, the links between the two realms suggest that CE may occur at the crossroads of the mainstream sector and alternative sector (brown/black arrows in the Figure 1). Such feedback loops across the two spheres enable to retain value of, and add new social, environmental and economic value to, a given circulating resource. In other words, alternative economic spaces may become valuable sinks for resource outflows from the mainstream by capturing and managing 'waste' from the globalized stocks locally. The same locally reproduced resources may be then transposed back to the mainstream where they may be managed through global supply chains. For example, *heidenspass* receives discarded textiles such as towels or jackets from the mainstream international private companies, which are then being transformed by young employees into useful bags for the same private companies in the form of corporate gifts. Such business-to-business (B2B) dynamic only further blurs the boundaries between the mainstream and alternative realms. The case of EMS, Ltd., on the other hand, illustrates how food surplus and food donations, i.e. 'captured value' from the mainstream supermarkets is being captured by the downstream and circulates locally. This, however, may be subject to contestation in case any remaining food waste and packaging are viewed as outputs to be transposed back to the mainstream private waste management companies for processing (e.g. anaerobic digestion in case of organic matter).

The Figure 1 further suggests that the 'outflows' of resources, or in other words - negative environmental externalities (i.e. resources that negatively affect critical ecosystem properties and functions that threaten human well-being), are reduced in case of the alternative economic realm. This is because alternative economic spaces such as *heidenspass* or EMS, Ltd. are more committed to retaining value of resources circulating across the entire ecosystem out of primarily economic reasons. The presented conceptual model also demonstrates that both mainstream and alternative spheres are greatly interconnected through the web of (functional) social relations, which give logic and meaning to cross-realm transposition of resources. Such social relations are at the same time broadly determined by the institutional contexts in which they are embedded (Grannovetter, 1985). Institutional contexts describe how institutions, i.e. 'organizational fields' consist of 'routing and recognized practices, which themselves are embedded in networks of agents' (Storper, 2013:120) and which 'engage in common activities and are subject to similar reputational and regulatory pressures' (Owen-Smith & Powell, 2008:6). Institutional norms enacted by governmental institutions or by companies themselves, may facilitate or constrain deployment of certain stocks of capital by the mainstream or alternative forms of organizing. This depends on the ability of the governmental institutions to manipulate transaction and production costs across the two realms. Governmental institutions at local, regional, national and global scales may also apply certain economic tools to tackle negative environmental externalities associated with specific resource flows, which may affect, both directly and indirectly, CE performance within both economic spheres in terms of the quantity and quality of available material resources. Such economic tools may include regulations (e.g. recycling directives that constrain harmful behaviours in private companies), taxation or financial incentives (Santos, 2012). For example, in October 2018 the

UK government announced a £15 million fund 2019/20 in order to increase redistribution of food surplus from large retailers and food manufacturers in collaboration with businesses and charities (GOV.UK, 2018). Interestingly, the case of EMS, Ltd. reveals that the enterprise attracted collaboration with large food retailers and manufacturers out of reputational pressures facing such large corporate businesses to green their models, rather than out of legal obligations, which are not in place. Claims can be also made on legislating sustainable procurement practices by public authorities in order to oblige more private companies to purchase goods and services with inherent social and environmental value such as those embodied in *heidenspass* products. This could ultimately lead to increased competitive advantage among the private companies and SEs with implications for greater socio-environmental impacts.

While the concept of economic diversity is often linked to the highly 'romanticized' notion of localism in many academic circles (Samers, 2005), the presented conceptual model demonstrates that the diversity of alternative economic forms greatly stems from the convergence of global and local economic dynamics. Similarly to the study conducted by Cannas (2018), the selected case studies imply that alternative economies can, and even must, coexist with the mainstream, globally-linked and monetised economic organisations in order to realize their socio-environmental mission. For example, the case of *heidenspass* reveals that this concerns not only procurement or, in other words, internalization of, the mainstream negative externalities (i.e. 'waste') as resource inputs for (re-)production, but also international trade of ready-to-use goods through online sales. There is a question, however, as to what extent activities at the local level should be enhanced through links to regional and global institutions in order to maximize the value they deliver (Gritzas & Kavoulakos, 2016). This is because such multi-level geographical scales across which both mainstream and alternative spaces operate and 'close loops' are likely to have implications for the performance of the CE, which is deemed genuinely circular when it occurs at the local level wherein distances between economic spaces are significantly reduced, and hence negative environmental externalities lessened (Stahel, 2013).

3. Conclusions

This paper demonstrated the need to reintegrate, or re-embed, economic spaces into socio-ecological and political contexts, whilst making a distinction between the mainstream and alternative binaries, when exploring pathways toward sustainable CE development. This is in the line with the premises of ecosocialism, which postulates increased concerns about social and environmental repercussions associated with pursuing linear production models. The constructed conceptual model provides an opportunity to reflect on the possibilities presented to SEs and their partners to rethink material circulation across the two economic realms, and to question the capitalist neoliberal logic of production for the sake of production. Even though alternative economic forms of organizing such as social enterprises are rarely recognized as motors of any profound change and usually remain concealed from the mainstream discourse, the presented model exposes them through claims on far-reaching positive social and environmental impacts they can deliver to local communities. More importantly, by creating demand for alternative markets of everyday products, social enterprise projects such as *heidenspass* indirectly influence large capitalist enterprises, thus creating a positive feedback loop whose benefits go beyond SEs' communities of direct reach.

There remains, however, the danger of 'overusing' such alternative economic spaces by the private sector as vessels for greening measures to pursue business as usual and perpetuate negative patterns such as overproduction. This is where regulatory institutions have an opportunity to intervene and ensure that 1) private companies are obliged to amend their unsustainable procurement practices and production processes; 2) alternative economic spaces have enough autonomy and resources to pursue their missions and facilitate CE development at the local level. More significantly, public authorities should also look into, and address, the root causes of the socio-environmental problems (e.g. overconsumption), which are being signalled and rather only symptomatically addressed through the existence of such alternative forms of organizing. In this way, local, circular and alternative economic initiatives could become more than just 'a drop of water on the arid soil of the capitalist desert' (Löwy, 2015:42).

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Circular Economy - Part 2

Packaging re-use in the circular economy: an LCA evaluation for Italy

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Abstract
Re-use is among the most important tools to increase the lifetime of materials and products, preventing the generation of waste and reducing the need for final sinks, and this is especially true for packaging. For this reason, it is important to have an overview of the re-use of packaging items in Europe and to quantify the environmental benefits of such practice.
The pluriannual research described in this paper has started with a qualitative and quantitative assessment about the practice of packaging re-use in Italy. Thirty-eight types of packaging items that are currently re-used were identified. For each of them, the constituent material, the market of use, the sector of use, the main basic characteristics (e.g., size and/or weight), the possible reconditioning process applied, and the type of service based on which is managed were defined.
Then, a Life Cycle Assessment (LCA) was performed for some of those packaging items that require a reconditioning process, i.e. intermediate bulk containers, steel drums for the transport of chemicals and petrochemical products, reusable plastic collapsible crates for fruit and vegetables distribution, and refillable glass bottles for the delivery of mineral water in the domestic and Horeca sector. For each typology, the life cycle perspective was used to assess the impacts of the packaging as a function of its number of uses (the so-called "rotations") and to quantify the contribution of the main stages (production, reconditioning, distribution, and end of life) to the total impacts of the life cycle. Moreover, each assessment investigated if the analysed system based on re-use performs better than an equivalent system based on single use. These LCAs were performed mainly with primary data about the packaging system, collected through tailor-made questionnaires and field surveys at some facilities located in Northern Italy. The adopted methodology and the main results are reported in the paper.

Keywords: packaging, re-use, waste prevention, LCA, single use

1. Introduction

Re-use plays a central role in sustainable development and in the circular economy as a waste prevention activity (European Environmental Agency, 2018). Due to their purpose to contain consumable goods, packaging items are particularly prone to re-use. In this sector, recently, there has been a growing demand for returnable items from various industrial sectors (e.g., food & beverage, automotive, chemicals, oil & lubricants), as well as from the final customers willing to decrease the use of disposable items. This will drive the global market of returnable packaging to grow from USD 37.9 billion in 2018 to USD 51.2 billion by 2023, at a compound annual growth rate of 6.2% (MarketsandMarkets, 2018).

Despite packaging re-use is undoubtedly a good measure for preventing waste, when looking at the environmental impacts of the system where the reusable packaging is used, the picture looks much more complex. In order to correctly evaluate the environmental consequences of a packaging re-use practice, a life cycle perspective should be employed, especially when the packaging needs a reconditioning process. In this case, the reusable packaging system reduces the amount of material produced and disposed but it introduces, at the same time, additional burdens associated to the cleaning, sorting and repairing stages, requiring a careful evaluation.

In this work, the LCA methodology was applied to evaluate the environmental performance of some reusable packaging items in the Northern Italian context. Main objectives of the study are to calculate the potential impacts of a reusable packaging system as a function of the number of uses and to quantify the contribution of the main life cycle stages to the environmental impacts. Particular attention was paid on the burdens of the reconditioning process, in order to provide the operators with indications for a better management. The adopted methodology and the main results are reported in the following sections.

2. Methods

A methodology was firstly defined for the collection of reliable and uniform data on packaging re-use, to be used for statistical purposes as well as to check the compliance set by the European Commission legislation on waste. The suggested methodology was then applied to the Italian context, as a case study, generating a qualitative and quantitative assessment on the topic. As a

result, 38 different types of reusable packaging items were identified for the Italian market, most of them made of plastic (37% of the sample), followed by steel (24%) and wood (18%). Beverage & food resulted the most involved sector of use, accounting for 39% of the total types of packaging (Rigamonti et al., 2019).

For each typology, data on the main basic characteristics (e.g., average size and/or weight), on the applied reconditioning process (when performed), on the type of service based on which the packaging is managed (e.g., rental) were defined. When possible, a quantitative characterization was also performed by the acquisition or estimation of some parameters such as: the population (i.e., the total number/weight of items assumed as the available stock), the number of rotations (i.e., the number of times the packaging is used before sending it to disposal/recycling), and the overall packaging lifetime (Rigamonti et al., 2019).

Among the types of packaging that require a reconditioning process (53% of the total), some were selected in order to evaluate their environmental performance with a life cycle approach. The selected typologies, belonging both to the industrial and Horeca/domestic sectors, were:

- Intermediate Bulk Containers (IBCs) designed for the transport and storage of bulk liquid and granulated substances (e.g., chemicals, food ingredients, solvents, pharmaceuticals). They consist in a high-density polyethylene (HDPE) container (defined as "bottle"), housed within a tubular steel cage that is attached to a pallet. The pallet may be in wood, plastic or steel. The National Packaging Consortium in Italy (Conai) reported that 7038 tonnes of HDPE bottles and 16021 tonnes of steel (cages and steel pallets) were reconditioned for IBCs in the year 2017;
- Steel drums used for the transport of chemical and petrochemical products, built in a cylindrical shape. In the year 2017, according to Conai, about 5870 tonnes of steel drums (equal to 373,885 items) were reconditioned and placed again on the market;
- Reusable Plastic Crates (RPCs), generally in polypropylene granulate, designed for the transportation of fresh food products, especially fruit and vegetables. They can be folded, in order to provide a cheaper return when empty and have rounded inner edges to prevent product damage. RPCs are progressively replacing single-use packaging items in the Italian large-scale retail. In the year 2017, the Consortium EURepack (European Reusable Packaging & Reverse Logistics Consortium) rotated about 305 million of RPCs, corresponding to a population of 44-51 million crates (considering 6-7 rotations per year);
- Refillable Glass Bottles (RGBs) for the distribution of mineral water, composed of the glass container, a screw aluminium cap and an informative label in paper. According to recent indications of CoReVe (the Consortium for Glass Recycling in Italy), about 228,000 t of RGBs were rotated in the year 2017, corresponding to a population of 57,000 t (4 rotations per year). The 1-liter format, being the dominant in the market, was taken as reference.

Table 1 reports, for each analysed type of packaging, the main basic characteristics, a brief description of the reconditioning process and the reference source where the complete LCA study is available.

Table 1. *Characteristics of the packaging types analysed in the LCAs and brief description of the reconditioning process.*

Typology	Material		Average weight	Number of rotations	Reconditioning process
IBC Biganzoli et al. (2018) 	Cage - steel		22 kg	1-5	First, too damaged IBCs (24% of the input items) are separated, sent to material recovery, and replaced by new ones. The remaining 76% of IBCs are washed with hot pressurized water and a mix of chemicals. After washing, IBCs are further checked and the HDPE bottles that result not sufficiently cleaned are removed from the structure and replaced by new ones (on average, 33.6% of the washed bottles are discarded here)
	Bottle - HDPE		16 kg (1 m^3)		
	Pallet	Plastic	19 kg		
		Wood	23 kg		
		Steel	20 kg		

Typology	Material	Average weight	Number of rotations	Reconditioning process
Steel drum Biganzoli et al. (2019) 	Low allowed steel	15.7 kg (215 l capacity)	1-10	All drums are washed internally and externally with hot pressurized water and a mix of chemical products. Then, they are dried, their shape is restored in case of damages, and finally they are quality checked. On average, 37% of the drums are discarded after being washed, because they are too damaged to be re-used
RPC Tua et al. (2019) 	Polypropylene	1.49 kg (12 kg capacity)	1-125	Crates are firstly inspected to identify possible breakages (the average breakage rate is 0.35% of the input RPCs). The remaining RPCs are sent to a washing step, where they are cleaned and sanitized with hot water and a mix of chemical products. After washing, crates are dried and further checked for breakages (0.2% of the washed crates is sent to recycling)
RGB Tua et al. (2020) 	Container - glass	452 g (1L capacity)	1-30	98.69% of the distributed bottles are returned to the bottling plant (1.31% is lost at each delivery). Here, caps and labels are removed and sent to proper recycling. All bottles are washed with hot water and a mix of chemical products. Bottles are then checked manually and by electronic inspection to verify the absence of damage. In this stage, about 1.85% of the washed bottles are discarded. Regenerated bottles are filled and equipped with new labels and caps
	Cap - virgin aluminium alloy	1.8 g		
	Label - paper	1.0 g		

The environmental assessment was performed according to the LCA methodology based on the standards ISO 14040 (2006) and ISO 14044 (2018) and the Product Environmental Footprint - PEF Guide (Manfredi et al., 2012) with its recent update (Zampori and Pant, 2019).

In each study, the life cycle perspective was applied to assess the variation of the impacts of the re-use system as a function of the number of uses (the so called "rotations") and to quantify the contribution of the main stages, especially of the reconditioning stage. The function of all the analysed systems is to provide the final user (industrial or domestic sector) with a certain capacity for the distribution of food, beverage or chemicals by means of reusable packaging items. The carrying capacity of 100 items at each delivery was thus selected, considering the following Functional Units (FU):

- for IBCs, 100 m^3 of carrying capacity at each delivery (equal to 100 IBCs), with the number of deliveries (n) ranging from 1 to 5;
- for steel drums, 21.5 m^3 of carrying capacity at each delivery (corresponding to 100 steel drums) with n ranging from 1 to 10;
- for RPCs, 1200 kg of carrying capacity at each delivery (corresponding to 100 RPCs) with n ranging from 1 to 125;
- for RGBs, 100 litres of carrying capacity at each delivery (corresponding to 100 RGBs) with n ranging from 1 to 30.

For n equal to 1, refillable items are used only once and then discarded. Thus, the reference flow is 100 packages. For n equal to 2, refillable packages, after the first use, are collected and sent to reconditioning. X items (24 IBCs, 37 steel drums, 0.55 RPCs, and 3.13 RGBs) are discarded due to damages or because of losses in the distribution stage and must be replaced, while the others (1-X) are made available for the second delivery. Thus, the reference flow is (100+X) new items. In general terms, for the n^{th} delivery, the reference flow is (100 + X (n-1)) new packages, as shown in Figure 1.

The system boundary (Figure 1) of each analysed type of packaging includes:

- the production of the packaging components and their assembly;

- the reconditioning process (transportation from the user to the reconditioning facility, consumption of electricity, thermal energy, water, chemical products, and the treatment of wastewater, solid residues, and exhausted air);
- the end of life of the packaging (after *n* uses and those discarded at each reconditioning process). In this stage, cases of multi-functionality related to the recovery of energy and materials in the valorisation of the disposed items were solved by expanding the system boundary to include the corresponding avoided productions (Finnveden et al., 2009).

Moreover, a distinction should be made for the stages of product packing inside the reusable packaging and of transportation of goods, depending on the type of final user. For the industrial packaging items (IBCs, steel drums, and RPCs), these stages belong to the use phase of the packaging, which is outside the system boundary. On the contrary, for RGBs, destined to the Horeca/domestic sector, the filling of bottles with water and their distribution to the final customer were included in the boundary as operations performed before the use phase.

The geographical context for the assessment was northern Italy while the timeframe the year 2015 for IBCs and steel drums and the year 2017 for RPCs and RGBs. The foreground system was mainly described with primary data collected through the collaboration of companies involved in the analysed sectors. Mail questionnaires, phone interviews and field surveys to reconditioning facilities allowed to gather primary data on the studied re-use practices: information about packaging components (i.e., mass and material, way of manufacturing, end of life treatment), the layout and mass balance of the reconditioning process, and the way of distribution and packaging return (i.e., covered distance and type of vehicles). For the processes of the background system (such as chemicals or electricity production), the reference was the ecoinvent database, version 3.3 *allocation recycled content* approach (LCA on IBCs, steel drums, and RPCs) or version 3.5 *allocation, cut-off by classification* approach (LCA on RGBs). The software SimaPro (PRé Sustainability, Amersfoort, The Netherlands) supported the data processing.

The evaluation was based on a wide spectrum of indicators on the environment, on the human health and on resources management. They are:

- 12 indicators from the impact characterisation method ILCD 2011 (European Commission - Joint Research Centre, 2011), evaluated at the midpoint level: Climate Change (CC), Ozone Depletion (OD), Human Toxicity (Non-Cancer effects; HT_{NC}), Human Toxicity (Cancer effects; HT_{C}), Particulate Matter (PM), Photochemical Ozone Formation (POF), Acidification (A), Terrestrial Eutrophication (TE), Freshwater Eutrophication (FE), Marine Eutrophication (ME), Freshwater ECotoxicity (FEC), mineral, fossil & renewable Resource Depletion (RD);
- the energy indicator from the Cumulative energy demand (CED) method (Hischier et al., 2010);
- an indicator related to Water Depletion (WD), expressed in terms of m^3 of water consumed or saved. The indicator quantifies the net water consumption in the system (water withdrawal from the environment minus the water release in the environment), according to results returned by the life cycle inventory of the SimaPro software.

In the more recent LCA study related to RGBs, the same 12 indicators of the ILCD method were updated according to models and associated characterisation factors proposed in the new Environmental Footprint Life Cycle Impact Assessment Method, version 2.0 (Fazio et al., 2018). From this method, also the impact categories of water scarcity and of resource use-energy carriers were selected in substitution of the CED and the water depletion indicators, respectively.

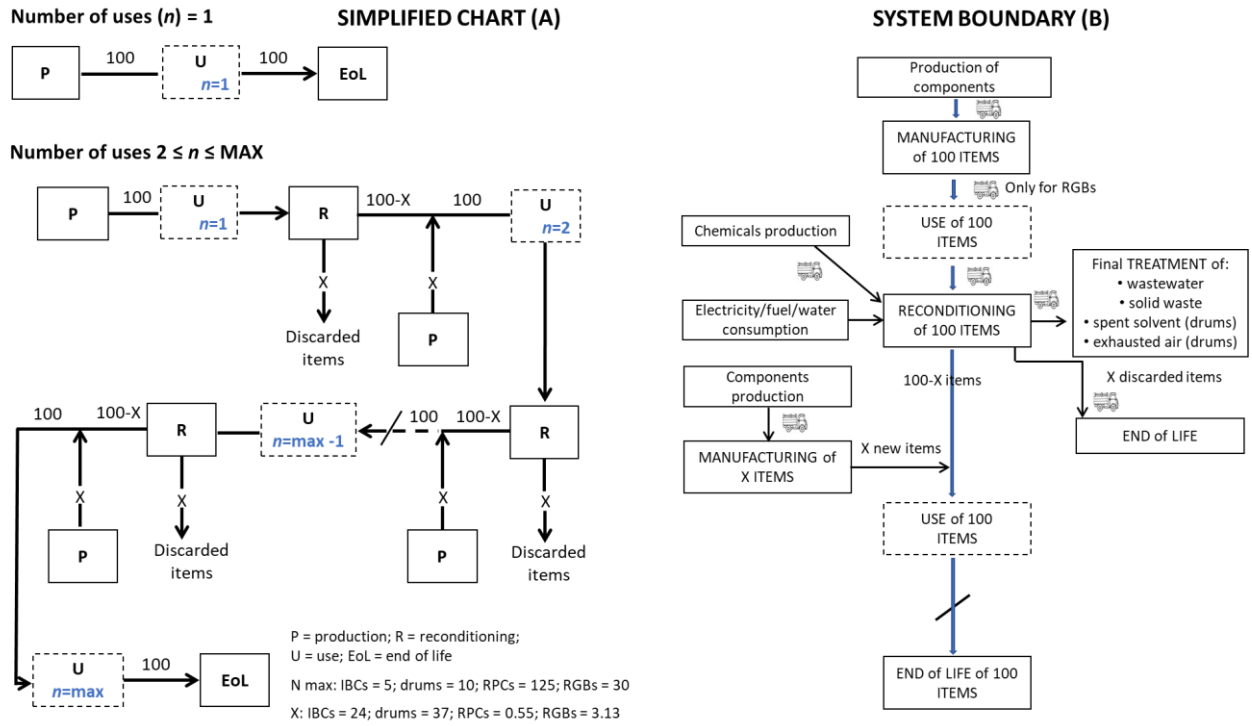

***Figure 1**. Simplified chart of the life cycle of 100 packaging items as the number of rotation changes (Figure A) and relative system boundary (Figure B).*

3. Results and discussions

The potential environmental impacts of each reusable packaging system were calculated for each number of rotations. In the interpretation step, a contribution analysis was performed to understand which stages most influence the impacts. Specific attention was dedicated to the burdens of the reconditioning stage.

At the end of the assessment, the reuse-based system is compared to an alternative system where the packaging of the same material and same capacity is used just once and then sent to recycling/disposal and substituted with a new one at each delivery. A summary of the main conclusions and recommendations is reported for each analysed type of packaging.

IBCs and steel drums

For both typologies, results show that major burdens of the life cycle are associated to the manufacturing stage of the packaging, in particular to the production of low allowed steel for the tubular IBCs cage and for the drum. The contribution of the reconditioning process obviously increases with the number of uses, but it remains modest and generally below 20% even when the packaging is used for the maximum number of times (n=5 for IBCs and n=10 for drums). Burdens of the reconditioning are mainly associated to the transportation from the user to the reconditioning facility (travelled distance of 400 km for IBCs and of 200 km for drums) and to the disposal of the residues found in the bottles of IBCs and in the drums, that are sent to incineration. These processes are not directly under the control of the reconditioning operators. The behaviour of the users is then important, who should remove any chemical residues from the packaging before its regeneration. Moreover, a widespread distribution of the reconditioning facilities on the territory could reduce the transportation burdens. For steel drums, a significant impact is also given by the cleaning process, and especially by the heating of the washing water, by the consumption of electricity for drums drying and by the use of solvents (solution of acetone, ethyl acetate, and butyl acetate). The cleaning process should be, thus, optimized by reducing the energy consumption and the solvent request. To this purpose, the solvent regeneration can be a good option (some Italian facilities recover up to 70% of the spent solvent avoiding its production from virgin raw materials).

Reconditioning and reusing these types of packaging is by far preferable to a single use practice when the same packaging is used only once, sent to recycling/disposal and substituted by a new one at each delivery. Indeed, burdens associated with the reconditioning process are more than compensated by the benefits of the re-use practice, i.e. the avoided production and disposal of new items. As regards IBCs, the environmental burdens of a system based on re-use are about 62-76% of those of a system based on the single use if *n*=2, 49-69% if *n*=3, 43-64% if *n*=4, 39-62% if *n*=5, depending on the impact category. For steel drums, potential impacts of the reusable packaging system are about 74% of those of a system based on the single use if *n*=2, 65% if *n*=3, and so on until 53% if *n*=10, on average. More details are reported in Biganzoli et al. (2018 and 2019).

Reusable plastic crates (RPCs)

For a low number of rotations (e.g., *n*=20), the burdens of the system are mainly associated to the production of the RPCs (52%-85% of the overall impact depending on the indicator; Figure 2). By increasing the number of rotations, the reconditioning step gains in importance within the RPCs life cycle, up to 32-74% for 125 deliveries (Figure 2). The main burdens of the reconditioning process are associated with the transportation of the crates from the users to the reconditioning plant (140 km on the average) and for this reason, a more widespread distribution of the regeneration facilities should be promoted within the territory. Other significant sources of environmental impact in the reconditioning stage are the consumption of the electricity and the washing step, i.e. the heating of the water by a conventional gas boiler. For these burdens, the management of the reconditioning facility should be optimized by reducing the energy consumptions and by promoting the use of alternative/renewable energy sources (e.g., production of electricity by a solar photovoltaic system or installation of a combined heat and power boiler).

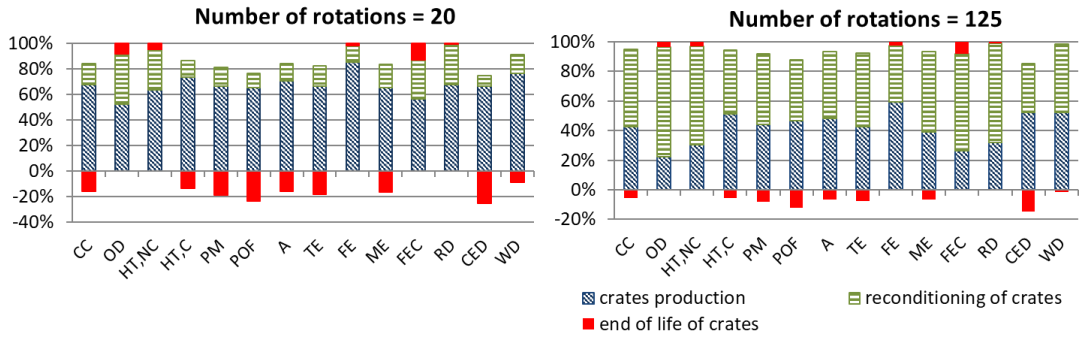

Figure 2. Percentage contribution of the life cycle stages "production", "end of life", and "reconditioning" to the total value of all the indicators for 20 and 125 rotations of the RPCs.

In the comparison with the corresponding single use system (where crates have the same capacity but are 60% lighter), for a very low number of rotations the burdens of RPCs are 2.6 (*n*=1) and 1.3 (*n*=2) higher than those related to single use plastic crates. Starting from three deliveries, results rapidly change in favour of the RPCs system. For example, for *n*=5, the environmental impacts of the RPCs system are 54-60% of those of the single use system, if *n*=125 the same value is 6-13%. The comparison for the category Climate Change is reported in Figure 3. More details about the complete study are reported in Tua et al. (2019).

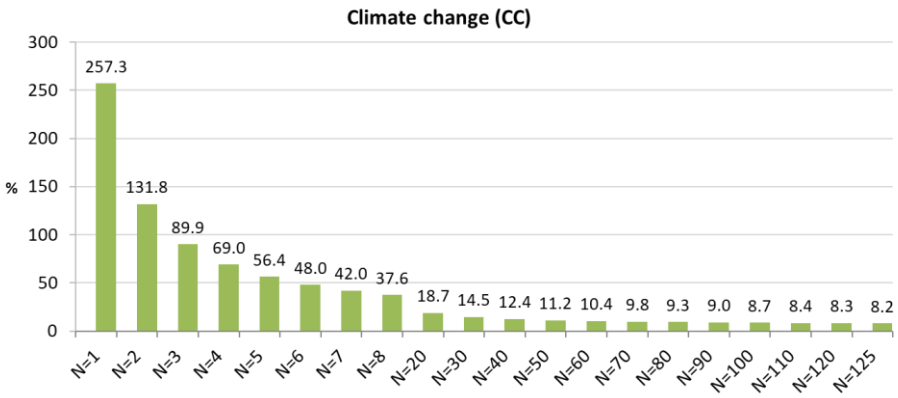

Figure 3. Comparison between the system based on reconditioning and re-use of plastic crates (RPCs system) and the single use system based on crates of the same capacity (but 60% lighter): for each number of rotations, the ratio between the value of the indicator climate change in the RPCs system and in the single use system is reported.

Refillable glass bottles (RGBs)

The potential impacts of the life cycle of refillable glass bottles are mainly associated to their distribution stage, i.e. to the transportation of the bottles from the bottling plant to the final user (230 km distance on the average) and to the return trip with the empty bottles of the previous delivery. For the maximum number of uses (n=30), the contribution of these stages can reach 80% of the overall impact indicator. The contribution of the reconditioning process is more modest, generally below 45%, even when n=30. Most of the burdens in this stage are associated to the electric and thermal energy consumption and to the replacement of the cap at each delivery (since the cap is made of primary aluminium).

When compared to the single use system based on 1-liter glass bottles (SGBs system), for a local market (within 200 km) the use of refillable bottles is by far preferable just starting from two deliveries. However, the distance between the bottling plant and the local distributor in the re-use system plays a key role in the impact evaluation. For a 400 km distance, at least 4 uses of the refillable bottles are required to achieve a better environmental performance, while for 800 km or more, the refillable bottles system is not convenient also for 30 uses (Figure 4). Further details on the complete study are reported in Tua et al. (2020).

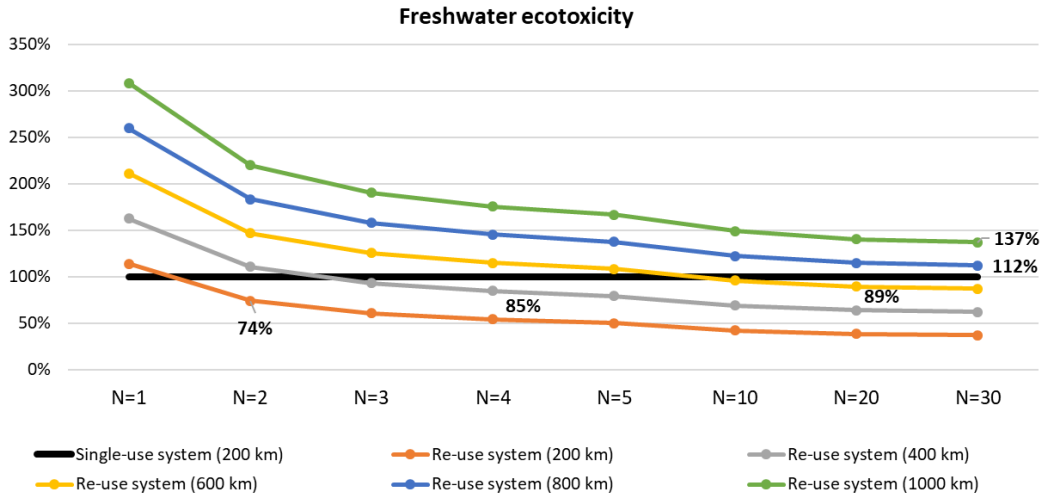

Figure 4. Comparison between the value of the indicator in the RGBs and in the SGBs systems (the value of the indicator in the SGBs system is put at 100%), for each number of deliveries and for different values of transportation distance in the RGBs system. The category of freshwater ecotoxicity was taken as reference because it resulted the most influenced by the travelled distance.

4. Conclusions

The LCAs performed on reusable packaging items in Northern Italy show that re-use is generally preferable to the single use. This is true also when the single use packaging is lighter than the reusable typology of the same capacity, like it was for plastic crates used in the distribution of fruit and vegetables.

Although these proven benefits, in the re-use practice the additional stage of reconditioning is inevitably involved, requiring a careful environmental evaluation. In some cases, like IBCs or steel drums, this stage shows a low burden even for the maximum number of uses (contribution lower than 20% of the total impact for most of indicators), while for other typologies like the RPCs, the reconditioning contribution gains in importance as the number of rotations increases (up to 74% of the total impact for 125 deliveries). In general terms, the burdens of the reconditioning process are mainly associated with the energy consumptions and with the disposal of residues of substances previously contained by the packaging, especially if they are hazardous (it is the case of residues from IBCs and steel drums). In the reconditioning of refillable glass bottles, a significant burden is given also by the substitution of the cap made of primary aluminium. Indeed, refillable packages can be made by some single use elements that worsen the impacts associated to their life cycle. Finding alternatives to the used material or reducing its weight (the cap in this case) should be considered in the design phase.
Finally, the transportation stages generally cause significant burdens on the environment, especially when the packaging items are heavy. The minimisation of the travelled distance and an updating of the fleet, mainly based on Euro 3 trucks in all analysed sectors, is thus recommended.

This research has revealed that LCA is a proper methodology to assess the actual environmental benefits of each practice of packaging re-use and to provide recommendations for a better management. The absolute priority for this type of studies is the availability of reliable and representative data about the investigated system in the geographical context analysed. For this reason, it is important to promote the cooperation with the companies, by encouraging them to share data about their sector.

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Zero-waste Campus: From Concept to Practice

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Abstract

Following rapid urbanization and improvement of living conditions in developing countries, people's consumption behaviours have altered, leading to an increase in municipal waste quantity and changes in components. This problem is especially significant in China, and has imposed heavy burdens on the end-of-life disposal of wastes, mostly incineration and landfill. The Government of China started the "Zero-waste City" initiative in 2019 to encourage each "unit" in the city, including community, company, and school, to reduce and separate its own waste. However, most efforts have been focused on communities and universities, while secondary schools and the younger age group have been neglected. Construction of a zero-waste campus in secondary school context not only relieves pressure for municipal administration, but more importantly, educates teenagers to adopt a more environmentally-friendly consumption pattern. Therefore, we launched a zero-waste program in Nanjing Foreign Language School, which consisted of three steps. First, based on field surveys we characterized the quantity, composition, and monthly variation patterns of campus waste throughout a year; second, we explored factors that caused waste generation with the methods of literature review and face-to-face interview; third, we provided recommendations to reduce, reuse, and recycle wastes on campus. Results show that the total waste generation was about 98.0 metric tons in 2019 and the majority was food wastes, followed by plastics, papers, and garden wastes. Based on our analysis, we provided suggestions on waste reduction and recycling including: 1). providing food in the cafeteria based on surveys so as to reduce food wastes, 2). on-campus recycling of food and garden wastes with composting technologies, 3). working with student organizations to separate recyclable wastes. This study managed to combine planning with actual implementation, and provided a feasible model for zero-waste in secondary schools. Finally, this study also explored the possibilities of introducing composting to recycle organic waste.

Keywords: solid waste management, green campus, sustainable development, waste characterization, secondary schools

1. Introduction

Over the years, with the improvement of living conditions and the changes of consumption behaviours, municipal wastes increased greatly throughout the world. At the same time, the components of municipal waste are more and more complex and therefore separation has become costlier and more difficult exerted a great burden on the end-of-life disposal systems like landfill and incineration. As rapid economic and societal development took place in China over the past decade, annual municipal waste generated nearly doubled, reaching an annual total of 225.65 million tons in 2018. The increase of municipal wastes has brought a great challenge the sustainability of cities, and has attracted increasing attention from policy makers.

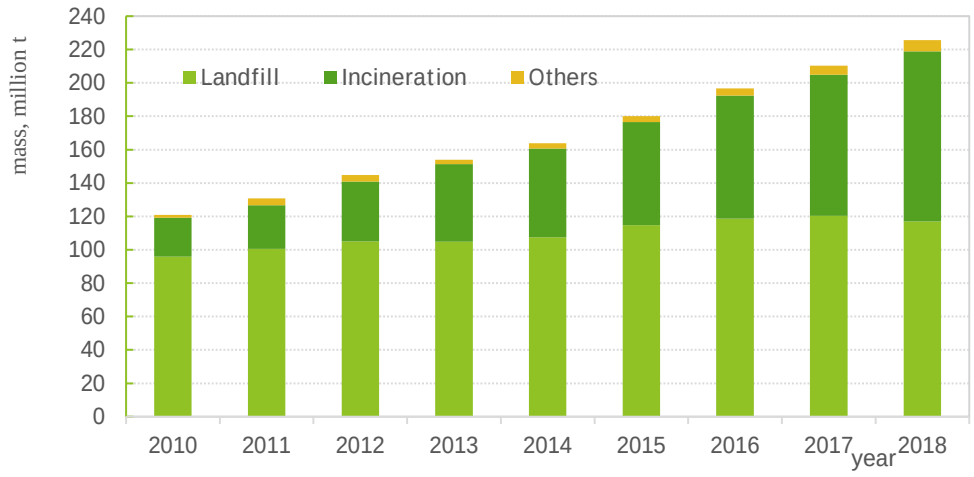

Figure 1. *Annual volumes of wastes disposed in China*

Therefore, more emphasis has been put on waste minimization approaches from the life cycle perspective, especially the sustainability of current lifestyles. Governments, as well as individuals, are driving efforts to explore more efficient waste management methods. In 2018, the State Council of China released the plan for construction of zero-waste cities, emphasizing household waste separation based on communities and institutes (Council, 2018). Zero-waste means the conservation of all resources by means of responsible production, consumption, reuse, and recovery of products, packaging, and materials without burning and with minimized or even no discharges to land, water, or air that threaten the environment or human health (ZIWA, 2018). Shanghai was the first city to implement mandatory household waste separation, and was been followed by 46 more cities. Nanjing, a major city in southeast China, will also implement similar policies before the end of 2020. Under this situation, each institute (university, community, company, school, etc.) will be required to separate and recycle its household wastes. But the specific pathway towards achieving this goal still remains a question and needs to be explored in practice.

Educational institutions play an important role in promoting the zero-waste city policy. Moreover, as the cradle of the future generation of the society, schools' emphasis on environmental protection influences students' consumption behaviours, and potentially enhances environmental awareness of the whole society. Previous reports and literature were focused on defining the concept of "zero-waste campus" and exploring ways to incorporate education and management in schools to minimize environmental impacts of campus activities in the aspect of waste. Adeniran et al. (Adeniran et al., 2017) tried to set up a campus waste management system, by characterizing the solid waste generation in the University of Lagos and analysing the distribution of these wastes; Mason et al. (Mason et al., 2003) provided an administrative framework for implementing zero-waste campaigns at a university; Setyowati et al. (Setyowati et al., 2018) conducted an assessment of the efficiency of the waste management system in Gadjah Mada University with the criteria set by the UI Green Metric World University Ranking. However, these studies mostly focused on "ideas" or "plans" and did little for the implementation of a zero-waste campus plan. Furthermore, previous researches into campus waste separation were mostly focused on universities, while waste separation of younger students in secondaries schools has seldom been studied.

Considering determination of waste generation and components as the first step for waste management (Gallardo et al., 2016), a zero-waste program was launched in Nanjing Foreign Languages School, consisting of three steps. First, based on field surveys we quantified the amount and components of waste generation on campus, as well as its monthly variations

throughout a year; second, we explored the factors that caused waste generations; third, we initiated a series of actions to reduce, reuse, and recycle wastes on campus and reflected on the results. In the discussion part, the experience was further generalized into a model for zero-waste in secondary schools. This paper aims combine concept with practice to provide a model for planning and implementing zero-waste, to promote institute-based waste reduction, and to ultimately contribute to the reduction of municipal waste.

2. Methods

Primary data of household waste quantity was collected through weighing at the waste storage sites on campus. The ratios of different components were determined with sampling of dustbins at four chosen sampling points, and weighing each type of waste separately. The plan distinguished two procedures based on the following considerations: 1). directly weighing at the waste storage site eliminates inaccuracy caused by changes in waste generation intensity within a day, whereas directly sampling dustbins to determine quantity would be influenced by the point-of-time of sampling; 2). sampling a number of representative dustbins could better depict waste composition than sampling from the waste storage site where waste from all sources were mixed together. The waste generation was calculated monthly and the unavailable data were inferred according to the waste generation changes of Xuanwu District, Nanjing. We explored the factors that caused waste generations through reviewing literature and analysing evidence. All data were processed in Excel software.

2.1. Description of the study area

Nanjing Foreign Language School (NFLS) is located in Nanjing city where there are 53 colleges, more than 600 elementary, and secondary schools. NFLS is a non-boarding secondary school with more than 4,500 students and faculties. The campus covers an area of 45,057 m^2, including six academic buildings, an administrative building, a library, a stadium and a cafeteria. There has been both official and unofficial efforts towards more efficient waste management. Officially the school separately collects the three types of wastes: food waste from the cafeteria, household waste from buildings, and green waste, and entrusts different companies to transfer and dispose them. Unofficially a student-initiated environmental protection club advocates waste separation among students and faculties, including this zero-waste campus initiative.

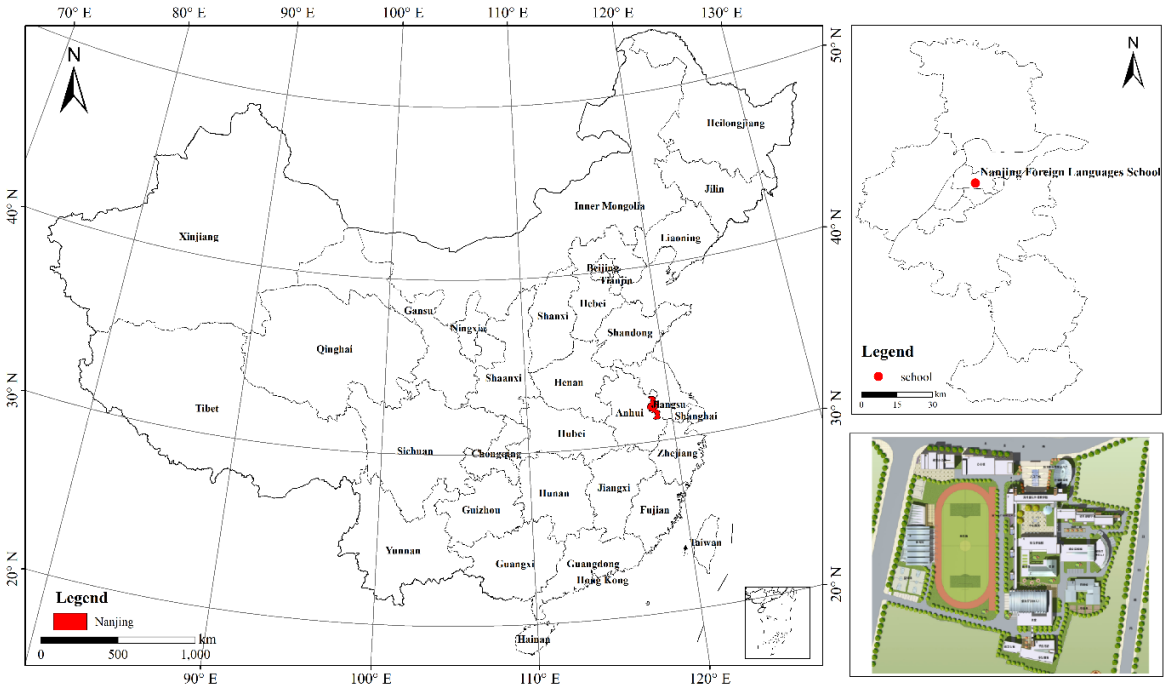

Figure 2. *Location of Nanjing Foreign Languages School*

2.2. Total waste generation quantity

In order to examine the daily household generation quantity, a coefficient of weight for each bag was determined by taking five samples from the campus waste storage site and averaging their weight. Total amount of waste at the storage site was estimated by multiplying the coefficient with the total number of waste bags counted at the site. This process was carried out three times (one time per day, three randomly selected working days) in the first week of each month, and the average result acts as the daily waste generation for that month, assuming that daily variation within a month is neglectable. The number was multiplied by the number of workdays in that month to determine monthly generation. The quantities of the food wastes generated in the school cafeteria and green waste were acquired through interviews with cafeteria manager and dustmen on campus.

2.3. Sampling Procedure

In order to determine the proportion of each type of waste, firstly an investigation was done on all dustbins in the campus and found that household waste on campus generally consisted of six categories: PET, other plastics, tetrapaks, paper, food wastes, and others. However, the intensity and component of waste generation vary in dustbins from different part of the campus. Thus, we divided the campus into four function areas to better depict spatial disparities in waste generation: 1). the administrative building; 2). the teaching buildings; 3). the laboratory building; and 4). the sports ground and gym. One dustbin was randomly chosen from each area as sampling point. Waste from the sampled dustbins were manually separated into the six categories and each component was weighed. Taking into consideration the temporal variation of components, sampling was conducted three times a week on the first week of each month during the research period. The study found a coefficient for each component in household waste through: 1). adding up the weight of a component from all samples 2). dividing it by the total weight of all samples. Annual generation intensity of each component was calculated through multiplying the estimated annual total waste generation intensity with the coefficients.

2.4. Monthly variation

Seasonal consumption behaviours and holidays lead to temporal changes in the quantity of wastes generated on campus. Considering these variations, the originally planned sampling period extends from October 2019 to September 2020, excluding parts of February, July and August due to holidays. However due to practical reasons like the innovative coronavirus epidemic, on site sampling was only conducted over a period of four months, from October to January. To define the trends of change in other months, an inference is made based on the generation patterns of Xuanwu District, Nanjing, where NFLS is located. Using data provided by the Xuanwu District Urban Management Bureau in 2019, the waste quantity of NFLS from February 2019 to September 2020 are given monthly through the following equation:

$$W_j^{campus} = \frac{\sum_{Oct.}^{Jan.} W_i^{campus}}{\sum_{Oct.}^{Jan.} W_i^{Xuanwu}} \times W_j^{Xuanwu} \times D_j$$

Where:

W_j^{campus} refers to the inferred waste generation quantity per month;

W_i^{campus} refers to the average daily waste generation quantity of NFLS in respective months given by sampling;

$W_{i,j}^{Xuanwu}$ refers to the average daily waste generation quantity in Xuanwu District in respective months;

D_j refers to the number of schooldays in respective months.

3. Results

3.1. Waste quantities and monthly variation

The NFLS campus generated an average of 543.5 kg of waste daily, with 282.6 kg from the school cafeteria, 21.7 kg of green waste and 239.2 kg of household waste from the garbage bins. The estimated annual generation in 2019 is 98.0 metric tons, with per capita generation of 0.12 kg/day, considering only school days. The total generation appears significantly lower than campus waste investigations conducted in universities, however per capita waste generation stays within the interval, with the University of Lagos generating 32.2 metric tons waste daily, per capita 0.56 kg/day (Adeniran et al., 2017); the Turitea campus of Massey University per capita 0.04 kg/day (Mason et al., 2003); the Taman Universiti per capita 0.16 kg/day (Kadir and Sani, 2016); the University of Northern British Columbia per capita 0.05 kg/day (Smyth et al., 2010); and Nanjing University Xianlin campus (20000 students and faculty) per capita 0.23kg/day (Chen et al., 2017).

The monthly variation of wastes generated in NFLS is presented below in figure 3. The trend differs from studies conducted in communities or cities (Denafas et al., 2014, Gu et al., 2018) in that the summer and winter holidays have a major influence on the waste amount in June, July, August, and January. Since the number of workdays is taken into account in the equation for calculating monthly variation, these months yielded a significantly smaller waste generation intensity compared to other months.

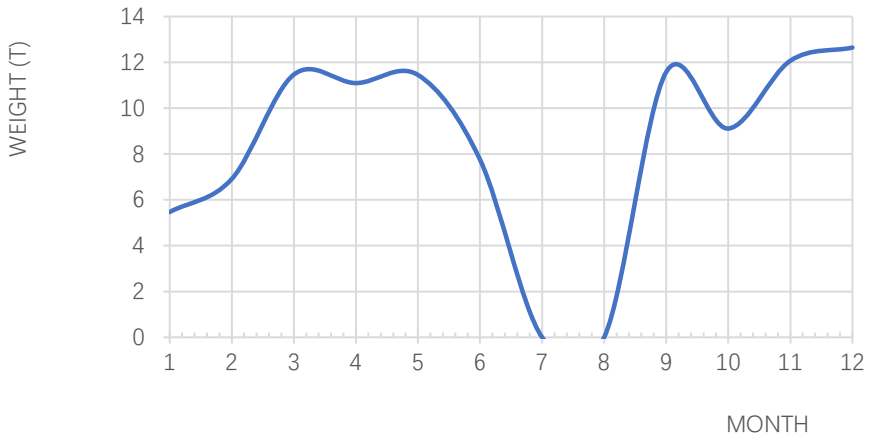

Figure 3. *Monthly variation in 2019 (t)*

3.2. Components of waste generated on campus

The components of the overall waste are shown below in figure 4. A comparison of the annual generation intensity of each component with Taman Universiti (Kadir and Sani, 2016) is shown below in figure 5. Other wastes including textile, metal, and hazardous wastes are not commonly observed in NFLS.

Food waste is a major component of the wastes generated on campus, taking up to 52% (by weight) of the waste stream, with cafeteria generating 91%, and the other 9% mixed with other household wastes. The cafeteria generates around 300 kg of water-containing food waste per day and currently disposed in landfills. Waste composition investigations yielded similar larges percentages at Nanjing University, Taman Universiti, and National University of Malaysia, respectively 55%, 61% and 43% (Adeniran et al., 2017, Kian-ghee et al., 2011). Solid components and liquids were filtered and separated when food wastes were collected in the cafeteria. With relatively low water content, food wastes could potentially be fed to black soldier fly larvae to produce protein, and low oil-and salt kitchen waste could be disposed applying composting methods.

Paper makes up 14% of the waste stream, relevantly close to the proportion observed in the University of Lagos (Adeniran et al., 2017), but appears to be significantly lower than numbers observed in the University of Northern British Columbia (Smyth et al., 2010) at 29.1%. The components are towel paper and used printer paper (books, used scripts, test sheets etc.), while cardboards and newspaper are not common in NFLS. As a result of mixed disposal, most paper lost their recycling potential because books and recyclable papers are contaminated by liquids and food residue, and mixed with non-recyclable towel papers. Therefore, in order to recycle or reuse these papers, they must be separately collected.

Tetrapaks are the third largest component, at 11% of the total waste stream. Many had leftover drinks in them. These tetrapaks need to be cut open and cleaned before being collected and effectively recycled. The rate of tetrapak generation in NFLS appears higher than studies conducted in Universitat Jaume I and Taman Universiti, respectively at 1.24% and 1.37% (Gallardo et al., 2016, Kadir and Sani, 2016). If these tetrapaks are fully diverged from the waste stream, approximately 10 metric tons of tetrapaks could be recycled annually in our campus, which has a good environmental and economic benefit.

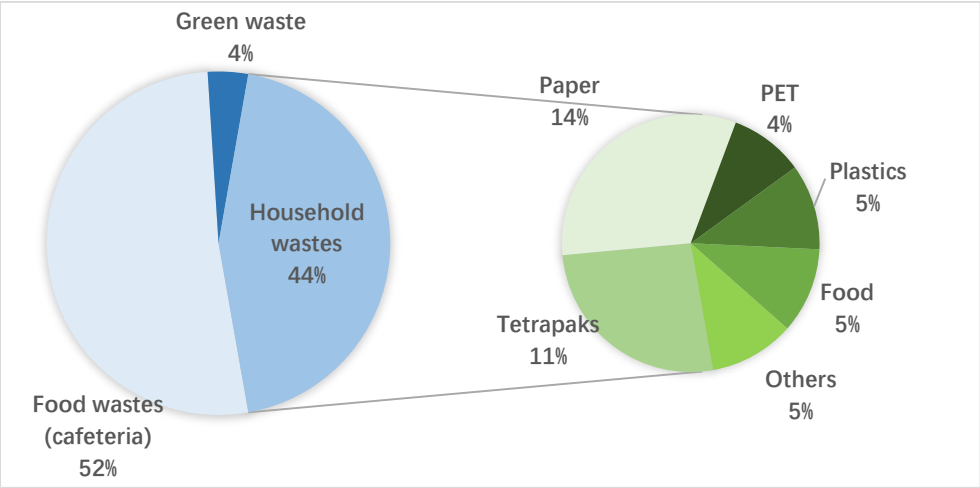

Figure 4. *Overall waste composition*

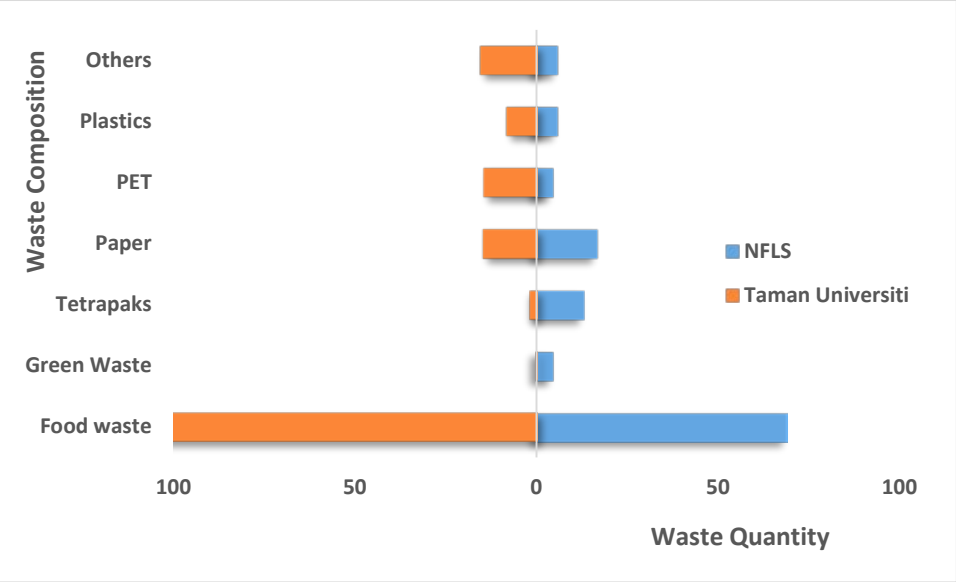

Figure 5. *Waste composition compared to Taman University (g×person-1×day-1)*

3.4 Actions on recycling the wastes

To push forward separation of wastes generated on campus, we launched a campus waste separation initiative, as part of our zero-waste campus program, which included: 1). replacing mixed collection dustbins with sorting bins; 2). publicizing waste separation ideas; 3). recruiting one student from each class to join our waste separation initiative as person in charge for that class; 4). promoting voluntary activities of waste separation. A large sorting bin with weighing function was installed in the public area, and smaller ones were placed in each classroom, collecting waste paper, tetrapaks, and plastic. Campaigns of waste separation were conducted in every class, and active and interested students were recruited as the person in charge of each class. Students were asked to separate their own wastes inside the classroom. Every day the person in charge of each class would collect the wastes in the classroom bins, clean the tetrapaks and transfer them to the large sorting bins. This

mechanism continued for four months, and data of the collected recyclables were collected and compared with the waste generation data determined when this waste separation mechanism was not operating to evaluate its effectiveness. Over the course of four months, the student-oriented voluntary waste collection efforts managed to separate 61.26 kg paper, tetrapaks, and plastics.

4. Discussion

4.1. Consumption behaviours behind waste generation

For a non-boarding school, most students and faculties stay on campus for around ten hours a day (from eight in the morning to six in the afternoon) on workdays. Few students or faculties stay on campus during holidays. Short school hours and strict rules of secondary school limit consumption behaviours. Major input sources of solid wastes include meals from the school cafeteria, a convenience store, vending machines, and paper education materials. Due to the strong reliance of students' consumption behaviours on the school, material inputs are largely decided by school management, from food flavour and amount in the cafeteria to the goods sold in the convenience store and vending machines.

Most people have one meal per day in the school cafeteria, and that accounts for the main part of the food waste. The cafeteria in NFLS, similar to many Chinese secondary schools, provides students with various choices of food in portions. Delivered food is restricted in most secondary schools, thus limiting the source of food waste to the food sold on campus. This concentrated food waste stream from the school cafeteria presents an ideal opportunity for diverting food waste from landfills by reducing and recycling this food waste (Wilkie et al., 2015). One key drivers behind the mass amount of food waste on campus is oversupply, which is avoidable through more reasonable management (Abdelaal et al., 2019). In addition, several studies indicated that large portion size could lead to increased consumption of calories and food waste (Levitsky DA and T., 2004). To cope with excessive waste produced in the cafeteria kitchen and find a suitable portion size for students, the school could analyze eating patterns and prepare and serve food based on the appropriate forecast (Babich and Smith, 2010); education of catering personnel and students as improved communication could also contribute to the sustainability of school cafeterias(Marais et al., 2017).

On-site sorting experience showed that a large proportion of household wastes are food packaging, generally plastic packaging, PET bottles, and tetrapaks. The significantly high appearance of tetrapaks and plastic beverage bottles could be explained by certain popular goods sold in the convenience store vending machines. As parts of plans to improve environmental sustainability, many cities globally have passed plastic prohibition acts or bottled water bans (Council, 2007). However, a study at the University of Vermont indicated that simply banning bottled water on campus could result in higher consumption of other higher calorie beverages, and potentially increase plastic waste (Berman and Johnson, 2015). Better ways to reduce packaging could include encouraging reusable water bottles through environmental campaigns, and installing drinking fountains on campus.

4.2. Recycling motivation

Schools' waste generation intensity and recycling rates largely depend on students' intention to follow the 3R principle on a voluntary basis. However, their willingness to participate are influenced by a number of subjective and objective factors. The location of waste recycling bins, especially their distance to the most common points of consumption, has a strong correlation with students' plastic bottle recycling rate (Malakahmad, 2010, O'Connor et al., 2010). A study conducted by Low S.T. et al. ranked accessibility to recycling bins as the most important attribute of waste separation behaviour, followed by inventive for waste separation, reminder for waste separation, and information for waste separation (Sheau-Ting et al., 2016).

Study has proved that secondary school students and most school students will separate waste if facilities are available and they are taught how to do so (Liao and Li, 2019), which highlights the importance of incorporating environmental education into school management and student campaigns. The recycling rate in NFLS remains relatively low after the student-oriented environmental campaign and recycling efforts, and one explanation could be that only one set of large separation bin was installed, while smaller bins in separate classes did not have enough capacity. But given the great impact environmental campaigns could have on students' willingness to recycle observed in similar studies (Mason et al., 2003, Stoeva and Alriksson, 2017, Tangwanichagapong et al., 2017), there is great potential for student campaigns to play an important role in promoting waste recycling in secondary schools.

4.3. Policy Implication

Waste reduction, reuse and recycle remains a concept in most secondary schools, a slogan in environmental education instead of a practice that students are encouraged to engage in. Unlike students in a university or residents in a community, secondary school students are more reliant on the conditions and instructions provided by their schools. Therefore, to work towards zero-waste, the school should optimize management in the cafeteria to provide variable tastes and appetite for students so that they can choose what they like; secondly, adjust the amount of each portion based on student surveys so as to reduce excessive food; thirdly, goods sold in the school convenience store should avoid over packaging; and beverage machines could be applied to take the place of vending machines, and reduce the amount of tetrapaks and beverage bottles. More importantly, the school should work with student organizations improve students and faculties' responsibility in sorting the wastes they have generated. A student-oriented recyclable collection mechanism could be organized by the environmental club or by the student union to facilitate this voluntary job, which allows one or two active participants to instruct and influence the students around them. The collected wastes should be properly disposed of, reused or sent to recycling centres. Aerobic composting using kitchen waste from the cafeteria and green waste could be managed with composting by students on campus.

On a larger scale, the urban department in charge of transferring municipal waste should provide separate collection systems for recyclable wastes; the education department should guide schools to encourage student-oriented waste separation and recycling, to push forward zero-waste and to promote environmental awareness of students.

4.4. Uncertainties

Due to limitations in actual practice, certain data turned out inaccessible and some details still need to be improved. The influence of seasonal variation on the quantity of the wastes was given by inference, while its influence on waste composition was largely not taken into consideration. Furthermore, human manure is not considered in this study. Currently in Chinese cities, human manure is directly transferred to wastewater treatment plants through the sewage system. However this may result in a large amount of sludge and consequently a waste of nutrients which could potentially be utilized for urban agriculture (Wielemaker et al., 2018). A separate system to collect and treat human manure for maximize reuse could be developed. Chemical wastes generated in the laboratories and medical wastes generated in the clinic contribute only a very limited amount in common secondary schools, and are not considered in this study. These hazardous wastes are directly collected by waste treatment companies for special treatment and incineration.

4.5. Outlook: an improved waste flow

Characterizing wastes generation is only the first step of implementing a zero-waste campus, and therefore we need and decide to continue our research further.

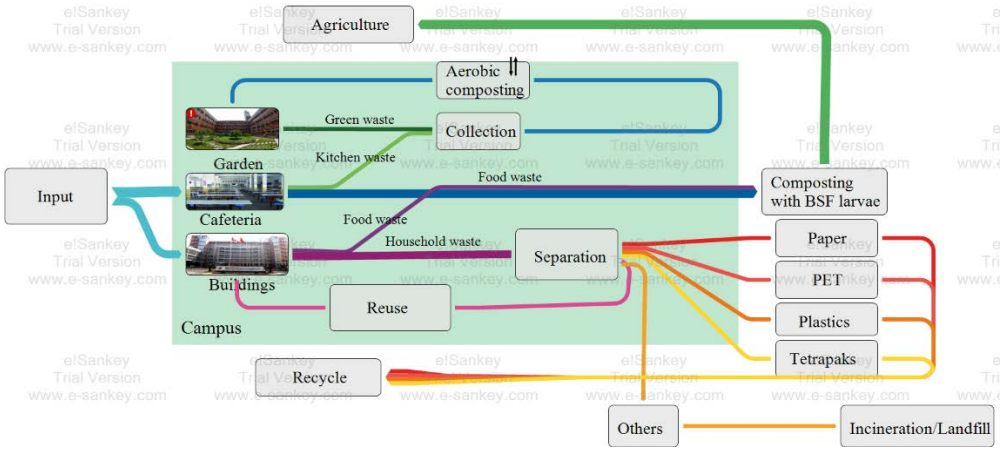

Figure 6. *Improved campus waste flow*

Figure 6 shows our vision of the model for an improved waste flow on a secondary school campus that would minimize end-of-life disposal such as incineration and landfill. Organic waste generated in the cafeteria could be separately collected in two categories: low-oil-and salt kitchen waste and high-oil-and-salt food waste. Food wastes could potentially be fed to black soldier fly larvae (BSFL) using BSFL composting techniques to produce protein additives and feed. Kitchen waste could be disposed applying composting methods, and the resulting organic fertilizers could directly be utilized on campus. Household wastes generated in the buildings should be separately collected, some reused on campus, and the rest sent to recycling centres. Our next step is to explore the feasibility and improve methods for low-cost composting technique that suits the campus or community scale to help deal with organic wastes.

5. Conclusion

Aiming at exploring a zero-waste campus, we launched a student-initiated investigation on waste generation in our secondary school campus, Nanjing Foreign Languages School. To determine waste generation quantity and components, on site sampling was applied over a period of four months, combined with the data of monthly waste generation patterns of Xuanwu District, Nanjing, where NFLS is located. Our analysis show that NFLS generates 543.5 kg of waste daily, with food wastes constituting 57% (by weight), green waste 4%, paper 14%, PET 4%, other plastics 5%, tetrapaks 11%, and other wastes 5%; Through research we observed significant monthly variation, mostly a result of holidays, A student-oriented waste separating and recycling program was experimented for four months, and managed to divert 61.26kg of recyclables from the waste stream. Our research pointed out that in secondary school, school management influences students' consumption behaviours on campus by deciding the input end, while student-oriented environmental efforts could potentially improve waste reuse and recycle. Finally, based on analysis, the study provided a list of policy suggestions on achieving zero-waste in a secondary school.

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Circular Economy - Part 3

Industrial Symbiosis Incentives: Mitigating risks for facilitated implementation

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Abstract

Industrial symbiosis (IS) is considered as a business model of the circular economy. This business model proposes symbiotic exchanges, also known as synergies, between companies, allowing the flow of resources, wastes and utilities. In recent years, the IS initiatives (Eco-industrial parks, Urban Industrial Symbiosis and symbiotic exchanges) have been exponentially growing around the world. This increase is related to raising environmental awareness and the opportunities to obtain economic, environmental and social benefits through the implementation of this model. Despite the exponential growth of IS initiatives, the companies are still facing problems in the achievement of reliable and permanent synergies, especially those without antecedents and IS background. Over the years the literature has identified several factors in the IS emerging process. Incentives are among these factors, being defined as unlocking tools or mechanisms related to diverse areas such as: economic, political, social, intermediaries, process, technology, etc. Authors believe that the large-scale implementation of IS incentives has not been properly addressed. In order to promote facilitated IS implementation and achieve a replicator effect, incentives should be fully addressed. In many case studies, it has been observed that the incentives for IS can be threatened by risks, compromising the implementation and hindering the emerging process. The aim of this paper is to contribute to unlock the emerging IS process, based on incentives identification, implementation risk identification and proposal of mitigation actions. With this purpose, this study developed an incentive identification framework based on the best practices of IS; a risk assessment model, based on internal and external risk factors and finally, a set of mitigation actions directed to the stakeholders. The main result of this study is a risk assessment model for IS implementation. The proposed methodology in this study, can be a useful tool for companies aiming to start symbiotic exchanges. This model might allow companies to have a facilitated implementation, allowing companies to prevent waste of resources in the emerging IS implementation process.

Keywords: circular economy, industrial symbiosis, incentive, assessment model, risk mitigation.

1. Typifying Industrial Symbiosis and its emerging process

Industrial Symbiosis (IS) is a concept of industrial ecology introduced in the early 70s (Short et al., 2014). Making reference to an environmental metaphor, in practical terms, this concept aims to create an ecosystem represented by a group of industrial actors sharing waste, resources and utilities (Chertow, 2000). The principle behind IS is quite simple, instead of being thrown away or destroyed, surplus resources generated by an industrial process are captured and redirected for use as a 'new' input into another process by other industries providing a mutual benefit or symbiosis (Lombardi et al., 2012). The firms involved through theses synergies can obtain economic benefits by sharing resources, wastes, information, knowledge, expertise, political support, supplying networks and distribution markets (Taddeo et al., 2012). In most cases, these benefits translate into reduction in the operational costs (Albino et al., 2016), reduction of greenhouse gas emissions (Johnsen et al., 2015), increases in knowledge and skills, jobs creation (Sun et al., 2016), tax benefits (Fraccascia et al., 2017) and economic profit. In the last 20 years, IS has been incorporated with greater importance in the industrial context due to the increasing concern about climate change (Boons et al., 2017), especially in the European Union (Domenech et al., 2019) , United States (Neves, et al., 2019) and China (Yu et al., 2015). As a consequence, the European Commission (European Commission, 2018b) and other countries have promoted legal frameworks, programs and plans that support the facilitated implementation of circular economy and its business models (Mirata, 2016).

Several authors have identified and characterized the IS emerging process (Mirata, 2004; Islam et al., 2016; Neves, et al., 2019), having a strong focus on understanding the early stage and promotion of IS synergies. These studies have also recognized the key factors that appear in this process. Over the years, literature categorizes these key factors in different groups: enablers, drivers, challenges, barriers, etc. Regardless of which classification and denomination literature suggests, these factors can intervene in three perspectives: factors that promote and facilitate the development of IS supporting or unlocking (enablers, drivers) (Golev et al., 2014; Islam et al., 2016); factors that hinder or constrain the implementation of this practice (barriers, challenges) (Golev et al., 2014) and factors that ignite the implementation (triggers) (Vladimirova et al., 2018). From these factors, one of the extensively studied in recent years has been the enablers (Corder et al., 2014; Islam et al., 2016). It was observed in literature that most of the studies do not discern between incentives and enablers. As a consequence, enablers and incentives are constantly confused, several times those concepts are put in the same category. Nevertheless, the authors consider that the incentives for IS are in a different category due to the different scope and context.

Enablers are factors that support the emerging process of industrial symbiosis. Incentives on the other hand, are instruments or mechanisms supporting the consolidation of the enablers (Henriques et al., 2019). These incentives must have a principle of replicability, meaning that they can be applied under different conditions and different national realities. For example, existence of regulations and policies that allow symbiotic exchanges has been identified in various studies as a fundamental enabler for the promotion of IS (Islam et al., 2016; Leong et al., 2017; Neves, et al., 2019). This policy is typically supported by instruments, such as, landfill taxes (Mirata, 2004), environmental taxes (Bruvoll et al., 2009; Johnsen et al., 2015) and industrial symbiosis plans (Mirata, 2016). All these instruments are incentives for IS.

The purpose of this paper is to advance the understanding of IS emerging process through the comprehensive identification and characterization of IS incentives. For this reason, we consider that it is necessary to analyse the incentives and correlate with their implementation risks. The final contribution of this study is the promotion of mitigation actions that encourage the reduction of these risks. These actions will contribute to the promotion of synergies in a more efficient manner.

This study has an empirical approach that is supported by implementation cases experiences, stakeholder consultations and external observation. The research was developed and structured in order to answer the following questions:

- What are the main incentives for IS implementation on a large scale?
- What are the risks related with the incentives and what is the nature of the risk factor?
- What are the actions that could be promoted in order to mitigate the risk associated to the incentives?

This research arises in the sequence of an extensive study developed in the context of the project SCALER (*SCALER-Scaling for Industrial Symbiosis and Efficiency Resource Project*, 2017), which envisages the promotion of industrial symbiosis practices in the European process industry.

2. Research methodology definition

The first step in this study was to define a methodology research that would allow the achievement of the proposed objectives. In this sense, Figure 1 represents the proposed methodology research model. This research methodology consists in two main phases; the first phase dedicated to the incentive identification by literature review and expert consultation. The second phase is dedicated to the incentive analysis in a detailed perspective by the development of a risk assessment model for risks evaluation, finally resulting in a full set of proposed mitigation actions.

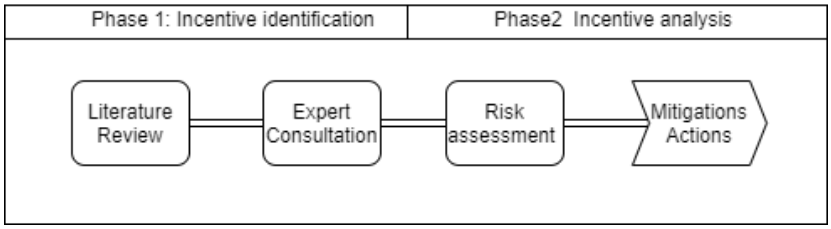

Figure 1. *Research Methodology*

Phase 1: Incentive identification

The IS incentives identification was conducted initially through a literature review and expert consultation. The main objective of this review was to identify IS implementation cases and their associated incentives. The identification was developed through searches in the Web of Science and Scopus search engines selecting scientific peer reviewed journal papers. Nevertheless, other publications were also considered, such as technical reports of EU countries, official documents of the EU, statistics, case studies and the best practices for industrial symbiosis (Vladimirova et al., 2018). A complementary method used for incentives identification was expert consultation through dedicated enquiry. The aim of this enquiry was to obtain the opinion of the experts in industrial symbiosis about their perspective on the role of incentives and their critical areas. The combination of the main findings from literature review and the expert enquiry, result in a final incentive identification.

Phase 2: Incentive analysis

Once the incentives were clearly identified, it was necessary to assess their associated risks. This assessment was promoted by a risk assessment model. This assessment is based on the basic principles of risk management, consisting of 3 main steps risk identification, risk analysis/ evaluation , and risk treatment (*ISO 31000 - Risk management*, 2009). Figure 2 represents the risk assessment model proposed for the purposes of this study.

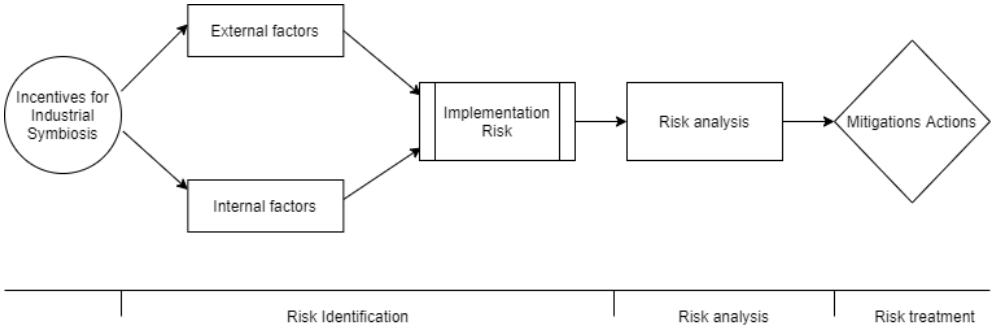

Figure 2. *Risk assessment model steps used*

The risk assessment model is structured in three sequential steps: (a) the first step called risk identification allows the identification of implementation risks through the analysis of external and internal factors by documentation review techniques (*IEC/ISO 31010 - Risk assessment techniques*, 2009); (b) the second step is the analysis of the implementation risks. This procedure allows to evaluate the factors associated, in order to propose measures for the risk treatment and (c) the third step defines mitigation actions associated to risk treatment.

It should be noted that the study is mostly based on an empirical approach, and supported by implementation cases experiences, stakeholder consultations and external observation. The approach used to regard the mitigation actions was developed in the generic perspective of avoiding and reduce the implementation risks. Mitigation actions implementation are highly dependent on case study specificities and slight adaptations based on empirical practices are advised.

3. Assessing implementation risks: New model proposal for IS incentives

Identifying incentives for IS

Regarding incentive identification, they were grouped by areas recognized as critical in the literature review. These areas are: financial, policy related, social, information related, process and technology. Through the expert inquiry (Vladimirova et al., 2018), the relevance of these areas was also validated by results crosscheck In general terms, the enquiry results considered that the critical aspects for developing and implementing IS are: economic aspects (economical gains, financing); ability of willing partner (social factors); and unblocking policies. We can conclude that in the incentive identification framework, there is great presence of political, financial and social incentives. Table 1 presents the final incentive identification framework, bringing together the identified areas and incentives.

Table 1. *Incentive identification framework*

Area	**Incentive**
Financial	• Co-funding investment Programs • Common Waste Market • Integrated method to calculated the overall benefits • Premium Tariff Energy • Biofuels Tariff
Policy-related	• Disaggregated industrial waste policy framework • Landfill Tax • Environmental and Energy Taxes • Improving the Energy Efficiency and Resource Efficiency • Green criteria as key element for public procurement
Social	• Training programs (Build awareness) • Collaborative networks • Sectorial clustering • Social Corporate Responsibility programs (SCR)
Information-related	• Knowledge and training (Institutional) • Networking initiatives • Dissemination initiatives (community)
Technology	• Transition to Industry 4.0 Programs • Databases and ICT tools
Process	Promotion of formal agreements and protocols

Regarding financial incentives, special tariffs rewarding companies that pursue the incorporation of renewable energies have proven to be important incentives in Nordic countries (Johnsen et al., 2015). The financing programs are also essential for IS on large scale implementation, especially programs supporting the purchase of infrastructure, utilities and services (Costa et al., 2010), helping to overcome barriers such as financial limitations of the companies to develop the initiatives by themselves. Other valuable instrument is the waste market or waste fund that works as a trigger for the purchase and sale of waste (Costa et al., 2010).

Regarding policy related domain, the most effective and predominant instrument has been the waste policy framework. Specifically disaggregated industrial waste policy (National, regional and local) that allows the synergies implementation between industries, through the simplification of industrial waste declassification procedure. Other important tools/instruments are taxes in several areas such as landfills, greenhouse gas emissions, footprint, etc. Regarding taxes, they can be separated in two main approaches; those that penalize environmental pollution or excessive and inefficient use of resources, such as

Norwegian CO_2 tax (Bruvoll et al., 2009) and those taxes that promote the use of alternative methods with less environmental impact. The Finish reduced taxation is one of the most influential cases in this approach (Johnsen et al., 2015). There are also other political incentives that have great relevance, which are the strategies for green growth, such as the Green Public Procurement (European Commission, 2016), resource/ energy efficiency programs (Adamides et al., 2009) and circular economy plans (European Commission, 2018a). These instruments gradually change consumption habits and mindset within the industrial sector.

Social and information-related incentives had also an important presence/role in results identified, mainly by those instruments and programs that support the creation of awareness at the community and institutional level. Some of the most popular instruments are collaborative networks (Raabe et al., 2017), clusters (Taddeo et al., 2012), training initiatives (Massard et al., 2013), dissemination programs, green marketing and action plans (Mirata, 2004). These instruments help to overcome barriers such as lack of trust and social inertia through the creation of awareness.

Regarding the technological incentives, they complement the other areas previously mentioned as they play a fundamental role in the implementation of IS on large scale initiatives. The programs for the transition to I4.0 allows the automation of the industry and consequently the control and monitoring of the production processes in an optimized way. Tools such as cyber-physical systems, cloud manufacturing and Internet of Things (IoT) are essential in this process (Kang et al., 2016). The shared databases and ICT tools are also important since the integration of datasets and geolocation data is crucial for matchmaking and mimicking methodologies (Holgado et al., 2018). Regarding process incentives, the promotion of protocols and formal agreements helps define terms of negotiation and execution times, facilitating the implementation process (Costa et al., 2010).

Assessing incentive implementation risks

In a risk management process, it is important to consider the context of the risks and their associated factors, where those can be internal (social, cultural, legal, regulatory, etc.) and external (strategy, capacities, norms, relationships, etc.). The purpose of any risk analysis is to understand the nature of the risk and its characteristics. The focus of the present risk assessment model was to analyse the internal and external risk factors from the companies' perspective. In this sense, the first part of the risk assessment model was dedicated to the risk identification, followed by their associated risk factors (internal/external) and finally by their associated implementation risks. Table 2 presents the risk factors and implementation risks.

Table 2. *Risk factors and implementation risks*

Incentive	Risk factors		Implementation risks
	Internal	External	
Co-funding investment Programs	• Dependence on state funds for the implementation of IS initiatives • Lack of receptivity • Lack of knowledge regarding available funding programs and lack of technical competences to prepare /submit proposals	• Lack of national funds to promote and maintain platforms that promote business links • High level of bureaucratic processes of co-financing programs and lack of standardized environmental regulation to support their implementation • Low receptivity of large companies	Low adherence rate to financing programs Loss of funding and programs
Common Waste Market	• Low waste quality in the residues, lack of controls and standards to guarantee the quality of the materials • Resistance of companies to initiatives/ projects that necessarily change their operations • Lack of knowledge of possible uses of available waste • Insufficient knowledge of technological capability and data management by companies	• Waste price instability, compared to the virgin raw materials market • Vulnerability at the Supply Chain level regarding Waste / by-products, • Partner location and logistics. Long distances and lack of transport might compromise the viability of synergies • Lack of funding to promote and maintain this initiative • Different national realities regarding waste management, classification and recovery	Low adherence rate to waste transaction initiatives Loss, discontinuation or cancellation of Waste Market initiatives

Integrated method to calculated benefits	• Insufficient knowledge and technological capacity • Lack of interest and awareness in the principles of industrial sustainability • Lack of data management by companies	• Different national realities regarding waste management, classification and recovery • Lack of regulation at a national or European level that forces the companies to participate in the implementation of a shared waste database	Low application/use by the end-users (industrial actors)
Premium Tariff Energy	• Inability to manage the responsibilities associate to adaptation process in order join this tariff • Dependence on state funds to cover the initial investment • Technological unviability	• Lack of national funding to promote and maintain this initiative • Low development level of regulation and policies that promote this tariff • High level of bureaucratic processes to acquire this tariff • Lack of standardized environmental regulation to support the tariff implementation	Low adherence rate of the end-users to the tariff (industrial actors)
Bio fuels Tariff	• Inability to manage the responsibilities associate to adaptation process in order join this tariff • Dependence on state funds to cover the initial investment • Technological unviability	• Lack of national funding to promote and maintain this initiative • Low development level of regulation and policies that promote this tariff • High level of bureaucratic processes to acquire this tariff • Lack of standardized environmental regulation to support the tariff implementation	Low adherence rate of the end-users to the tariff (industrial actors)
Landfill Tax	• Business scepticism about new environmental challenges and social barriers (resistance to change) • Lack of interest due to the low prices of land fill gates (In some countries)	• Low development level of regulation and policies that promote this tariff • High level of bureaucratic to effectively implement the land fill taxes • Lack of standardized environmental regulation to support the tax implementation	Alteration of landfill taxes for a less favourable approach for the IS promotion
Desegregated industrial waste policy framework	• Problems in adapting to new policies approach • Alteration of operations in order to achieve the new targets • Lack of initial investment to adapt the industrial process	• Long distances and lack of transport might compromise the viability of synergies • Lack of suitable partners for the synergies implementation • Limited diversity of waste /by-product streams due to the high homogeneity of surroundings companies • The bureaucratic complexity associated with transition and adaptation to new policies	Stagnation of policies that do not allow or hinder the development of IS initiatives
Environmental and Energy Taxes	• Business scepticism about new environmental challenges and social barriers (resistance to change) • Lack of initial investment to improve the industrial process	• Lack of funding to promote and maintain this initiative • Low development level of regulation and policies that promote energy and resource efficiency • Low development level of regulation and policies that promote these taxes	Alteration of energy/environmental taxes for a less favourable approach for the IS promotion
Green criteria as key element for public procurement	• Business scepticism about new environmental challenges and social barriers (resistance to change) • The resistance of companies to initiatives/ projects that necessarily change the method they operate at different levels (Social inertia)	• Lack of regulation at national or European level that stimulates the companies to participate in this kind of initiative • Problems in the purchasing process due to insufficient or unstable product offer	Low adherence rate by the companies that will continue consuming the same products
Improving the Energy Efficiency and Resource Efficiency through policy	• Lack of technical competences to prepare /submit proposals • Financial limitations for initial investment • Lack of motivation to apply / participate in these initiatives	• Lack of regulation at national or European level that stimulates the companies to participate in this kind of initiative • Lack of funding to promote and maintain the programs promoted for this policy • The bureaucratic complexity	Low adherence rate of the industrial actors in these initiatives Loss of funding and programs for energy and resource efficiency
Training programs (Build awareness)	• Lack of receptivity, trust and motivation among employees due to resistance to change • Business scepticism about new environmental challenges and social barriers (resistance to change)	• Lack of funding to promote and maintain the training programs • Reduced government presence as a driving agent	Low attendance and participation by the community and business actors
Collaborative networks	• Business scepticism about new environmental challenges and social barriers (resistance to change) • Lack of motivation and collaborative approach to join the network	• Lack of funding to promote and maintain this initiative • Reduced government presence as a driving agent	Low attendance and participation by the community and business actors

Sectorial clustering	• Mistrust due the fact that clusters normally are dominated by a few firms • Lack of receptivity due to resistance to change (complex cross-sector relationships)	• Lack of funding to promote and maintain this initiative • Reduced government presence as a driving agent	Low attendance and participation by the community and business actors
SCR programs	• Lack of funds to develop an SCR plan • Lack of trust and social inertia at various levels of the institution	• Lack of community interest • Lack of intermediaries to support this type of programs	Low implementation of SCR plans by companies
Networking initiatives	• Business scepticism about new environmental challenges and social barriers (resistance to change) • Reduced "circular" company culture can affect the implementation of IS practices • Lack of receptivity, trust and motivation among employees due to resistance to change	• Lack of cooperation between the scientific community and companies • Lack of receptivity of knowledge agents and business actors	Low attendance and participation by the business actors, scientific community
Knowledge and training	• Reduced "circular" company culture can affect the implementation of IS practices • Lack of receptivity, trust and motivation among employees (Social inertia)	• Lack of knowledge agents and entities trained to support and accompany this initiative	Low implementation of knowledge and training initiatives in the companies
Dissemination initiatives	• Lack of receptivity, trust and motivation among employees • Reduced "circular" company culture can affect the implementation of IS practices • Lack of employees with skills and knowledge to develop these initiatives	• Lack of community and business actors' interest • Lack of financing to disseminate IS appropriately	Low attendance and participation by the business actors, scientific community
Transition to Industry 4.0 programs	• Inability of the company to face new technological challenges • Insufficient knowledge of technology capability and data management by companies • Inability to manage responsibilities associated to this initiative • Confidentiality issues	• Lack of financing that generates dependence on state funds, such as, programs and projects • Low industry receptiveness or inability to make the necessary technology investments • Dependence on government participation as the main driver	Low attendance and participation by the companies Loss, discontinuation or cancellation of I4.0 programs
Share data bases and tools	• Lack of confidence in the availability of data, confidentiality issues • Inability of the company to face new technological challenges • Lack of knowledge and equipment for data collection and treatment	• Lack of financing to promote this initiative • Lack of trust from companies to share their data	Low adherence rate of the end-users to the databases (industrial actors)
Promotion of protocols and formal agreement	• Lack of personnel to take the responsibilities that the development of this type of documents implements • Lack of knowledge to develop protocols	• Mistrust in accepting commitments that could have legal consequences • Conflicts of interest due to the competitive nature of the industrial sectors	Low implementation of formal agreements and protocols in the emerging phase of synergies

It is important to highlight that most of the risks identified were caused by means of economic, social, political and institutional capacity risk factors. The social risk factors were those that had the greatest presence in our analysis. We consider that these can be divided into two perspectives; institutional (companies, industry, etc.) and community (business agents, community government entities, etc.). On the company side the lack of confidence in ecological concepts, trust environment and uncertainties in the return on investment (Taddeo, 2016), lack of motivation at various levels, self-interest nature of the industries (Tan et al., 2015), confidentiality issues (Kosmol et al., 2020) and the business as usual mind-set have turned out to be the most predominant. In terms of the community, factors such as lack of intermediaries, lack of industrial symbiosis expertise, low awareness about the opportunities provided (Johnsen et al., 2015), lack of environmental awareness, non-existent or low presence of the government as a driver were the most prominent. These risk factors mainly translate into low attendance in the initiatives.

Economically, most of the risk factors are related to the financial inability of companies to acquire the infrastructure, utilities and services that are required to implement some of the incentives (Costa et al., 2010). This incapacity generates dependence on state funds that are provided through plans, projects and credits. These financing instruments often do not have a continuity nature, which generates uncertainty in their refinancing and puts the continuity of the initiatives at risk (Vladimirova et al., 2018).

In policy terms most of the identified factors are related to the absence or ambiguity of regulations and the existing legislation regarding industrial waste management (Costa et al., 2010; Allard et al., 2012). It should be emphasized that in some cases, even if there is an industrial waste policy framework, they do not often effectively support the creation of synergies. Another important political factor were the uncertainties that exist regarding the direction and approach that new national policies will take, which stipulate new requirements, needs and regulations (Vladimirova et al., 2018).

Mitigating implementation risks for facilitated implementation

The last step of the presented risk assessment envisages the formulation of mitigation actions that minimize the risk associated to the implementation of incentives (Henriques et al., 2019). The aim of this set of actions is to reduce the frequency, magnitude, and severity of the risk impact. The mitigation actions are completely based on the main findings of the risk analysis. Since most of the risk factors identified in the previous step were economic, social, political and institutional capacity, a structure of actions was promoted that responds directly to these risks and the actions that must be taken by the diverse stakeholders involved. We considered stakeholders as: national entities (ministries, agencies, authorities, etc.); regional / local government (Chambers, regional agencies, business councils, associations, etc.); intermediaries (clusters, consultancies, etc.); knowledge agents (R&D organizations, universities, etc.); businesses (companies, industries, etc.). In this sense, the following set of mitigation actions are proposed regarding the different stakeholders in order to avoid and reduce risks on incentives implementation.

Table 3. *Set of mitigation actions*

Stakeholder	Mitigation actions
National Entities	• Promote new policies and legal frameworks that support the transition to a more sustainable industry, aligned with a clear European legislation (standardized) • Reinforce the participation in IS initiatives and programs, the role of the state cannot limit itself as a funding entity but should also be incorporated as a promoter • Reinforce the allocation of sufficient national funds for IS incentives, which must necessarily have a character of continuity to overcome the barriers associated with uncertainty • Promote and prioritize supranational initiatives that are aligned with the collective efforts to tackle the climate change (e.g. European Green Deal) (European Commission, 2019)
Regional/ local government	• Reinforce the commitment in dissemination of IS and its benefits, greater participation and involvement in the promotion of the Circular Economy and its business models, through conferences, workshops, action groups, or regional communication plans • Increase engagement through actively participating in IS programs, clusters, initiatives in progress. It is fundamental that the industrial sector feels their support of the local/regional authorities • Increase the community awareness in environmental problems and sustainable development through the knowledge transfer • Prioritize industrial symbiosis strategies within the scope of Research and Innovation Strategies for Smart Specialization,
Intermediaries	• Reinforce the dissemination of good practices, anchors companies' experiences, circular economy and other topics that help creating awareness in the industrial sector • Reinforce the negotiation process through the creation and development of protocols, agreement of timing (with stakeholders), formal partnership, etc. • Development and promotion of mechanisms (methodologies, tools, etc.) that allow to measure which benefits involves the incorporation of symbiotic synergy

Knowledge Agents	• Reinforce the participation in clustering and networking initiatives, this will help to overcome the social barriers related to the different approaches of the two sectors (Industries actors and scientific community) • Encourage a close relationship with the industry, developing applied research linked with real industry needs and practical problems
Businesses	• Boosting the training & dissemination initiatives in topics such as the circular economy, their business models, green thinking and green growth. These actions have the main objective of overcoming social barriers • Reinforce the technological investment areas, such as purchase of utilities, IT skills improvement and training among employees • Boosting the participation in initiatives such as clustering/ networking and really engage with partners and initiatives • Build trust environment in the initiatives, promoting open mindedness to receive anchor companies, knowledge agencies, local authorities' representatives and other intermediaries • Reinforce the transfer of knowledge will be fundamental to mitigate the risk associated with the loss of key players and high turnover culture • Reinforce the participation in associations and industrial clusters, due its supportive role in the IS emerging process

4. Conclusions

In recent years, the exponential growth of IS initiatives around the world has generated the need to deeply understand the IS emerging process and its different factors. The current study has analysed the incentives that contribute to the industrial symbiosis implementation. This paper has systematically reviewed the incentives for IS, its implementations risks, and promoted mitigations actions. In order to achieve the initial objectives this article promoted an incentive assessment for industrial symbiosis, with a special focus on understanding how implementation risks can be mitigated.

In general terms, companies are encouraged to develop synergies mainly for economic reasons. Whether for direct gains, such as reduced operating costs or revenues from the incorporation of new business models, or on the other hand, indirect gains such as government funds, credits, projects, etc. Concerning implementation risks, it was possible to verify that most of the implementation risks that were revealed through this study are related to economic, social, political and institutional capacity risk factors. The source of these risk factors is varied but they are mainly due to barriers such as economic inability, lack of trust environment, uncertainties, lack of interest/motivation, etc. In order to promote measures to mitigate these risks, the mitigation actions from the perspective of various stakeholders were derived. In general terms, the actions are directed for business practice, policy transition, awareness-raising and engagement reinforcement.

Without disregarding the results obtained in this study, we consider that this study had some limitations due to its nature. The risk assessment model was based on methods such as observation, literature review and expert consultation. The mitigation actions were proposed in order to avoid the impacts of risks, nevertheless, a real case validation will strengthen the present mitigation actions. For future studies the proposed methodology should be supported by real case implementation scenarios, which will help validating the full methodology and preliminary results.

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Sustainable Value Chains and Trade

A classification of new data sources for sustainable product management in a circular economy

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Abstract
The information and communication technology architecture of a company and its dynamic adaptation to technological developments such as the Internet of Things, Big Data, Artificial Intelligence, Blockchain (collectively known as digital technologies) are of relevance to implement a sustainable circular economy. The sustainable circulation of resources could be seen as a means to an end for sustainable development. For organizations, the goal is to investigate under which conditions their products are designed and used to maximise sustainability performance and circularity. Making informed decisions in this context means that the sustainability and circularity performance of products needs to be assessed on a case-specific level. These assessments, however, are time, effort, and data-intense endeavours. At the same time, it is not yet clear how and which data could and should be collected and shared along the product life cycle to assess the product's sustainability and circularity performance as a prerequisite for a sustainable circular economy. This research gap is addressed by adopting a sequential mixed-methods approach combining (1) a systematic literature review of 375 documents, (2) a quantitative analysis of 233 and qualitative content analysis of 154 selected articles, and (3) a cross-disciplinary focus group with ten (industry) experts. The main results of this work are: (1) a synthesis of findings and descriptive review of articles concerning digital technologies for sustainable product management (2) an understanding of potential and existing application cases of digital technologies for sustainable product management (3) insights from industry experts regarding their sustainable product management experiences and practices as well as existing and potential new data sources for sustainable product management along a product's life cycle. Finally, the key findings are contrasted to other studies, and an outlook for further research is given.

Keywords: Circular Economy, Sustainable Product Management, Product Lifecycle Data, New Data Sources

1. Introduction

In today's linear economy, the lack of a comprehensive and integrated view of the physical life cycles of products leads to products being designed and used in an unsustainable way (Mayer et al., 2018). An alternative to the linear economy that is gaining momentum in business, politics, and academia is the concept of circular economy (CE) (Ellen MacArthur Foundation, 2015; European Commission, 2015, 2020; Kirchherr, Reike, & Hekkert, 2017). In a CE, material flows should preserve their highest value as long as possible and circulate in loops within the economy to minimize negative environmental impacts (Kirchherr et al., 2017). Major modifications of how material information is collected, exchanged, and managed throughout the (physical) product life cycle will be necessary to ensure a sustainable circularity of products (de Sousa Jabbour, Jabbour, Foropon, & Godinho Filho, 2018). Thus, the information and communication technology (ICT) architecture of a company and its dynamic adaptation to new (digital) technological developments are of relevance to implement a CE (Garcia-Muiña, González-Sánchez, Ferrari, & Settembre-Blundo, 2018). Some of these technological developments are, e.g., the emergence of the Internet of Things (IoT), artificial intelligence (AI), Big Data, or blockchain technology – collectively known as digital technologies (DTs) (Kristoffersen, Aremu, Blomsma, Mikalef, & Li, 2019). However, it is not yet clear how and which data should be collected and shared along the product life cycle intra- and inter-organisationally. Therefore, the following research questions are addressed in this study:

(1) Which digital technologies are linked with sustainable product management approaches in the current scientific literature?

(2) What are existing and potential applications for digital technologies along a product life cycle for sustainable product management in literature and practice?

The overarching goal, to which this study wants to contribute, is the utilization of the full potential of DTs for sustainable product management (SPM) along the whole life cycle of a product in a CE. A holistic SPM can be considered as one among

several, complementary strategies for a sustainable CE[1]. SPM goes beyond a reductionistic and sole circularity focus that neglects a variety of sustainability issues, most prominently the social dimension, and which comes at the danger of inducing CE rebound effects (Figge & Thorpe, 2019; Zink & Geyer, 2017). Besides CE-related ones, SPM comprises other complementary practices such as sustainability assessment, sustainable supply chain management, or sustainable product development. SPM practices share a comprehensive life cycle perspective and the inherent dependency on the exchange of material and product-related information. A life cycle perspective is generally indicated by a set of phases that can be considered as independent stages to be followed by a product and can be summarized under three main stages (Kiritsis, Bufardi, & Xirouchakis, 2003; Terzi, Bouras, Dutta, Garetti, & Kiritsis, 2010):

(1) Beginning-of-life (BOL): including the product-, process-, or plant design activities as well as manufacturing (production) and internal logistics,
(2) Middle-of-life (MOL): including (external) distribution, use-phase, and support (e.g. maintenance and repair),
(3) End-of-life (EOL): where products retire and are either recollected by the manufacturing company itself (reverse logistics) or disassembled, refurbished, recycled, reassembled, remanufactured, reused, disposed.

With DTs, we refer to the new technologies mentioned above, that have encouraged a paradigm shift for industrial production. This paradigm shift is frequently subsumed under the term "Industry 4.0" that refers to the fourth industrial revolution (Kristoffersen et al., 2019; Wichmann, Eisenbart, & Gericke, 2019). Of these DTs that are of concern in this study, the IoT concept describes the increasing interconnectedness of devices and the formation of new networks of information. As identified by Atzori, Lera, & Morabito (2010), the IoT can be realized in three paradigms: internet-oriented (middleware), things oriented (sensors) and semantic-oriented (knowledge), and their alignment is central for the usefulness of the IoT (Gubbi, Buyya, Marusic, & Palaniswami, 2013). Artificial intelligence (AI) generally refers to technologies that are capable of performing certain tasks equally good or better than humans (Vinuesa et al., 2019), such as machine learning and deep learning (Copeland, 2016). Big data analytics refers to the strategy of analysing large quantities of data that can be distinguished by their volume, variety, velocity, veracity, variability, and value (Sivarajah, Kamal, Irani, & Weerakkody, 2017). The most recent of these DTs is blockchain technology, which is characterised as a chain of time-stamped, cryptographically secured, immutable blocks of consensus-validated digital data. Any correct information stored in a blockchain can, therefore, be seen as appropriate and valid information; thus, blockchains have a significant potential to enable smart-contracted verifications of sustainability-related data allowing the development of new and sustainable business models (Chapron, 2017). From the perspective of SPM, these DTs can be seen as key enablers for wider adoption of and an accelerated transition to sustainable and circular business practices (Kristoffersen et al., 2019).

The remainder of this paper is structured in the following way: After the brief introduction about DTs, CE and SPM given in chapter 1, the methods used in this study are described in chapter 2. In chapter 3, the results from the theoretical and empirical parts are presented, and concrete approaches of DTs for SPM are listed and discussed. Finally, in chapter 4, a conclusion and outlook are given.

2. Methods

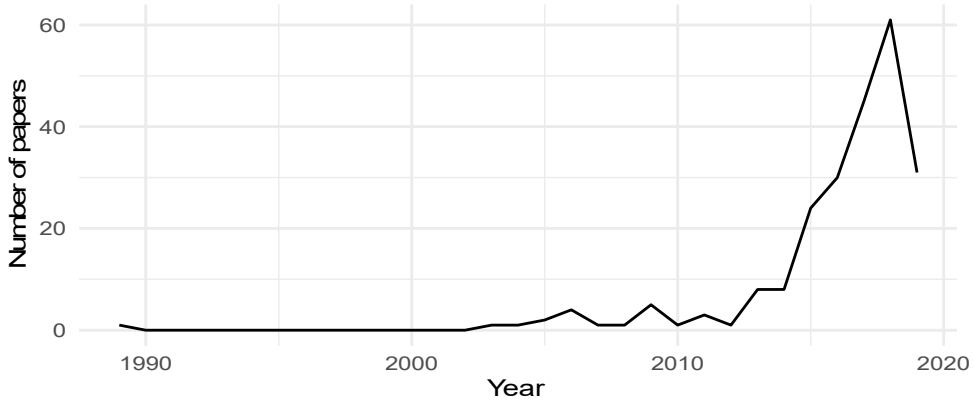
This exploratory research study adopted a sequential mixed-methods approach combining (1) a systematic literature review[2] (2), a quantitative analysis and a qualitative content analysis of selected papers, and (3) a cross-disciplinary expert focus group[3]. Despite a dissent about the mixed method terminology, we describe the research design as a sequential mixed-method approach. A mixed-method approach is especially useful when the research question concerns a complex phenomenon or different facets of the same phenomenon, such as theoretical and practical aspects. Additionally, for a sequential mixed method

[1] Geissdoerfer, Savaget, Bocken, & Hultink (2017) identified for instance sustainable business models as a complementary strategy for a CE.
[2] The literature review was conducted, and the documents were analysed in early 2019.
[3] The focus group was organized in October 2019.

approach, it is described that the supplementary component of a study enhances the validity of the results by enriching and expanding the knowledge gained from the core component of the research process (Morse & Niehaus, 2016). In this study, the literature review is seen as the core component, and the focus group is the supplementary component.

Firstly, a systematic literature review (Fink, 2005; Seuring & Gold, 2012) was conducted of which the main elements are described in Table 1:

***Table 1**: Analytic categories of literature review with results (own representation based on (Seuring & Gold, 2012, p. 552))*

Description	Results
Aim of research	Exploring potential and existing applications of DTs for SPM and investigating potential new data sources for SPM
Method of data gathering	Keyword research[4] in title, keywords, and abstracts in Scopus[5] database e.g. TITLE-ABS-KEY ("circular econom*" AND "internet of things") – all keywords can be found in section 3.1
Number of publications and time period covered	375 documents were found in March 2019 (233 without duplicates) with publication years ranging from 1989 to 2019. 
Method and type of data analysis	Quantitative and qualitative content analysis in MAXQDA
Analytic categories for analysing the contents	The first part was deductively derived as the different DTs and SPM terms were used for the categorization. For the second part, the categories "concrete approaches" and "existing/in-use" and "potential applications" of DTs for SPM were inductively derived
Quality measures	Transparent process and documentation (e.g. for each combination of the keywords and results found in the database), other researchers reviewed database and search terms, as well as discussion rounds and quality checks within the research team were done to ensure a coherent research approach

Secondly, the literature sample was analysed quantitatively, together with qualitative content analysis. Content analysis is described as an effective means for conducting literature reviews transparently and systematically (Fink, 2005; Seuring & Gold, 2012). The qualitative content analysis was based on the approach described by Mayring (2014) and adapted to suit the particular material. Mayring (2014) describes three forms of interpretation of which "structuring" was applied in this study to filter out particular aspects of the content (p. 64).

Third, a cross-disciplinary expert focus group workshop was undertaken with ten selected participants (convenience-based sampling) from the industry network of the Christian Doppler Laboratory for Sustainable Product Management enabling a Circular Economy[6]. The focus group comprised of following participants that spanned the product life cycle BOL to EOL:

[4] Keyword search in literature databased is recommended as a technique particularly for covering a specific topic that might be addressed across various academic fields and consequently across several journals (Seuring & Gold, 2012, p. 551).
[5] https://www.scopus.com/
[6] In Christian Doppler Laboratories, application-oriented basic research is pursued at a high level, and expert scientists cooperate with innovative companies. The Christian Doppler Research Association is an international best practice example

3 representatives of automotive suppliers, 2 representatives of automotive engineering service providers, 2 representatives of automotive industry clusters, 1 sustainability and compliance-oriented PLM solution provider, 1 IT solution provider, 1 end-of-life treatment and recycling provider. A focus group is a particular type of group interview with approximately six to ten participants and is led by a moderator. The method is especially relevant to determine different perceptions and motivations in a specific area as well as to understand how people think or feel about an issue. The advantage in comparison to individual interviews is a more collaborative process of ideation, which can lead to completely new and unexpected insights. On the other hand, focus groups are mostly not representative for a specific target group as they operate with small groups of participants. The moderation of a focus group is essential as the characteristics of people can vary greatly, and discussions should be dynamic but still balanced (Henseling, Hahn, & Nolting, 2006).

3. Results and Discussion

3.1. Systematic literature review

In the systematic literature review, 375 articles and reviews on the intersection of SPM, information technology (IT), ICT and data-sciences approaches (subsumed under the umbrella term DTs) were screened and classified. Figure 1 a) shows the focus of the review on overlaps between SPM approaches and terms (i.e. Circular Economy (CE), Product Life cycle Management (PLM), Sustainable Product Development (SPD), Life Cycle Assessment (LCA), Life Cycle Analysis, Eco Design, (green/sustainable) Supply Chain Management (SCM), Industrial Ecology, Life Cycle Management) and terms related to DTs (i.e. Industry 4.0, Internet of Things (IoT), Big Data, Blockchain, Artificial Intelligence (AI)). Figure 1 b) shows the selection process and the number of analysed documents in each research step.

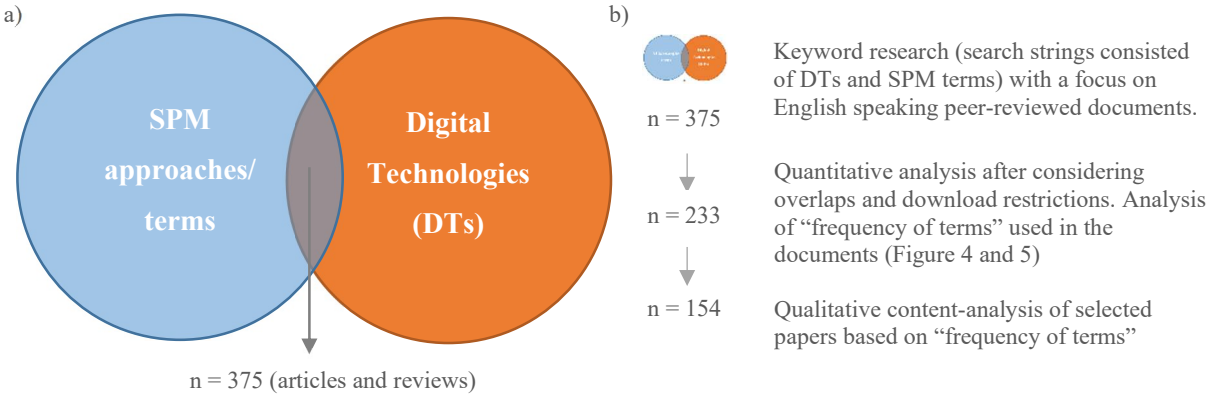


Figure 1: *a) Intersection of two areas as research focus b) Numbers of selected documents after each research step. SPM = Sustainable product management, DTs = Digital technologies (own representation)*

3.2. Quantitative and qualitative content analysis

In total, 375 documents (articles and reviews) could be found in the Scopus database at the intersection of DTs and SPM - without considering potential overlaps between the categories. The number of documents found in the different categories can be seen in Figure 2. In terms of the prevalence of the different DTs in the 375 documents, AI was the search term that was referred to the most (115 documents), followed by Big Data (102 documents) and IoT (99 documents). Industry 4.0 (52 documents) and blockchain are the least popular (7 documents). The most prevalent combination of search terms was Life Cycle Assessment or Life Cycle Analysis and AI. By using Life Cycle Management as a keyword, IoT and Big Data were combined most often with it. By using PLM as a keyword, most articles were found when combining it with the terms IoT and Big Data, followed by industry 4.0 and AI. In the green or sustainable supply chain management literature, AI and Big Data

for promoting this collaboration. Christian Doppler Laboratories are financed jointly by the public purse and the participating companies. For information about this laboratory see: https://circular.uni-graz.at/en/

were referred to the most. In combination with CE, IoT, and the general term industry 4.0 appeared most often. In combination with the term SPM or sustainable product management and each of the DTs no document could be found in the database.

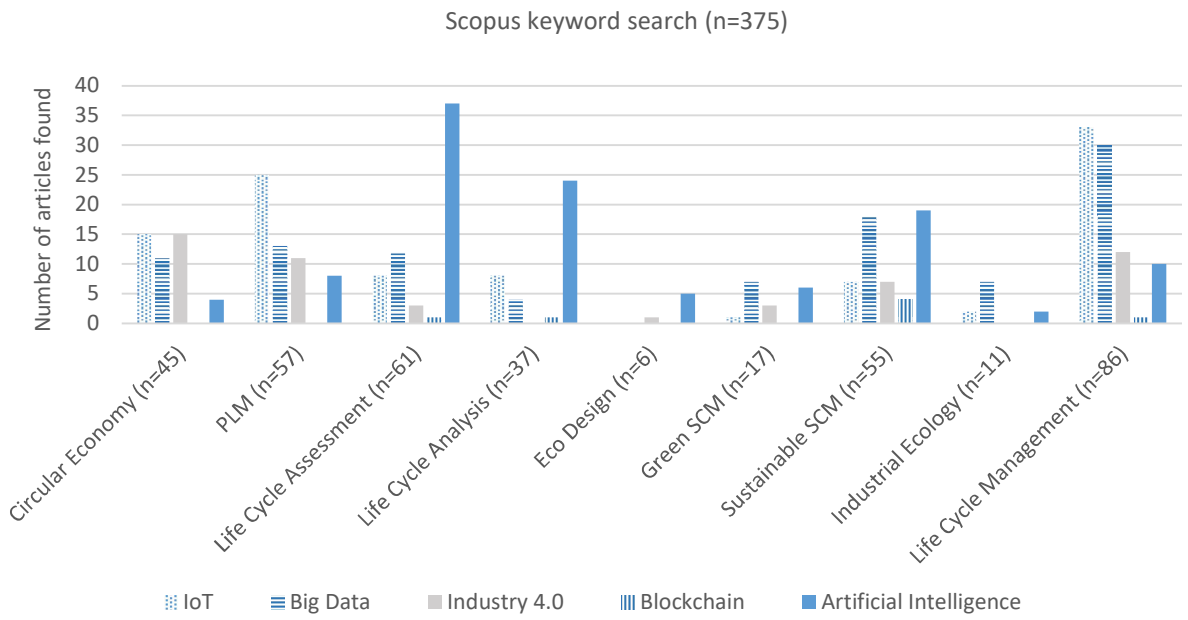
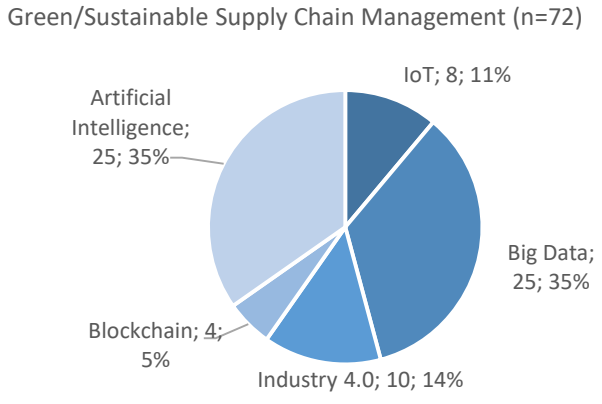


***Figure 2**: Categorization of documents by SPM and DT terms. PLM = Product Lifecycle Management SCM = Supply Chain Management, IoT = Internet of Things (own representation)*

Initially the term "Supply Chain Management (SCM)" was included in the keyword search process but was refined to "Sustainable SCM" and "Green SCM". Figure 3 shows a comparison of the keyword search results from a) green and sustainable SCM and b) conventional SCM literature combined with terms earlier subsumed under the term DTs (IoT, Big Data, AI, blockchain and the overarching term industry 4.0). The findings show that studies about green or sustainable SCM and DTs were referring the most to Big Data and AI followed by industry 4.0, whereas for the conventional SCM literature it was found that AI was referred to the most, followed by Big Data and IoT (Figure 3a and b).

a)



b)

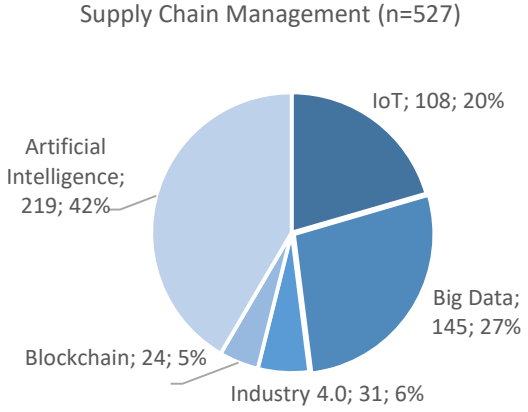


***Figure 3:** Number of articles found combining DTs with a) green and sustainable SCM and b) SCM. IoT = Internet of Things (own representation)*

The 375 documents were furthermore condensed to a sample of 233 documents for the quantitative analysis by eliminating overlaps[7] between the categories (i.e. documents that used more than one DT term in their title, keywords or abstract were only downloaded once). The 233 documents were downloaded and imported to the software MAXQDA. In a first step, an automatic coding via the "lexical search" function was applied using the following search strings: (1) life cycle assessment OR lca OR life cycle assessment, (2) supply chain management OR scm, (3) product life cycle management OR plm OR product life cycle management, (4) circular economy OR ce, (5) industrial ecology, (6) eco design OR eco-design OR ecodesign, (7) life cycle management OR lcm OR life cycle management, (8) life cycle analysis OR life cycle analysis OR life cycle analysis. After the auto-coding in MAXQDA, the function "code frequencies" was applied. Results show that Life Cycle Assessment (LCA) was most frequently used as a term and appeared in 44,6% of the articles, followed by SCM and PLM. In 8,6% of the documents, none of the keywords could be found (Figure 4).

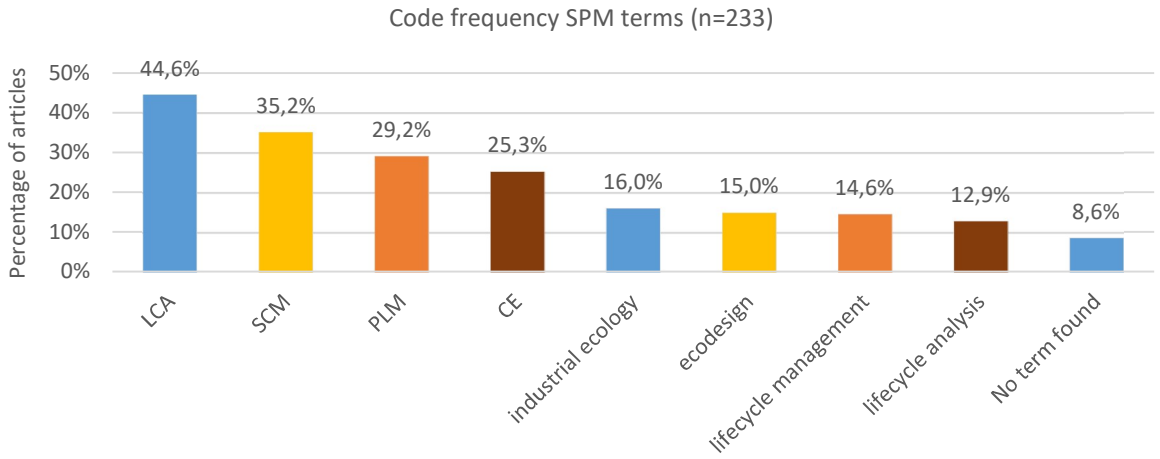


Figure 4: *Frequency of Sustainable Product Management (SPM) terms in documents. LCA = Life Cycle Assessment, SCM = Supply Chain Management, PLM = Product Lifecycle Management, CE = Circular Economy (own representation)*

In a second step, the same approach was applied to check whether the documents in the sample are using DT terms in their text, with the following keywords: (1) internet of things OR IoT, (2) Big Data, (3) artificial intelligence OR AI, (4) industry 4.0, (5) blockchain. The results of the function "code frequencies" showed that most of the documents (62,7%) referred to IoT followed by Big Data and AI. In 13,7% of the documents, none of the keywords could be found (Figure 5).

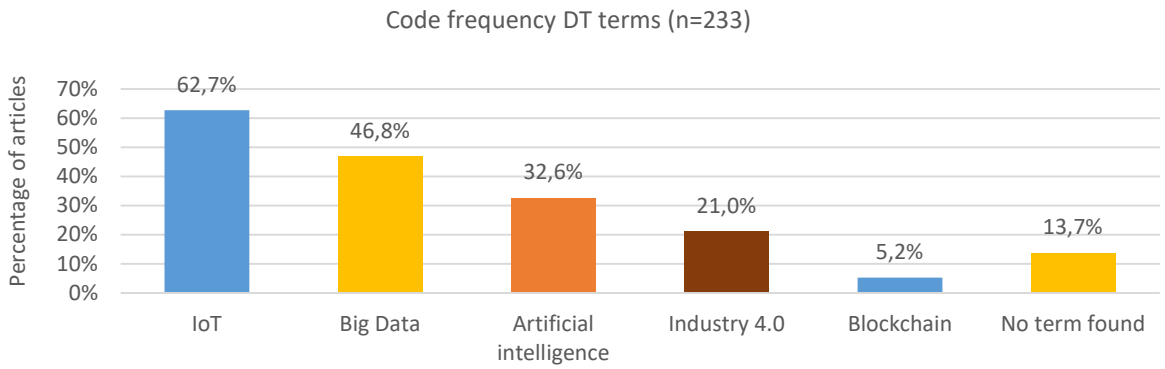


Figure 5: *Frequency of digital technology (DT) terms in documents. IoT = Internet of Things (own representation)*

[7] Overlaps have not been eliminated in this first research step because it was the intention to get an overview of which DT is most often associated with which SPM approach. By eliminating the overlapping documents earlier, such an overview would not have been possible.

By using the results of the auto coding-search function, documents in which none of the DT terms were stated explicitly have been excluded from further investigations (exclusion of 33 documents). Additionally, a screening of the documents that used the terms defined for DTs less than five times in the whole article was conducted and thereby additional 46 documents were excluded, which did not focus on DTs. After this step, 154 documents remained for the qualitative content analysis which was also done in MAXQDA.

By conducting a qualitative content analysis of the 154 selected documents, 30 articles were found that describe existing or potential applications of DTs for SPM. The descriptions of the given examples varied in their level of detail from merely naming a potential example (e.g. Big Data analytics to improve supply chain efficiency) to very detail-rich descriptions of the applied DTs used for SPM with a concrete use case from practice. In the 30 identified studies, 32[8] cases could be identified where an organization was named that applies DTs for SPM. The main result of the qualitative content analysis of the 154 papers is a comprehensive insight into the current state of research regarding DTs for SPM. A taxonomy of DTs and their current and potential forms of applications for SPM is being developed. Table 2 provides a condensed overview with a classification of the examples found according to the three main product life cycle stages BOL, MOL, and EOL. Additionally, use cases from practice were added to the examples if they were described in the sample.

Table 2: *Classification of potential applications of DTs for SPM. (Sources: #1 (Kaleel Ahmed et al., 2018), #2 (Li et al., 2015), #3 (Tao, Wang, Zuo, Yang, & Zhang, 2016), #4 (Zhang, Ren, Liu, Sakao, & Huisingh, 2017), #5 (Lv, Kim, Zheng, & Jin, 2018), #6 (Fahmideh & Beydoun, 2019), #7 (Xu, Cai, & Liang, 2015), #8 (Cooper et al., 2017), #9 (Bressanelli, Adrodegari, Perona, & Saccani, 2018), #10 (Ge & Jackson, 2014), #11 (Corbett, 2018), #12 (Tu, Chung, Chiu, Chung, & Tzeng, 2017), #13 (Okorie et al., 2018), #14 (Kaab, Sharifi, Mobli, Nabavi-Pelesaraei, & Chau, 2019), #15 (Saberi, Kouhizadeh, Sarkis, & Shen, 2019) #16 (Nobre & Tavares, 2017))*

<table>
<tr><th>Life cycle stages / Technology</th><th>BOL</th><th>MOL</th><th>EOL</th></tr>
<tr><td rowspan="9">Big Data (analytics)</td><td>Trend mining algorithm for predictive life cycle design to extract knowledge from large-scale data
Case study: smart-phone design algorithm (#4)</td><td>Online buyer conversations that appear in social media for feedback on repair orders
In-use: Toyota (#6)</td><td>Making EOL product recovery decision and reverse logistics plan (#2)</td></tr>
<tr><td>Platform for collaboration and knowledge sharing (in manufacturing)
In-use: Toyota (#6)
(#2)</td><td>Consumer behaviour patterns informed to add a new human dimension to LCA (#7)</td><td></td></tr>
<tr><td colspan="3">Social media and real-time simulation gaming have been used to strengthen the supply chain collaboration (#2)</td></tr>
<tr><td>Creating comprehensive supplier profiles help to choose qualified suppliers (#1, #2)</td><td>Shared transportation with other companies that deliver products to the same regions (#2)</td><td></td></tr>
<tr><td>OEMs and suppliers can pre-define reuse or recycle features in the early product development phase (#10)</td><td></td><td></td></tr>
<tr><td colspan="2">Control on demand volatility to meet sustainability goals (#1)</td><td></td></tr>
<tr><td>Manage logistics effectively:
integrate accurate and finely tuned production schedules, procurement plans, staffing, distribution models
In-use: Pepsi and Kimberly-Clark
(#1)</td><td></td><td></td></tr>
<tr><td colspan="3">In operations: improvement in supply chain efficiency and to create green responsive, flexible, and intelligent SCs with the use of mobile, geolocation and digital technologies (#1)</td></tr>
<tr><td colspan="3">Identify supply chain risk: assess the likelihood of a problem and its potential impact (#1)</td></tr>
</table>

[8] Companies or examples described as “in-use” that use different DTs are counted per example given in the literature e.g. Toyota applies Big Data analytics and IoT and therefore is counted twice.

	Reducing inventory through better forecasting to reduce the company's **environmental footprint** (#1)		
	Estimation of **land use, seed use**, irrigation, and use of nutrients, manures, and pesticides. **In-use:** U.S. Department of Agriculture (#8)		
	Prepare the Emissions and **Generation Resource Integrated Database** to provide resource mix, heat input, and select air emissions data for U.S. electric power generation. **In-use:** U.S. Environmental Protection Agency (#8)		
IoT and Big Data (analytics)	Predictive maintenance of equipment **In-use:** Intel (#5)	Use travel trajectory data: utilization of **electric vehicles** and the consequent **greenhouse gas** emissions (#7)	**Prediction of remaining lifetime** of parts or components (#2)
	Distribution and logistics: Leading retailers **optimize transportation** by using Global Positioning System (GPS); improves productivity by optimizing fuel efficiency and preventive maintenance (#1)		
	Supply chain **traceability performance** & identify **bottlenecks** (#1)		
		Preventive maintenance (#2)	
	Logistics: item location, storage incompatibility detection, quality of shipment conditions, fleet tracking (#3)	Personal advice to reduce energy and water consumption. **In-use:** Alpha (#9)	
	Information about **raw materials** can be made available (#3)	Energy management program **In-use**: Walt Disney World (#11)	
	Increasing equipment **energy efficiency** (#2 #3)	Worker-generated data collected through "LaborVoices" **In-use**: Walmart (#11)	
		Replace its exterior light sources by connected LED lighting **In-use:** SEAT and Philips Lightning (#16)	
IoT		**Tracks shoes condition** and identify replacement needs **In-use**: Cisco's sport shoes (#16)	
	Dynamic carbon footprint (#12)		
IoT and blockchain	More accurate and trustworthy **bills of landing** attached to containers. **In-use**: Maersk and IBM (#15)		**Recycling programs** (Reward based with tokens) **In-use**: Social Plastic or RecycleToCoin (#15)
Blockchain	**Smart contracts**: tracking and controlling sustainable terms and regulatory policy autonomously (#15)		
AI	**Predicting** life cycle **environmental impacts** and output energy of sugarcane production in planted or ratoon farms (#14)		
AI and blockchain	Improve **traceability and transparency** throughout a product's lifetime (#13)		

The subsequent empirical research step expands upon the findings regarding the state of implementation and potentials of utilizing DTs for SPM in literature by adding different viewpoints from industry experts.

3.3. Expert focus group workshop

Based on the findings from the quantitative and qualitative analysis of the literature, a cross-disciplinary focus group with ten experts was conducted. The results of the preliminary literature review showed that the number of publications that suggest concepts for potential applications of DTs in SPM is low. A small number of existing applications and only a few practical insights are reported so far. Therefore, the objective of the focus group workshop was to link and supplement theoretical knowledge with the understanding of the industry experts and investigate the status of application of DTs for SPM in practice. The focus was on gaining a better understanding of how and which data could and should be collected and shared along the product life cycle as well as naming corresponding (new) sources, actors, enablers, and barriers. The knowledge from the literature review was furthermore used to derive lead-questions for the workshop which was structured in three main thematic blocks: (1) Sustainable and circular data management in a CE (2) Circularity and sustainability assessment (3) Mapping indicators and data sources, actors, barriers and enablers for SPM.

The cross-disciplinarily focus group resulted in a collection of diverse viewpoints and statements from different industry-stands spanning a large proportion of the automotive product life cycle. The results showed that current industry sustainability practices are often driven by legal and customer (e.g. Original equipment manufacturer (OEM) and user) requirements. The meaning of sustainability in a CE context is not sufficiently clear to the experts to derive suitable indicators and relate DTs or (potentially) new data sources for SPM. It was mentioned that there is a perceived lack of harmonization and standardization of database information. Also, a participant mentioned that "*only parts of these topics [the implementation of DTs and potentially new data sources] are technology-driven*" because also personal and intra-organisational issues should be considered in the discussion about data-driven SPM in a potential circular value chain that should lead to a sustainable CE. However, the findings illustrate that the experts consider DTs as possible enabler for generating new opportunities for SPM but also named potential barriers for a data-driven SPM in a CE, especially for the (sustainability) data exchange along a circular value chain (Figure 6).

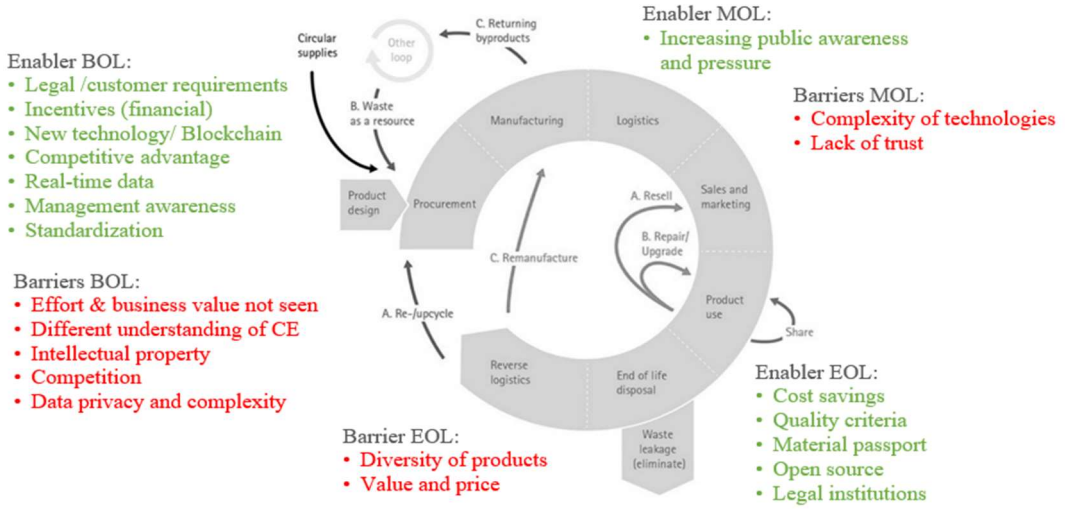


Figure 6: *Practitioner's perspective of (smart) enablers and barriers for data exchange in SPM. green= enabler, red= barriers (own representation based on (Lacy et al. (2014))*

Although DTs were mentioned from the experts as potential enablers for SPM, up to now, the level of implementation in the organizations they represented is in its early stage, regardless of its theoretically identified potential to accelerate the lagging transition towards a CE. It was challenging for the participants to give concrete examples of DTs for SPM or for an application in a CE context. However, the experts were able to name different data sources to develop "data-driven sustainable product management in a circular automotive value chain," as this was used as an example (Table 3). In this session, the brainstorming and discussions were guided by the following question: Which data sources do the actors [along a circular automotive value cain] have and/or who are the specific providers of sustainability data?

Table 3: *Classification of potential data sources for a circular automotive value chain (own representation)*

BOL	MOL	EOL
• Third-party certifications • MFA (Material Flow Analysis) • List of certified smelters • SHDB (Social Hotspot Database) • IMDS (International Material Data System) • Audits • Invoices & Self-reporting • VDA (Verband der Automobilindustrie) • Real energy data • Tracking of design decisions - CAD (Computer-aided design) • Lab analysis • PDM (Product data management) • Conflict minerals platform • OEMs (Original equipment manufacturer)	• Surveillance = primary data; tracking satellites (logistics) • Company monitoring data -> non-standardized • Ecoinvent • Online marketplaces • Locations - GPS • Open access database	• End of Life actors e.g. recycling companies • Collection points • ISO Certificates (International Standard Organization) • Statistics • Surveys

Generally, the findings from the focus group workshop suggest a low state of implementation of DTs in SPM, as the basic compliance management is dominating over more elaborate SPM approaches (e.g., LCA, circularity assessments), which are furthermore limited to traditional forms of information collection. A challenge that was particularly mentioned from the participants was the exchange of sustainability data along (multiple) product life cycles, especially regarding the communication between the manufacturing and end-of-life phases.

3.4. Discussion

The results of this study show a limited number but interesting variety of potential and existing forms of DT applications for SPM such as sustainable and efficient supply chain management and its traceability, real-time simulation, strengthen supply chain collaboration, effective and efficient logistics and inventory management, improved supplier selection possibilities, predictive life cycle design, predictive maintenance, manufacturing collaboration systems with a knowledge-sharing focus, trend prediction and social media data mining, a new human dimension of Life Cycle Assessment, personal user advice for more environmentally friendly behaviour, energy efficiency management programs, improved social working condition reporting, dynamic carbon footprint simulation, smart sensors and radio-frequency identification (RFID) solutions for tracking and reporting, improved product life cycle identification, servitized and adapted business models or product passports. This result is comparable to other recent studies such as the one from Nobre & Tavares (2017) that focused on Big Data and IoT applications on CE. The authors reported that they also encountered a variety of applications such as: closed loop product life cycle management, establishment of sustainable cities, energy grid optimization, ecologically designed products and buildings, sustainable agriculture. They concluded that this means that the utilization of Big Data or IoT concepts applies to many different actions that are taken in business or personal lives.

Most of the studies focused their descriptions either on one or two specific DTs, a concrete SPM concept (e.g. CE or sustainable supply chain management), or on a specific life cycle phase (e.g. IoT in manufacturing). Zhang, Ren, Liu, & Si (2017) concluded after their literature review about (1) IoT and its application in PLM and (2) big data and data mining technology in manufacturing that *"[…] the overall solution for the whole life cycle is seldom investigated"* (p. 628). Additionally, they reported that *"there is a lack of systematic solution of automatic identification and capturing for life cycle data, which may lead to two problems: (1) during the manufacturing and maintenance process, data acquisition is inaccurate and incomplete; (2) the research and development (R&D) cycle of product is prolonged, and maintenance time is increased. These problems hinder the decision-making of whole life cycle, and ultimately affect the implementation efficiency of Cleaner production."* (p. 628).

In this study, the collective term DTs includes IoT, Big Data, blockchain technology, AI, and industry 4.0. The focus was mainly on the first four terms because industry 4.0 is mostly used as an umbrella term under which the different technologies are subsumed. For AI, the least SPM application examples were found compared to the other DTs, although the findings of the keyword search in Scopus and the quantitative analysis of the selected articles showed that AI is frequently used as a term in the sample (see Figure 2). However, only a small number of application examples for SPM could be found because the term was not used in the article's main text but their references. It was found that in many cases, DTs are not applied as stand-alone tools but complement each other. Tao et al. (2018) described in their study that "*[…] internet of things technology and devices are employed to collect various data generated in the entire produce life cycle, cloud technology is used to realize the data management and processing, and artificial intelligence is used for data mining and realizing added-value, the big data-driven manufacturing era is coming*." (p. 3563). This is compatible with the result described in the previous paragraph as most articles focus on one or two specific DTs and, therefore, may lack the capacity or space to describe upstream or downstream processes that may include the use of AI.

An interesting application of a DT for SPM was found in the study from Li, Tao, Cheng, & Zhao (2015). They described that Big Data not only could be used for "greening" the transport planning by making it more efficient but technological developments and the implementation of DTs could enable opportunities to *"share transportation with other companies that*

deliver products to the same regions" (p. 677). Examples like the latter one could be linked to research issues such as industrial ecology or industrial symbiosis. These research topics could be described as the antecedents of CE. Thus, using DTs for fostering closer collaborations of different organizations (also outside their current partner networks) can be seen as an enabler for a transition towards a CE. In a study about Big Data for sustainable and green SCM from Kaleel Ahmed et al. (2018) they have described that there are already many manufacturers that have *"adjusted their manufacturing philosophies and introduced environmental programs into their organizations"* (p. 1250). More of these examples are needed to stepwise implement SPM and thereby accelerate the lagging transition towards a CE.

Clear categorizations of DTs applied for PLM in general or SPM and a detailed description of how DT applications could be implemented for SPM were often lacking. Also, only some of the examples found in the literature could be useful for assessing the sustainability and circularity performance of products, and more are needed to derive a comprehensive taxonomy. For instance, for an increased circularity of resources, a special emphasis is on the collection of product life cycle data. Additionally, sharing data about the material quality and other product-related data or additional information on the recyclability and specific material composition issues are key in a CE.

The neglection of the social dimension of sustainability is described in recent CE studies (Kirchherr et al., 2017; Murray, Skene, & Haynes, 2017). In this study, the lack of incorporating the social dimension of sustainability can be confirmed, although the focus was not only on CE but on SPM literature, where CE is considered as one among other approaches. Only two studies were found where social sustainability issues have been mentioned. The first one is from Saberi, Kouhizadeh, Sarkis, & Shen (2019) about how blockchain could be used for a better assurance of human rights and fair work practices. And the second example comes from Corbett (2018), where they describe a digitally enabled approach of how workers in factories around the world can directly and anonymously report any conditions or practices they are exposed to. The example is called "LaborVoices" and is used in one of the world's largest multinational retail corporation - Walmart Inc.

It was found to be very beneficial to supplement findings from the literature with practical insights from industry experts. Especially to be able to link different topics such as theoretically described potential applications of DTs with the status quo and perceptions of the industry experts. The experts mentioned that the focus on the huge potential of DTs is not enough, but also the "human-side" (e.g. personal and intra-organisational issues) should be considered and incorporated. A more holistic and interdisciplinary perspective on DTs was barely included in the literature studies in the sample. One example was found in a study by Zhou et al. (2017). They explicitly mentioned that with the increased use of DTs a *"specially established information department, who analyzes and mines the collected product life cycle data to provide decision suggestions for other departments"* (p. 999) would be necessary. Or in the study from Haddud, DeSouza, Khare, & Lee (2017), they have described it in a more general way: "*There are many challenges and barriers that can be encountered when adopting the IoT. […] Challenges with obtaining the access to employees who possess the required knowledge and skills remain another key factor hindering the IoT adoption. In addition, incorporating new technologies into existent business environments, structures, and models has always been a challenge."* (p. 1060).

4. Conclusions

In this study, the aim of analysing potential and existing approaches of DTs to improve SPM was carried out and the potential of DTs as new data sources along a product's life cycle was investigated with theoretical and empirical investigations. After following the above described research process, the following conclusions can be drawn:

- DTs cannot be considered separately from each other; most examples given in the literature describe that e.g. the Big Data analysis was based on data collected by applying IoT. Also, different DTs are found to be useful for different application cases (e.g. IoT for data collection, Big Data for data analysis) and therefore are often most fruitfully used as complementary tools but should be centrally managed.

- While in recent years the number of publications that provide concepts and frameworks for potential applications of DTs in PLM grew significantly, the degree of implementation of DTs for SPM that is being reported in scientific literature is rather small. Also, more general management and operations, as well as PLM issues, were discussed (e.g. to create new competitive advantages and strategies for growing revenue or to measure the financial impact of decisions before they are implemented) than explicitly SPM related applications for DTs.
- Social sustainability topics were underrepresented.
- The level of application and implementation of DTs for SPM is influenced by different factors such as the technological affinity of a company. Most “in-use” examples came from large corporations where most likely also additional positions with skilled workers can be more easily created than in smaller enterprises.
- Although the use of DTs could be extended for SPM in many organizations, major inhibiting factors for SPM in practice are the lacking communication between the actors in the manufacturing and end-of-life phases and the prevailing, limited accessibility of data from the upstream supply chain.
- A more holistic view on the whole product life cycle and further trans- and interdisciplinary perspectives on the application and implementation of DTs for SPM could reveal completely new approaches, apart from currently described often technologically-driven examples, how to contribute to the utilization of the full potential of DTs for SPM along the whole life cycle of a product in a CE.

In summary, DTs can provide new possibilities for a more dynamic SPM in the future. Up to now, the full potential of DTs for a comprehensive use in SPM is blurry and the potential use cases are rather discussed in theory than implemented in practice. Therefore, a "translation" into action and practice is needed to understand real-life impacts and to unlock potentially untapped synergies of DTs for SPM. Working on comprehensive and holistic data-driven SPM approaches could offer unique chances to unlock these synergies and implementing them may be a prerequisite for a sustainable CE. Beyond efficiency issues and more towards a holistic utilization of DTs for SPM could provide the necessary traction in the lagging CE transition.

Limitations and further research

This study provides an overview of the current state of research of DTs for SPM, but the authors also recognize some limitations of the research procedure. The keyword search process yielded more than 375 documents but only (journal) articles should have been included in the sample. The selection was based on an auto function from the database, but the qualitative content analysis showed that also some other document types were included (i.e. one book chapter and conference articles). The goal of the qualitative-content analysis was to capture most examples of potential or existing DT applications for SPM mentioned in the literature sample but there is no claim for comprehensiveness.

The upcoming research steps will be dedicated to evaluating and expanding the taxonomy of DTs approaches for SPM empirically and developing a matrix that links data sources and approaches with sustainability and circularity aspects. To further investigate the research gap, a survey among industry experts is planned that builds on the findings from the literature review and the insights from the focus group workshop.

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New management approaches in a research & development focused innovative eco-system

Managing knowledge-based value chains in a changing business environment, whilst maximizing translational impacts

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Abstract
The paper is based on management research program related to ZalaZONE Proving Ground and its ecosystem. The research results and themes shown are run in order to study and understand features of knowledge-based value chains in rapidly changing business environment, whilst striving for maximizing translational impacts. The summary report consists of three fields which are understanding impacts of new technologies, classification of business and research entities in view of their characteristics in order to develop a comprehensive business model approach and developing method to evaluate translational economy impacts of complex value generating structures. The current paper summarizes the actual status and current outcomes of the related researches.

Keywords: value chain, business model, added-value, ecosystem, innovation

1. Introduction

ZalaZONE Proving Ground, as strategic R&D infrastructure project of Hungarian Government, aims offering testing and validation services for classic vehicle dynamical tests but also for trial of automated, connected and autonomous vehicles. The project well fits to the technology transition of the automotive sector as shifting from traditional vehicle products toward higher and higher levels of autonomous solutions. The continuous balancing of current market needs and ambitions of the new technologies lead to the necessity of a dynamically flexible business approach. The economic impact of an infrastructure like a proving ground goes beyond its pure borders, resulting in translational impact through the value chain and the operational surrounding. Next to that, the competitiveness of the high-added value environment firmly depends on the maturity of the innovation-based ecosystem of the facility.

***Figure 1**. ZalaZONE Proving Ground (Hungary, Zalaegerszeg)*

These considerations generated the complex management research program related to ZalaZONE Proving Ground and its ecosystem in order to study and understand features of knowledge-based value chains in rapidly changing business environment, whilst striving for maximizing translational impacts. The research program consists of three basic research lines: 1) understanding and forecasting of impacts of new technologies, 2) classification of business and research entities in view of their R&D&I characteristics in order to develop a dynamic competitive business model approach, and 3) simulating translational economy impacts of complex value generating structures. The current paper summarizes the actual status of the related researches.

2. Why technology in focus?

Nowadays the megatrends of global economy and revolutionary changes driving to the rapid development of technology resulted in that center of gravity of world economy is emerging in several ways. In addition, technological advances are shortening development cycles, bringing companies with integrated global networks to the forefront. Capital and knowledge are concentrated in the leading global companies, often ahead of small and medium-sized enterprises. In the near future, industrial activity is expected to be even more built around the rapid flow of information, so that flexible movements of capital and knowledge, as well as mobility and flexibility, will be decisive.

The development of ICT results in global collaborations, which will bring with it an increase in the role of the network-oriented economy. An example of such a structure is M2M (Machine-to-Machine), where machines communicate without human intervention to promote efficient production. The role of 3D printing, which is already used in many fields, will continue to grow in the intelligent industry. Robotics and AI (Artificial Intelligence) will play an important role in the coming decades (Salamon, Tófalvi, 2008).

One of the outstanding industry trends is Industry 4.0. The kay features of the new industrial revolution might be characterized by the quick information flow, strong technological development and utilization of big data management. New technology concepts such as IoT (Internet of Things) and CPS (Cyber Physical Systems) are emerging that connect electronic, mechanical, and IT units and also their users. In order to utilize advantages of the opportunities of Industry 4.0, companies need to integrate new trends and technologies in order to produce the right products and provide competitive services.

Based on these forecasts, strong economic restructuring is expected, also taking into account the latest crisis due to the pandemic situation. In addition to Industry 4.0 as a trend, the mass customization of products as a development trend also helps to serve consumers quickly and in line with their expectations. Recognizing the need for change and ability to make change more and more become important factors for survival. As a result of this multiple changing environment, the role of driving forces of the new technology trends are key to understand and interpret on each single companies level. These driving forces must be monitored, analysed, evaluated and actioned according to those with a negative or positive effect.

In the leading European industrial cultures, there is strong focus on learning, skills development and expertise, as the emergence of new technologies also develops new competencies. In addition to individual market expansion, professional collaborations of companies with research universities and research institutes and also becoming more and more important.

As summary, number of new trends will emerge that will affect the economies both globally and locally. The automotive and manufacturing industries are the areas that are expected to bring about the most significant technological changes. However, for new technologies, the right knowledge background is essential; and this process carries with it the importance of learning. Companies will need professionals even more as corporate and production systems become more complex with the advent of Industry 4.0. All of these factors and trends are expected to lead into a new knowledge-based society. However, it can be seen that the global megatrends significantly influence the structures, strategies and operations of any organizations, so almost all small and medium-sized enterprises, multinational companies and other economic organizations firmly depend on external environmental impacts.

Hungary has already taken huge steps in digitization, but this process further needs to be continued. Recently, the automotive industry has been at the forefront at the international level, but at the same time the sector is strongly affected by new technologies (autonomous mobility, alternative and electric vehicles). A key project is the automotive test track at Zalaegerszeg, which represents a serious potential for intensive involvement in global automotive processes.

In addition to the technological development it is essential to take into account the changes of market needs and accordingly the increasing needs of customization of product and services. Some researchers mention" customizability" also as a megatrend, as many companies are not in a position to apply globally or only doing that with difficulties (Weiss, Schweiggert, 2013).

Looking at the Industry 4.0 as major industrial technology trend, it is apparent that it serves to track technical advances, and at the same time it also facilitates those advances. Its essential element is the ability to react quickly, being constantly available and speeding up processes. As this level of intervention in the processes requires a high level of IT background, Industry 4.0 shall be paralleled with IoT (Internet of Things). The IoT also covers both technical and economic activities; it also has an impact on traditional manufacturing approaches. As a research stated (Kagermann et al., 2013), eight appropriate measures are needed to implement Industry 4.0 are:

1. Standardization and Reference Architecture
2. Managing complex systems
3. Comprehensive Broadband Infrastructure for Industry
4. Caution and safety
5. Work organization and planning
6. Training and continuous professional development
7. Regulatory framework
8. Resource efficiency

Industry 4.0 is now one of the most significant industrial trend in Europe, its main field of implementation is production facilities, while also specializing in the research, development and production of innovative manufacturing technologies. There is a unique position to take advantage of the new types of industrialization opportunities. Building on technological capabilities, Industry 4.0 offers a product enhanced with unique and digital service content, organizing a new value chain (Losonci et al., 2019). The new value chain already brings with it more knowledge-intensive and complex products and services. In response to these changes, advancement can be considered automatic in many cases, as well as in the case where subsidiaries develop products as the parent company manage development. In addition, ownership can be encouraged by development as the introduction of innovation-driven activities (Szalavetz, 2016).

Such innovation-driven activities lead to the appearance of new materials, the use of new technologies - laser technology, 3D printing technologies, simulations, artificial intelligence, etc. The combination of all this brings with it the emergence of new value chains and new technologies bringing new value chain actors. It is not expected that everyone will be able to learn and apply them on their own, or become a leader in the innovative operation of a new technology and service. Platform-based cooperation and the application of an innovation strategy can be used to overcome this obstacle and to increase value creation.

The next wave of innovation is expected to be brought about by the Internet of Objects, Data and Services, known as the Internet of everything, in which the "subject" and the object can communicate in real time. (Kagermann, 2015)

The explanation for this lies in the fact that the new dominant technologies do not necessarily replace immediately the present technologies, but instead, develops and binds the two together, so that by cooperating further, the processes can be carried forward incrementally. Technology change in vehicle development is an example for this; looking at either hybrid vehicles or extension of ADAS (Advenced Driver Assistant Systems) prove the parallel existence of the "old" and the "new" technologies for a while. It can be said that a technology change typically does not alone, but it occurs in such a way that the effects of new

developments reach wider players (Fleischer, 2018). Based on all this, it can be concluded that the current period of time is a rather complex business environment, shaped by old and new actors with different old and new competencies on several levels. The relationships of interests and values of the actors and the various relationships that have developed between them, induce a constant change in the economic structure (Simai, 2018). The propulsion can be given by different driving forces and these drivers can also be seen as a kind of trend. The driving forces are trends that greatly influence or shape possible futures (Retek, 2018). The service can be seen as knowledge integration from another perspective. Within this, the knowledge of various fields will be combined according to the customer needs (for example, like Informatics and Technical Sciences or Economics and Social Sciences. The different areas appear together and work together to create new values in a more efficient way.

The efficiency of a sustainable knowledge-intensive service is highly tied to universities or other similar competence bases. In the course of cooperation between different fields, the provision of services must move within the framework of the service model. It is important to separate this type of value-driven cooperation from traditional R&D cooperation (Kulcsár, 2015).

A business marketing model of innovation-driven collaboration arose questions like: How does a company need innovation? What ensures that innovation with devoted resources really creates competitiveness for a company? Innovation activity is a continuous and complex task, so it is not a one-time or evening activity. In innovation-based cooperations, strategic decisions of the managerial behaviour play a key role in terms of sustainable competitive advantage. The relationship between entrepreneurial and managerial behaviour and marketing skills might cause an unstabilized relationship, which is partly caused by managerial behaviour and partly by the inappropriate appearance of marketing within the organization. In addition, a correlation between managerial behaviour and innovation intensity needs to be established in order to sustain technical innovation and strengthen thinking in the overall innovation portfolio (Piskóti, 2016).

Services themselves play a key role in supply chain systems. The output of a service can be, by definition, a tangible physical product or a service product. The nature of value chain differs at the two types of supply chain systems, namely Service Only Supply Chains (SOSC) and Product Service Supply Chains (PSSC). In the case of SOSC, the product is essentially a pure service and a physical product plays no role. In the case of PSSC, the service is provided by providing a physical products service. (Wang et al., 2015)

Amor, et al. (2018) gives an overview on the comparison of classic industrial organizations (IO) and product-service systems (PSS). PSS players usually develop products or services building on ICT technologies and striving for high market value from point of view of customers, financials and satisfaction. In PSS models, the basic inputs are the products, the service, the knowledge as capital. In contrary, the classic IO models look at the products and services and basic output. PSS, against IO, opens clear communication channels with partners and customers, growing trust, transparency, risk sharing while integrating positive externalities.

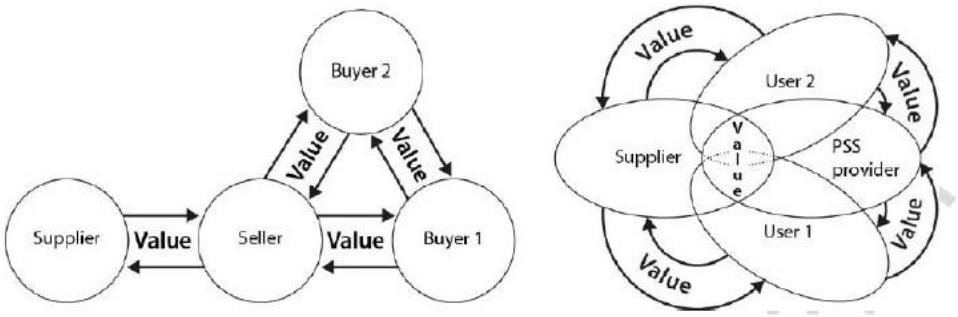


***Figure 2**. Comparison of classic IO and PSS concept*

3. Value creation as basis of added value

The value chain approach provides the background for exploring the relationship between corporate activities that contribute to the production of a final product which meets consumer demand and thus adds value.

The spread of value chain analysis is named after Michael Porter, who was one of the first to introduce the concept of value chain in his work "Competitive Advantage" (Porter, 1985). The company-level value creation is analysed in the Porter model that is still widespread and widely accepted. The value chain model created by Porter identifies the value the company provides to its customers as a competitive advantage. However, the value provided to the end user is a coordinated group of the value of activities, including all value components created by each activity of the company. Porter's value chain model identifies activities that contribute significantly to value creation, all by breaking down activities into primary (direct value creation) and secondary (supporting value creation) functions.

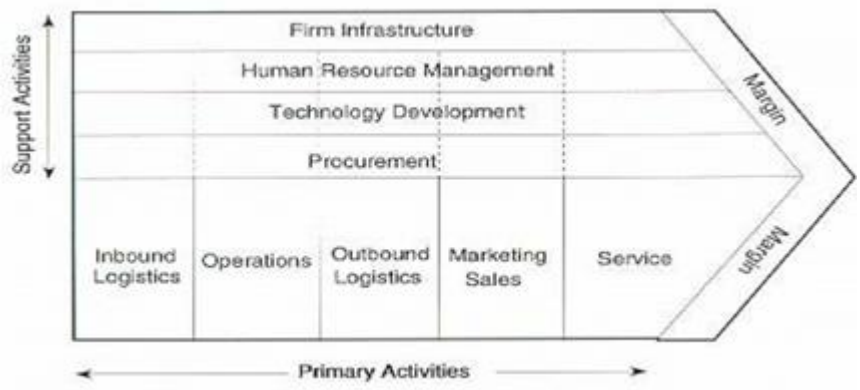


***Figure 3**. Porter's value chain*

The base model created by Porter has been interpreted by many researchers, with examination for its applicability in different fields, so there are just some key references here on that.

More than two decades have passed since the development of the Porter value chain model, and although its principles still remain relevant, the application of the model became limited in some areas. The basic concept provides the most analytical opportunity for vertically integrated manufacturing-type companies, primarily from the perspective of the company under study.

Activities in the value chain form a sequential, linear group that are connected to each other through the flow of information, material, resources or finance. Each organization focuses only on its own activities, knows the previous and next activities in the line, but ignores the importance of how they affect the whole chain and what value-creating interactions can be observed between each activity (Herrala, Pakkala, 2009).

Nowadays, the acceleration of technological development and global processes, the change of market demands requires a much more complex value system approach from companies. There is a strong consensus among researchers and corporate professionals that innovative products drive technological, industrial, and social change (Schoenmakers, Duysters, 2010). From a micro perspective, the application of a new innovation affects a company's existing marketing resources, skills, knowledge, ability or strategy, can affect all activities in the corporate value chain. In innovative industries, there is a need to develop a value chain framework that provides a multi-directional and systematic approach by measuring and identifying the novelty of technology and knowledge-base on each value process in the companies.

In recent decades, many authors and researchers have been involved in expanding the classic value chain approach. According to a research (Feller et al, 2006), the value is a subjective experience that depends on the context (like when the same product or service does not represent the same value in different situations). Secondly, value is created when the customer demand is met through the provision of products or services. Finally, the value is the experience that comes from the customer. Due to the different functions and definitions of value, it becomes necessary to integrate product lifecycle management, supply chain management, and customer relationship management into the value creation processes. Among the improved approaches, it is important to mention the Value Chain Operations Reference Model (VCOR), which was developed as a value chain framework that integrates product development, supply chain management, and customer management processes. This opens up opportunities for the development of an integrated value chain, which creates a successful basis for the implementation of service-oriented value creation. (Ouzrout et al., 2018).

In the changed economic environment, in innovation-driven industries, knowledge- and competence-based collaborations are gaining more and more prominence. One of the main catalysts for high value-added activities is the added value generated by human knowledge and technological knowledge. As a result, knowledge, as one of the most important sources of competitive advantage, appears as an essential condition for value creation, and as an essential component of innovative value chain models.

The knowledge-based value chain model developed by Lee Yie Yang (2000) builds the approach to the basic framework of the Porter value chain, according to which the knowledge value chain consists of knowledge management infrastructure, knowledge management process activities and knowledge performance. These infrastructure components and activities are the building blocks by which a company creates a product and provides value to customers. According to knowledge-based value chain theory, all elements of activities can create change, and then all values flow to the end point of the business value chain, interconnected and thus, create the total value of the business enterprise. In the case of a knowledge-based value chain, the added value comes from the specific knowledge chain.

Value chain models vary from industry to industry, so value chain model scan be distinguished between markets. While Porter examines value creation in a chain primarily from a single firm perspective, the value chain models used in the organizational market provide a broader perspective, and value flows are tracked from the perspective of multiple firms, essentially based on examining customer-supplier relationships. At these models, therefore, the exploration of multidirectional value creation processes is already emerging. There are several approaches to value chain models of organizational markets in the literature. Evans and Berman's (2001) model focuses on the creation of a value-oriented corporate strategy and the role of customer management is of paramount importance in terms of the value created. The organization’s value chain management model (Al-Mudimigh et al., 2004) builds value-creating processes on the foundations of strategic goals, the organization’s mission, and organizational culture, making it suitable for analysing ever-changing customer needs.

Over the years, value chain thinking has gone beyond Porter’s original concept of analysing a firm’s internal activities and their interrelationships within a systematic approach (Bovet and Martha, 2000). Current processes look at value creation as multidirectional rather than linear, with the result that successful companies increasingly develop a multifaceted value chain.

Value-creating networks allow organizations to go beyond borders through collaborations and improve efficiency. Networks give companies the opportunity to form a variety of federal partnerships that can complement a company’s existing competencies to produce greater added value. Normann and Ramírez (1993) developed the concept of value constellation, in which different actors in the value chain continuously generate value. Contrary to Porter’s view, activities are not performed one after the other, but simultaneously, and value is created together. In this new value network, the focus of organizations is on the value-creating system itself, as opposed to the system of the company or industry (Peppard, Rylander, 2006). The actors in the value networks connect with each other and carry out the “right” activities for them, which are able to provide the fastest, cheapest performance and create value for all parties. Parolini (1999) carries on the results developed by Normann and Ramírez

on the assumption that value systems are seen not only as a set of economic actors but as a series of activities that jointly participate in value creation. In Parolini's model, the focus is on the value creation system and its activities.

Bovet and Martha (2000) also use the term net worth in their concept, which has been defined as a partnership network. According to them, net worth is a dynamic, high-performance network between customer/supplier partnerships and the flow of information aimed at implementing value-creating processes. In contrast to the value chain, value in the value network is created through the interconnected activities (sub-competencies) of several companies, which not only affect the customers of the network, but also society and all companies participating in the network.

Pil and Holweg (2006) use the concept of the value network to map multidirectional value-creating processes. In their view, there are a number of new ways to increase performance in the value network framework. Value creation processes can be vertical (companies explore opportunities toward adjacent levels of the existing value chain; up or down), horizontal (companies identify opportunities), or even diagonal (companies are more integrated between value chains and levels to connect performance and reduce the risk).

4. Methods and research work

When studying an innovation ecosystem, one of the basic questions is how to qualify the single members of they are integrated part of the system or not, in other words, how to define the system boundary. A study (Xiuqin, et al. 2018) investigated features of various key characteristics of research and development organizations and identified three categories of them:

- R&D service providers,
- Knowledge-Intensive Business Services (KIBS),
- New Technology-Based Firms (NTBS).

This classification was taken as a basis (Toth, 2020) and an assessment approach was developed to evaluate features of an innovation-based ecosystem. The following factors were evaluated through various sub-criteria: knowledge characteristics, origin of organization, location, business activity, position related to innovation, internal innovation. The classification can be made in a two-way method, first a preliminary assessment then an interview approach to complete and align the profiles based on the view of the assessed organizations. The analysis was made for eight players related to the ZalaZONE research and development environment, the results are shown by Figure 4. The advantage of this method, further developing concept of Xiuqin et al. (2018), that a matrix logic applied to get profile on both the R&D&I nature of the single organizations and in the same time, get perception on ecosystem level. It is important to emphasise that classification in to the three categories is not exclusive, so the mix of the three characteristic groups is the relevant information.

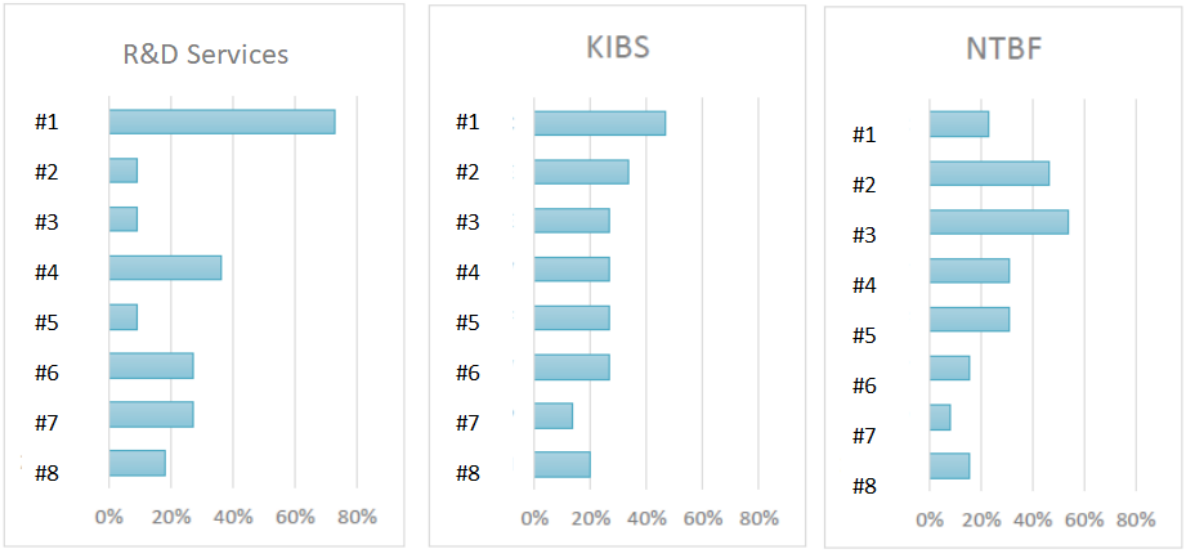


***Figure 4**. Chacteristics analysis of the ZalaZONE innovation ecosystem players*

After having the base profile on the R&D&I nature of the players, the business perspective is analysed using the business model concepts. For this purpose, the classis business model approaches were studied in detail and, by using the methodology of synthesis, an integrated and upgraded model was developed, taking into account the features of the innovation ecosystems and the players assessed by the tool shown in Figure 4.

The concept of a business model is very important in management, but there is still no consensus in researches on what exact content an optimal business model should have. Classical business model descriptions are based on the traditions of business strategy in order to link business with different views of company strategy and performance.

The traditional definition emphasizes the value-creating function of a business model: “A business model describes the plan or architecture and mechanisms of the value creation, delivery, and capture. The essence of the business model is to crystallize the needs and ability of customers to pay and provide value to it. It makes consumers to pay for value and converts those payments into profit to enable the various elements of the value chain so as to be properly designed and operated.” (Alt & Zimmermann, 2014) A similar definition was used by Wirtz and co-authors based in their publication (Wirtz B., 2015).

The concept of business model from can be interpreted by four perspectives (Liu & Mannhardt, 2019):

1. business model is described as a tool which main purpose is to create value for businesses, capture it and transfer it.
2. business model is defined as an intermediary between technological innovation and the market and as a means of trading new technologies with new or adapted business models.
3. business model is seen as set of strategic variables that are the source of competitive advantage.
4. business model is explained as a value network that goes beyond the activities of a central company to include its customers and partners.

Emerging technologies and the increasing use of the internet are also encouraging start-ups to compete and attract the attention of consumers. Using the right business model strongly affects customer or user confidence at startup. So the key to the right business model is to prioritize the sustainability and growth of start-ups, this aspect is very important for innovation ecosystems where players are typically young organisations (Bednár & Tarisková, 2018).

These elements are interlinked, helping the company management to determine the right business model. The business model always should provide an answer to the main challenges of the customers or the targeted market. Based on Shi, Manning (200) researches, the business model framework includes four basic and interrelated elements: the change model, the organizational model, the resource model, and the financial model. The change model describes the added value that a firm offers to other economic actors in the market, including customers, suppliers, complementary organizations, and competitors. The organizational model includes roles and responsibilities, activities, and business processes that enable the flow of product, information and money, thereby updating exchanges between the firm and the stock market with partners. The resource model incorporates the diversity of firm resources that are needed to mobilize and thrive in the organization. The financial model defines the objective functions of the company that combine the other three elements of the business model (Shi & Manning, 2009).

The business model also explains how each innovation can create a new market or distort the competitive advantage of its main competitors (Micieta, et al., 2020). In fact, key competencies tend to dominate employee performance over managerial functions and organizational culture, while valuable competencies are rare, hard-to-imitate, and hard-to-replace factors that all become key sources for success. At the end, these all make competence a force that competitors cannot easily follow.

To embrace digital change, strategists, managers, and operational management also need to know the business model and work together to further develop it. The future 9x9 business model provides the framework for this concept. The latest trends and their implications are integrated into individual components of business models to be successful in the future (Tewes, et al., 2018).

Based on the literature research work and analysing the found relevant business model approaches, a framework model was outlined, which combines the elements of the examined business models, and finally integrates them into a customized model developed in a new structure, taking into account the specifics of R&D&I cooperation systems described in previous chapters.

Table 1. *Synthesis of the studied models into an innovation-specific business framework elements*

The summarized contextual elements of the examined models	**Model areas of the proposed business framework using clustering technique**
Determination of value Value proposition	*Value proposition*
Defining customers Target market segment Product or service palette Revenue generation model Outgoing offers Mission Determining the size of the market	*Market and customers*
Abilities Competences Entrepreneurship Activities	*Competences and abilities*
Marketing channel Branding Differentiation Distinction in competition	*Marketing channels*
Network control Connection with the ecosystem	*Networks and ecosystem connectivity*
Key activities Organizational efficiency Processes Adaptability	*Operational model and organizational processes*

System of activities Business processes Operating model	
Key resources Capital Influence of resources Tangible resources Intangible resources Appropriability Sustainability Human resource Employee value	*Resources and capital*
Key Partners Customer Contacts Value Chain Value Networks Customer information Product and service flow Supplier value Customer value Partnerships Relations with stakeholders Multi-value configuration Distribution channels	*Create value*
Cost structure and model Profit Financial aspects Low operating costs Premium pricing Effective use of assets Capital employed	*Financial model*
Sectoral technology trends Boundaries Competitors	*Trends and impacts*

The defined business model elements can be structured along two aspects. One of the axes is the dynamics of the ability to react to R&D&I circumstances, like how quickly it is possible to introduce the content of the given element into the organizational operational processes. The other axis is the intensity of R&D&I driving force, which reflects the intensity by which it is related to field of research and development, how much it triggers and how much the real driving force is shaping the processes and performance that strengthen contribute to higher level research and development outcomes.

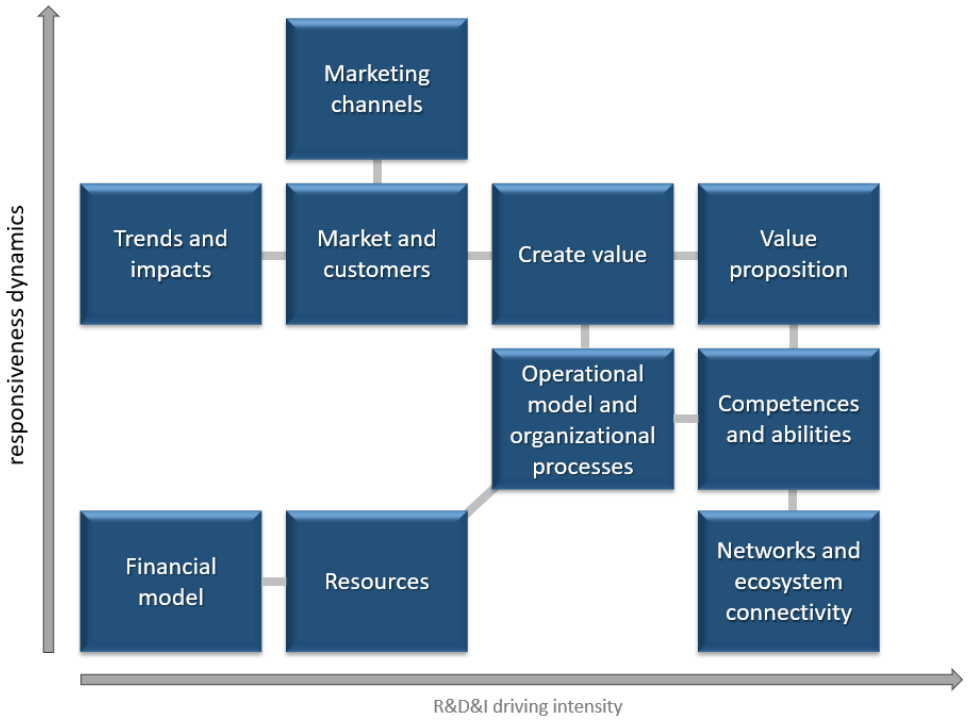


***Figure 5**. Structure of the proposed model for innovation-based ecosystems*

Considering dynamics of changes in technology and business environment, it is found that time factor is also should be involved into the model frameworks. For this purpose, the future-oriented elements of the 9x9 operating model of Tewes at al. (2018) were studied in detail and an customized set of elements was defined, specifically taking into account ZalaZONE innovation environment as it is shown by Table 2.

***Table 2.** Future-oriented elements of ZalaZONE research environment in the developed business model framework*

Business model framework elements	Future-oriented content elements
Trends and impacts	Industry 4.0 new mobility New technologies
Value proposition	A new dimension of value
Market and customers	Experience-based products Customization
Competences and abilities	Creativity Personalized development Innovation-oriented skills
Marketing channels	Digital interaction interfaces Virtual devices
Networks and ecosystem connectivity	Sharing knowledge Lifelong learning
Operational model and organizational processes	Flexible organization
Resources and capital	ICT infrastructure Intellectual property and resources

	Problem-solving thinking
Create value	Value-based ecosystem Importance of information
Financial model	Dynamic pricing Flexible cost model Solution as Service

5. Results and Discussion

Examining traditional models, one of the most important challenges today is that in a complex and dynamically changing economic environment, the effective value chain can implicate effects in several directions at the same time (both in a time and time-varying way), with multiple values, sub-value chains, and different the added value levels. This chapter makes an attempt to draw up the basics of a concept for evaluation of translational impact of accelerator-type research infrastructure projects like ZalaZONE Proving Ground. In this work, earlier experiences and learnings from other researches in the field of value chain as shown above, were also considered.

According to the concept worked out, the basis of a business activity is the value provided to the customer, which gives the primary value creation line of the current approach, as it is indicated in Figure 6. To achieve this competitively, related services and products are needed, like the usual vertical value chain structure can still be typical.

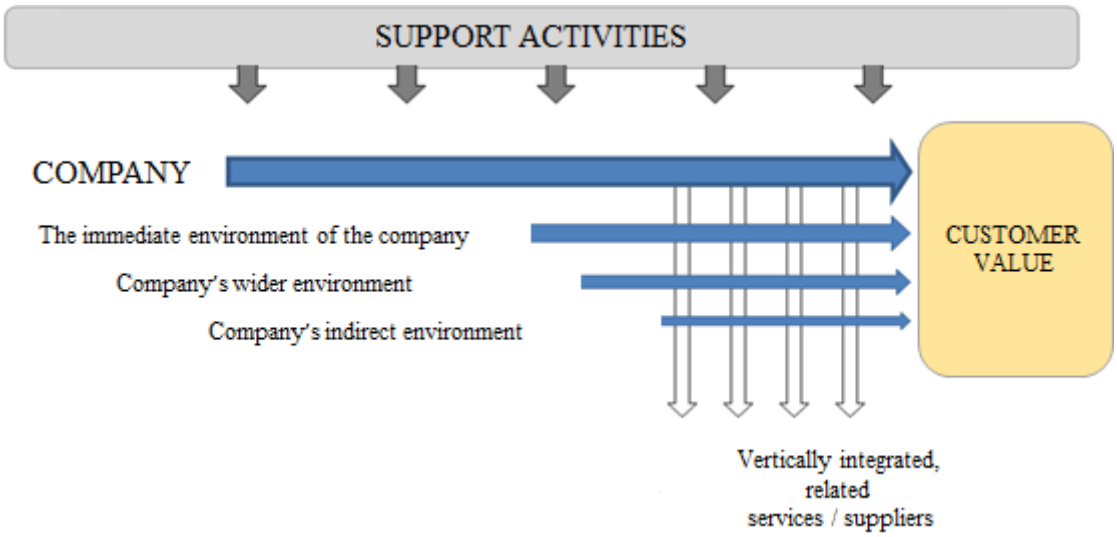


***Figure 6**. Concept of the horizontally and vertically integrated value chain*

However, the basic supposition of the concept is that the so-called catalyst-type business activities, together with the emergence of additional business activities in a region or environment, are able to increase their competitiveness while generate impacts in the direct, broader, and indirect environment. As a result, vertical integration is also multiplied, so that the value chain still remains two-dimensional but becomes multifactorial. In this perspective, the support activities that are necessary for the normal value chain are also included. The horizontally and vertically integrated value-creating model is relevant where a business activity has a spill-over effect (translation) or, conversely, it can fulfil its value-creating potential through the related activities.

In the current ZalaZONE model, the translational economic and business impact is what gives new dynamics to the classical, horizontally and vertically integrated model. In such cases a business typically “brings further in” both customers and suppliers, not only in a territory-concentrated way, but in a larger geographical area, essentially influencing its sectoral environment. Thus, both the traditional horizontal and vertical value chain models become multifactorial, making necessary a complex and systematic description of the value chain.

The need for horizontally and vertically integrated value chains, especially when integration also has a translational effect, typically arises at high value-added, innovation-oriented and development-sensitive business activities. In these types of activity, knowledge can be defined not purely as a vertically appearing service element (education), as most probably it provides the basis for the competitiveness of the business. Adding this perspective to the model is therefore necessary as a third factor; although it is interpreted as a non-material element, its location is not a given place, nor does it mean a highly dynamic element of integration, together with all the challenges of its management.

A feature of the developed model concept is the ability to analyse value in both vertical and horizontal directions in the case of a proper value creation process and following a strategic approach. When examining a given company in the system of cooperation structures, it is desirable to analyse not only the process of activities valuation, but also the translation and knowledge dimensions. Based on this approach, value added feature is disconnected from the “core company”, and it is arose from simple relationship collaborations, but the real effect occurs at the level of the economic system or the so-called innovation ecosystem. In the interpretation of the model, the degree of economic and value creation effect is given by the set of three variables, being interpreted at the level of each of the individual economic and social actors involved in the analysis (Simon et al., 2020).

The proposed function of the value-added impact is:

$$VA = f(S, T, K),$$

VA: Aggregated Added Value
S: Services in Supply Chain
T: Spill-over effects
K: Knowledge Basis

The maximum value of the total value creation of a knowledge-based accelerator project (like ZalaZONE Proving Ground) is the maximum of the value creation calculable along three variables.

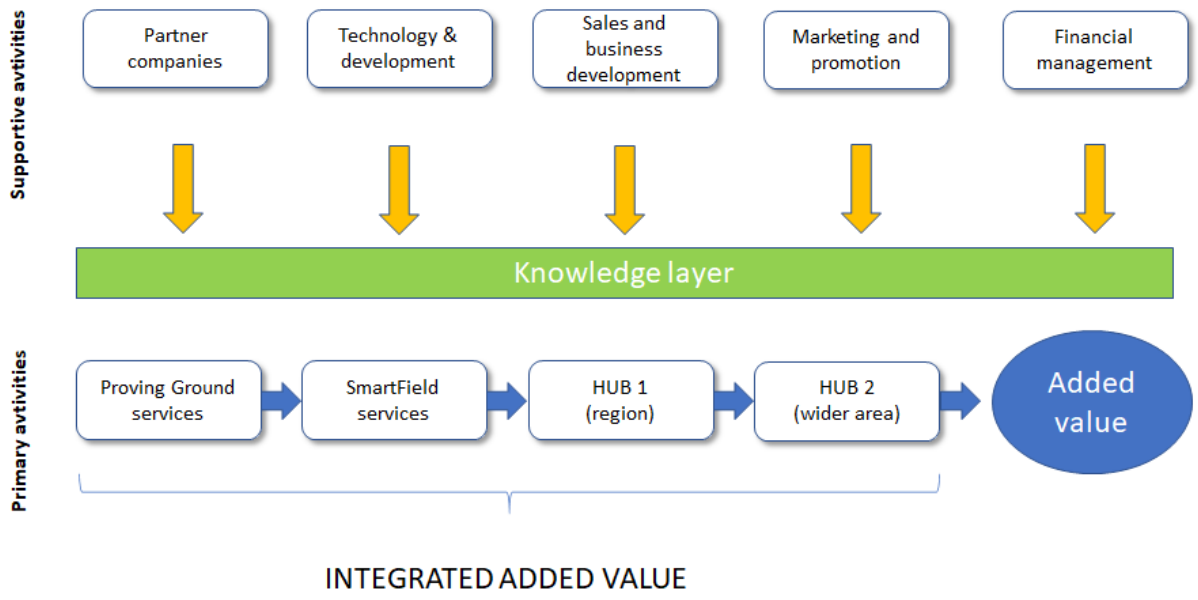
$$VA_{max} = (s*t*k)_{max}$$

Based on the principle of a system-level complex evaluation, the main goal shall be to maximize the cumulative effect of the interrelated dimensions, not purely to maximize the value at the individual level of each element. This assumes that in the complex model set up, there is a correlation between the individual impact dimensions, which is the subject of already running further researches.

$$S = f(T, K) \text{ és } T = f(S, K) \text{ és } K = f(T, S)$$

Based on the theoretical considerations of the above shown logic of evaluating the added value, a specific multi-dimensional value chain model can be described for each application area. As part of the current research, such a value chain figure was created for ZalaZONE, as it is shown by Figure 8. The direct environment of the project was analysed, taking into account the regionalities, the number and nature of the cooperating partners. In this respect, where the value-creating nature of the project has highly intensive effect on the cooperating companies, is described as a “smart field” zone. As next level of value generation,

economic operators in the region were named HUB1 and then the wider environment was named HUB 2. In connection with network collaborations, added value is further generated by connecting additional services or outsourcing services.



***Figures 7**. Multidimensional value chain of ZalaZONE Proving Ground*

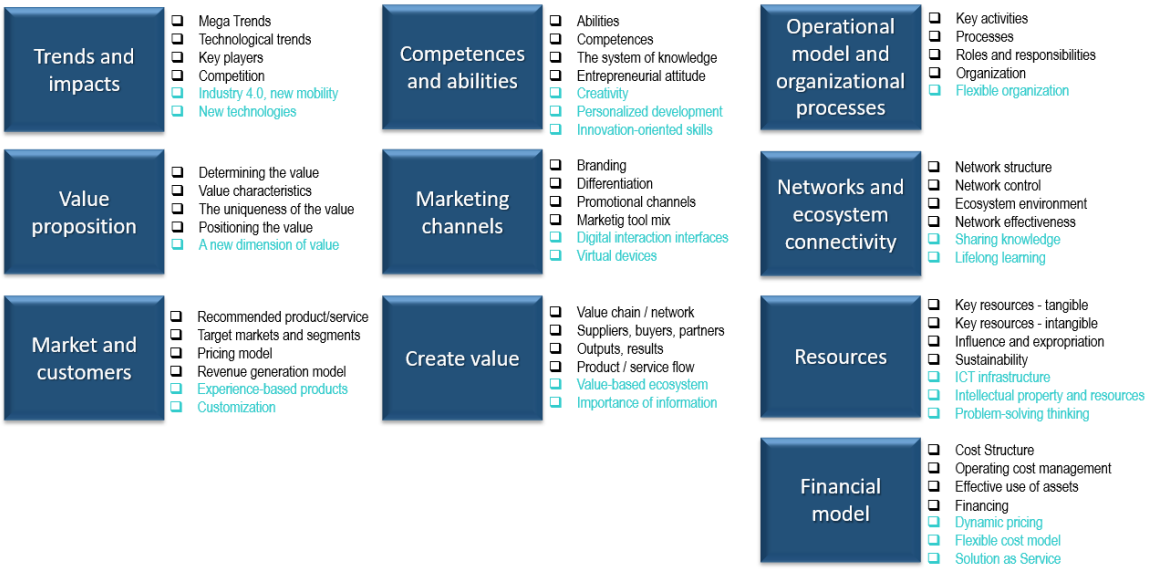
6. Conclusions

The rapid technology changes lead to dramatic changes in several sectors, influencing not only way of management and requiring new methods, but also affecting the complete business models. The current paper specifically focused on aspects of an innovation-based, research and development-oriented perspective given by the example of ZalaZONE Proving Ground and its environment.

Management researches related to ZalaZONE innovation ecosystem pointed out the necessity of the followings, these are the basic pillars of the current and further researches in the future:

- clear understanding and forecasting impacts of new and breakthrough technologies,
- developing new business model framework suitable for innovation ecosystem both at single players and system level,
- modelling and simulation of translational economy impacts in order to maximise added value outcome.

As the first conclusion of the research results, which are the actual, but not completed results state of the running researches, the new innovation ecosystem-oriented business model framework model was shown, Figure 8 summarizes the basic frame of the model elements and their contents with the classic and future-oriented features. This gives a guide for business management in contextual level.



***Figures 8**. Elements and content of the developed business model framework*

Behind the ten elements formed in the model, the sub-areas defined describe the structure of a business model in more detail. These include classic elements of business models, further expanded with future-oriented elements in a customised way, aligned with the given application environment (like in the current case of ZalaZONE Proving Ground). This latter element, time aspect makes the model future-oriented as Figure 9 shows it in a symbolic way. As the second conclusion of this paper, this approach then describes a general business model framework that is future-oriented, dynamic, and knowledge-based in the same time. Further researches related to specifics of the three axes and the interrelations are in process. The model in its current shape is applicable for creation of general business strategies in the given dimensions.

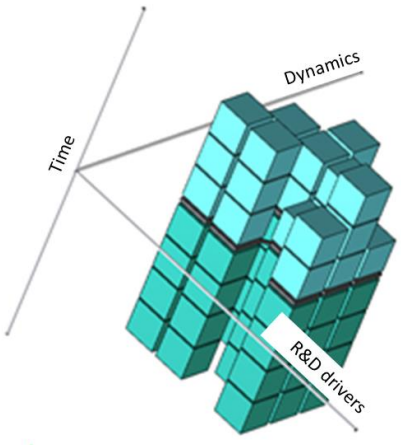


***Figure 9**. General concept structure of the business model approach for innovation ecosystems*

As the third conclusion of the project, beyond the business level, the translational impact area was the subject of the shown researches, concluding a three-factor model that is applicable for evaluation and simulation of the translation. Key elements of the supposed function were described, making possible further researches in this field, summarized in Figure 10. The

presented features and mechanisms for actions are applicable in complex innovation ecosystems where striving for maximising impacts related to added value is crucial.

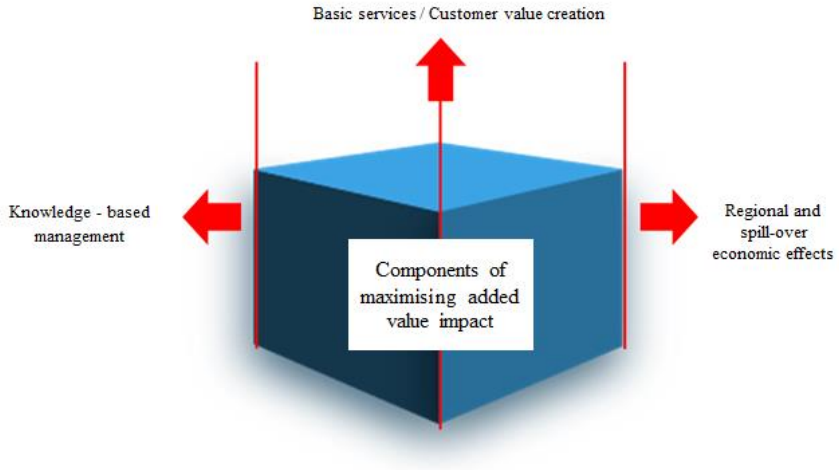


***Figure 10**. Three components of the translational impact of innovative accelerator projects*

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Sustainable Consumption and Consumers

Catch Me If You Can – reduction of food loss and waste during the spread of COVID-19

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Abstract

Food security and food waste are one of the most cardinal challenges of the modern world. Since the early eighties, international organisations like the UN and the FAO have worked on assessing and solving this challenge and it is because of their work, that we now know the extent of food wastage. In 2011, and estimated amount of 1.3 billion tons of food has been lost or wasted in the food supply chain all over the world, which is about one third of all the food produced. The ecological, social and economic implications of this amount of wastage are severe and developing and developed countries each have a role to play in solving this matter. This role was further confirmed by the creation and ratification of the Sustainable Development Goals (SDGs) by the UN in 2015, where sustainable consumption and food waste play a significant role in a number of goals, directly or indirectly. Several studies have assessed the generation of food waste through the Food Supply chains (FSCs) demonstrating the most common challenges in both upstream and downstream phases. Challenging that, the estimation of food waste levels is growing despite the fact that the measurements have several difficulties concerning the reliability. The estimation of food waste may lead to mitigation when businesses, households, communities take the responsibility to intervene.

Concerning food waste levels Gustavsson et al. (2011) found that food losses occur rather homogenously across regions, representing one-third of each region's food wastage, while the level of food waste varies much more significantly, from 4-16 percent in low-income regions to 31-39 percent in middle and high-income regions. But in both cases, it results in environmental impacts, such as waste of resources (e.g., land, water, energy, materials) and associated emissions and their intensity and extent vary according to local context and type of commodities (FAO, 2013). This pattern was also confirmed by other regional and national investigations. For example, according to the European Commission's investigations (EC, 2011), food waste generated in the 27 countries of the European Union was estimated to be approximately 89 million tons each year (or 179 kg per capita), where 42% was originated from households, 39% from processing, 5% from distribution, and 14% from catering services. It further noted that 60% of the household food waste is avoidable, while most of the food loss during process is unavoidable. A recent study in 2016 again acknowledged that household contributed the most to the food waste generation (47 million tons ± 4 million tons) in EU-28, followed by processing (17 million tons ± 13 million tons), both of which represented 72 percent of total EU food waste (Stenmarck et al., 2016). These estimations are valid for peacetime, not for COVID-19 times: from panic buying at grocery stores to restaurant closures, is bound to inflate those percentages, as several experts say.

Current study has to dedicated purpose: at first we demonstrate how the current coronavirus pandemic might influence the food waste patterns through the Food Supply chains (FSCs), at second what kind of solutions are available for potential reductions. By applying desktop research, we will map priority stakeholder actions according to the food waste hierarchy.

Keywords: Food waste, COVID-19 times, stakeholder actions, food waste solutions

1. Introduction

General overview. Food security and food waste are one of the most cardinal challenges of the modern world. Since the early eighties, international organisations like the UN and the FAO have worked on assessing and solving this challenge and it is because of their work, that we now know the extent of food wastage. In 2011, and estimated amount of 1.3 billion tons of food has been lost or wasted in the food supply chain all over the world, which is about one third of all the food produced. The ecological, social and economic implications of this amount of wastage are severe and developing and developed countries each have a role to play in solving this matter. This role was further confirmed by the creation and ratification of the Sustainable Development Goals (SDGs) by the UN in 2015, where sustainable consumption and food waste play a significant role in a number of goals, directly or indirectly. Several studies have assessed the generation of food waste through the Food Supply chains (FSCs) demonstrating the most common challenges in both upstream and downstream phases. Challenging that, the estimation of food waste levels is growing despite the fact that the measurements have several difficulties concerning the reliability. The estimation of food waste may lead to mitigation when businesses, households, communities take the

responsibility to intervene. Several good practices and innovative solutions could be found in the field of food waste mitigation (for e.g. an European project called 'FUSIONS', good practices in food waste prevention and reduction by the EC, best practices in reducing food waste of the FAO etc.).

Concerning food waste levels Gustavsson et al. (2011) found that food losses occur rather homogenously across regions, representing one-third of each region's food wastage, while the level of food waste varies much more significantly, from 4-16 percent in low-income regions to 31-39 percent in middle and high-income regions. But in both cases, it results in environmental impacts, such as waste of resources (e.g., land, water, energy, materials) and associated emissions and their intensity and extent vary according to local context and type of commodities (FAO, 2013). This pattern was also confirmed by other regional and national investigations. For example, according to the European Commission's investigations (EC, 2011), food waste generated in the 27 countries of the European Union was estimated to be approximately 89 million tons each year (or 179 kg per capita), where 42% was originated from households, 39% from processing, 5% from distribution, and 14% from catering services. It further noted that 60% of the household food waste is avoidable, while most of the food loss during process is unavoidable. A recent study in 2016 again acknowledged that household contributed the most to the food waste generation (47 million tons ± 4 million tons) in EU-28, followed by processing (17 million tons ± 13 million tons), both of which represented 72 percent of total EU food waste (Stenmarck et al., 2016). These estimations are valid for peacetime, not for COVID-19 times: from panic buying at grocery stores to restaurant closures, is bound to inflate those percentages, as several experts say.

***The effect on coronavirus pandemic on the FSCs*.** Figure 1 represents a common sematic model of the FSC (let's see the report of FAO on the state of food and agriculture in 2019).

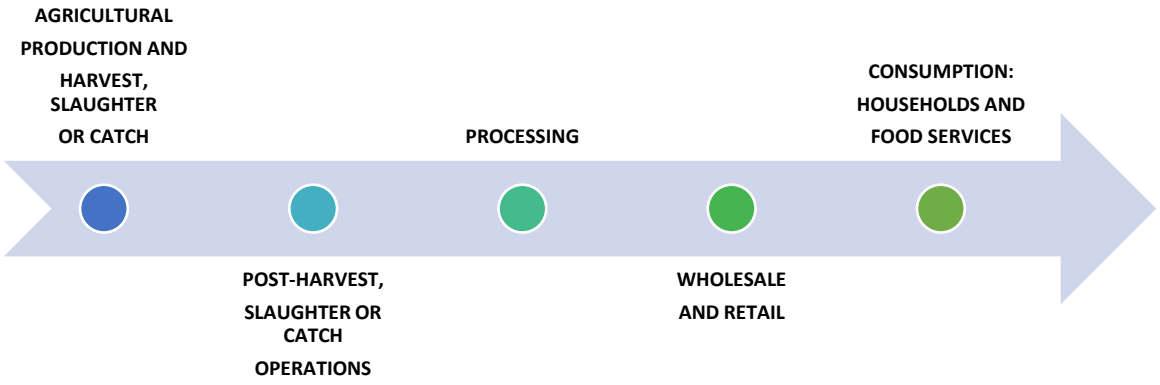

***Figure 1**. Phases of the Food Supply Chain. Source: FA0, 2019*

A new article of Royte, E. for nationalgeografic.org (published march 30, 2020) says that new stress situations occur along the FSCs. With restaurants, schools, caterers, corporate cafeterias, and some farmer's markets shutting down, farmers (first phase) also have fewer outlets for their highly perishable produce, exacerbating a supply bulge currently. Moreover, finding new markets for crops that don't keep, like leafy greens, is difficult. As Ben Feldman of the Farmers Market Coalition says: *"Farmers planned for their sales outlets months ago when they planted". "If their markets are forced to close and they can't pivot to other sales outlets, that produce will rot in the field" (Royte, 2020)*. Accordingly, the first new threat from food waste perspective is the growing amount of food left in fields. Obviously this might influence the food discarded afterward as well: post-harvest handling, processing. The Food and Agriculture Organization of the United Nations *("COVID-19 and the risk to food supply chains: How to respond?" at fao.org)* estimates several shortage of the management of FSCs from food waste perspective, like:

- due to logistical constraints and labour shortages inefficiencies in logistics (not being able to move food from point A to point B)
- due to reduced access to animal feed and slaughterhouses' diminished capacity (due to logistical constraints and labour shortages) similar to what happened in China.

It is important to note, that blockages to transport routes are particularly obstructive for fresh food supply chains and may also result in increased levels of food loss and waste. Especially fresh fish and aquatic products, which are highly perishable and therefore need to be sold, processed or stored in a relatively limited time are at particular risk. (fao. org, online)

Concerning upper phases of the FSCs, shortages of labour could disrupt production and processing of food, notably for labour-intensive industries (e.g. crops or fishing). Potentially food waste levels decrease during this stages, but it does not happen for social good. It seems that waste at restaurants is plummeting as eateries shut down, however it's likely to rise at those shifting to a take-out-only model. The food shortage fears of consumers also put significant stress. The panic of 'buy goods' resulted in depleted supermarket shelves and growing food stocks at home from which potentially several amount of food will go to waste. In addition to that the accumulation of food vulnerable groups of the society is harmed as Lindsay Boswell, chief executive of food charity FareShar says: *"given with one hand and taken away with the other"* (Financial Times online). However, discarding goods at groceries not just happen at home thanks to changing demand patterns, but both to unpredictable purchases and closure of other Consumer-Facing Businesses including restaurants, foodservice providers, and institutions. At the final phase, it is crucial to provide information and call the attention of consumers balancing on that they are expected to rarely visit groceries and to buy that amount of food which would not become food waste.

Food waste generation may be a persistent problem even under the normal functioning of the agricultural industry. However, should disruptions affect either the production chain or the supply chain, sudden spikes of food waste generation, followed by shortfalls or even shortages may be encountered. In order to be best prepared for any short, medium or long-term effects, we ought to understand the responsiveness of the agricultural sector to external shocks, such as sudden drops in demand and sudden labour shortages.

Production disruptions and supply side effects. A rather important aspect of food waste management is to be found on the input side: in agricultural production. At the time of writing, the full economic consequences of the COVID-19 pandemic are yet to unfold, and the "opening up of the economy" after the - quite possibly, first - lockdown is not yet taking place. Yet disruptions in food production and distribution have already occurred, albeit to a relatively limited extent only: durable foodstuffs, such as rice, flour and pasta have been hoarded by numerous consumers, but neither significant price increases nor food shortages have been experienced. On the supply side, the consequences of these minor disruptions may even go unnoticed on the long run, provided that governments on various levels can act quickly and effectively to prevent persistent adverse changes in the food production and supply chains.

An immediate effect of the lockdowns was the (temporary) laying off of droves of temporary and seasonal agricultural workers, typically from the Eastern states of the European Union and from Eastern Europe, who normally work for the minimum wage. (Euronews, 2020a) who were forced to return to their home countries because they couldn't afford to sustain themselves with no income. The backlash is already beginning to show, as these workers are now suddenly and sorely missed from the workpool, and crops are left to rot in the fields. (France24, 2020a) For some products, such as asparagus and strawberries, this already means that this year's crop has gone to waste (Euronews, 2020b). Coupled with looming drought on account of absence of precipitation for several weeks, pressure on the agricultural sector is mounting. (DW, 2020) Some agricultural producers did manage to enlist some local temporary workers, but the very same producers now fear that with the "reopening of the economy", they will be stranded without hand labourers to pick the fresh produce. Urgently redeploying temporary workers from Eastern Europe is high on the agenda. (Balkan Insight, 2020) Crucially, agricultural workers must return to the fields as quickly as possible.

Without much needed government coordination, it could be expected that producers, who can do so easily, will switch to other produce, potentially turning the threat of shortages in the supply of some produce into reality. Though ultimately this will depend on the associated indirect costs of making the switch, there are certainly some produce, particularly short-season, perishable crops, where temporarily switching to a less demanding and more easily storable alternative may appear to be a lucrative option in the short term. This is particularly easily implementable on farms where an assortment of crops is already being produced. However, any such switch is going to prove rather problematic on agricultural units where crop care and harvesting are mostly done by manual labour, and where mechanisation was not practical.

***Upheavals in consumption patterns and demand side effects*.** Sudden drops or sudden surges in the demand for certain foods may spark immediate disruptions right down the food supply chain, whose effects will inevitably force agriculturalists to reconsider their crop options. Understanding the root causes of these disruptions is an indispensable part of mitigating short-term consequences and preventing long-term damage.

As an immediate economic and social effect of the COVID-19 pandemic, essential parts of the economy were either shut down temporarily, or were forced to significantly change their operations on very short notice. Employed workers all across the spectrum, from every industry found themselves under radically different working conditions in the blink of an eye. Those, who could work online, or in the sectors deemed essential, were generally overloaded with the suddenly increased burdens of readjusting to the new reality. However, those, whose jobs had been suspended or scrapped, found themselves under uncertain, even precarious financial circumstances overnight. Particularly hard hit were those working under temporary or flexible contracts in any sector, whose employment would not be continued. In the European agricultural sector, this included permanently or temporarily employed agricultural hand workers. Strangely, whereas food stores and logistics firms serving the food industry were deemed essential, agricultural firms were not given these privileges.

The abrupt laying off of temporary workers started a domino effect. Perhaps the most dire consequence of the disruptions in the employment of seasonal and temporary workers is their sudden inability to cover even the most basic needs of survival, that at a time when they are most needed in the fields. As tens, perhaps even hundreds of thousands of workers were forced to trek to their home countries during the first days of the lockdowns, because they could not afford to pay the rent and living costs in their countries of work. Overnight, they found their livelihoods threatened or gone, and with most of them not holding any savings worth mentioning, even putting food on the table has become a sudden problem.

A similar phenomenon has been observed among those temporary factory and agricultural workers who did not work outside their home countries. Investigative journalists have recently reported that in the poorest parts of Hungary, the number of people not able to financially cover their daily food needs has multiplied within days. All this at a time when charitable organisations, who provide the crucial storage and distribution service in the food aid chain are unable to receive or dispatch donations either. From the financial support these laid-off workers would receive, they would aim to source durable, non-perishable basic foodstuffs for basic sustenance. (Direkt 36, 2020) With schools and public institutions all but closed, social meal services have taken a hit in a number of locations.

Online food retailers have been overloaded with orders since the lockdowns began. (TIME, 2020) During the period leading up to the lockdown, consumers who were previously accustomed to purchasing foodstuffs on a virtually daily basis were suddenly changing strategies: they began to panic buy and hoard durable foodstuffs. Products such as baking flour, rice, pasta, and even potatoes were practically sold out in anticipation of temporary but significant disruptions, and stores had to impose purchase limits. (Népszava, 2020) Due to the reserves in the food supply chain, lasting shortages didn’t occur, but retailers have had to increase prices of certain products to curb demand. The possible consequence of this hoarding could be the disposal of several additional kilograms of spoilt staple food in each household.

Another mounting problem comes from the hospitality industry, where restaurateurs, publicans and hoteliers are experiencing a sudden drop in demand for their products and services. Where established infrastructures for home delivery existed already,

restaurateurs may choose to dispatch food via delivery services, which could be their path to survival, with early afternoon closures wiping out their most profitable dinner service. (HVG, 2020a) However, significant commissions of around 30% of the meal price and higher VAT rates for delivery services (Portfolio.hu, 2017) mean that many restaurants would struggle to make ends meet under these circumstances. Delivery companies and restaurants have already written an appeal to the government to temporarily drop VAT rates for meal deliveries. (Forbes.hu, 2020a) Meals ordered for delivery are often basic, simpler meals. These don't allow restaurants for much room for markups, certainly not to the extent that they would be able to during in-restaurant dinners. Fine dining restaurants have very little hope of getting their gourmet meals to expecting customers on wheels. (Forbes.hu, 2020b) On top of this, virtually no cost savings could be realised on not opening shop either, since operating kitchens would need to use all utilities as before, and the most significant cost item is rent, which is due in spite of the lockdowns.

Economic approaches to estimating medium to long term effects of sudden changes in demand and supply. Sudden changes in demand and supply may have profound effects on food waste generation, with some foods never making it to the retail units, thus temporary shortages may be experienced. In order to prevent the generation of significant amounts of food waste, the root causes behind the disruptions need to be assessed. In the following paragraphs, disruptions affecting producers and consumers will be analysed.

Káldor's cobweb model is often used to predict future yields, in particular, to help predict the crops where the most severe yield fluctuations may be encountered. The model can be used to broadly simulate the consequences of an external shock - such as the COVID-19 pandemic and its immediate economic effects - on the anticipated future yields of some crops. According to Káldor's model, two outcomes - a convergent and a divergent one - may occur; convergent being self limiting and divergent being self enforcing, possibly causing runaway prices and unpredictable harvests. Ultimately, a convergent case occurs when the demand curve is more elastic than the supply curve, and conversely, a divergent case occurs when the supply curve is more elastic than the demand curve.

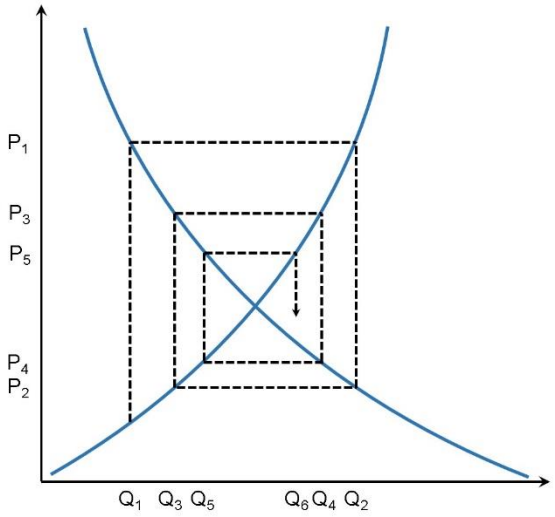

Figure 2. *Káldor's cobweb model for convergent case*

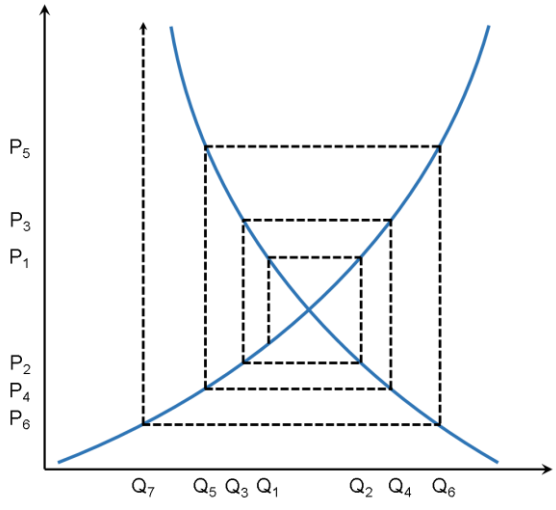

Figure 3. *Káldor's cobweb model for convergent case*

In predicting future shortages and oversupplies, the elasticity of the demand and supply functions must be estimated. In the following analysis, three scenarios - convergent, divergent and rapidly divergent - are being assessed. It is anticipated that in the divergent scenarios, agriculturalists will be forced to abandon the production of the non-stabilising crop, and if possible, will pursue the production of more stable, more predictable crops. To substantiate these assertions, critical characteristics of the crops and production processes have been identified and are demonstrated in Table NN. It is expected that factors such as

these would be considered by agriculturalists in planning their future harvests, thus these could be used to forecast their strategies.

Table 1. *Critical characteristics of crops and production processes, in the planning of future crop strategies. Source: own compilation.*

Critical characteristic	Convergent	Divergent	Rapidly divergent
Type of foodstuff	typically subsistence	typically nourishment	typically enjoyment
Labour demand	low	medium	medium to high
Capital demand	Low or medium	medium	medium to high
Number of annual cycles	≥ 1	≥ 1	≥ 1
Duration of cycle	Weeks or months	Weeks, extendable to months	Days or weeks
Sensitivity to harvest delay	Low	Medium	High
Harvest scheduling	Once a cycle	Continuous	Short seasonal
Production mode	Conventional (chemical based)	Possibly organic	Probably predominantly organic
Perishability, durability	Mostly durable without significant preservation efforts	May be chilled to extend shelf life (days, perhaps weeks)	Does not respond well to refrigeration (temperature change, frost)
Preservability	Probably not needed, not possible with some	Yes, freezing, drying, processing, preservation (cans, jars), distillation	Freezing, preservation (cans, jars), distillation
Nature of demand	Domestic and equalising export	Domestic, export	Primarily export
Typical examples	Potato, grains, sweetcorn, rice, marrows, carrots and beets, onion, cabbage, other staple crops	Strawberry, tomato, pepper, legumes (peas, beans)	Asparagus, raspberry, radishes, cucumber, melons

The authors have identified three key cases, with convergent, divergent and rapidly divergent trajectories. Characteristics are based on expert accounts and industry practices and observations. Low labour demand is associated with crops where manual labour is mostly employed during harvesting, which typically occurs once or twice a year, and is often coupled with largely mechanised processes. Frequently, a strong substitutive relationship may be observed between low labour and medium capital intensity (e.g. manual labourers and combine harvesters). Medium labour demand is identified to exist where harvesting is not a one-off action, but is repeated regularly - on a daily or diurnal basis - to collect fresh produce. Medium to high labour demand is considered to exist where the crops require regular attention and significant care, and where harvesting can only be done by hand.

Capital demand typically considers the extent of mechanisation and additional capacities for maintaining a steady flow throughout the supply network, thus including harvesting machines, separators, cool storage, refrigeration or deep-freeze facilities.

With reference to the characteristics of the crops themselves, cycle refers to the number of times crops can be brought to a discreet harvest within a year. Some crops, such as wheat, could have up to two cycles a year, others will have just one. Thus, duration of cycle refers to the time period crops take to mature. This can be used to help predict if an agriculturalist can recover some of their losses within the year, should a harvest fail in a cycle. Success of a harvest at the end of a cycle may be impacted by any forced delays, or even premature harvests. Thus, sensitivity to delays helps estimate if any produce can be salvaged should scheduling of harvests be disrupted. Harvest scheduling is closely linked to labour demand, but also capital demand,

and it indicates the typical nature and timing of a harvest: some crops are harvested during a single event, others are collected regularly over a period of weeks, even months, while yet others are more seasonally sensitive, and may only grow during certain times of the year. In this latter case, if a harvest is missed, producers will probably have to wait until the following year to aim to recover some of their losses. As for the production modes, though it isn't strictly necessary to use these techniques, it is likely that these be used in the case of these products.

Perishability and preservability, though seemingly refer to the same characteristic, they are considered to be different things. Perishability refers to the need to extend the shelf life of a fresh product, through non-intrusive preservation methods, such as chilling or cooling, whereas preservability refers to methods of processing the food, thus extending usability considerably, including freezing and making preserves, or even distilling into alcohol, if needed.

Nature of demand refers to the balance between domestic and foreign consumption. Equalising exports refer to foods being traded internationally to balance out temporary shortfalls in supply, but not necessarily as a steady source of income. Conversely, primarily export driven production typically aims for a steady income stream from abroad.

Solution for reduction. Fortunately, there are plenty of solutions for food waste reduction. For instance, a project financed by the European Union called FUSIONS was dedicated to identify solutions and test socially innovative projects to reduce food waste across all stages of the food chain. In brief, several databases are available for possible solutions. ReFED -an American multi-stakeholder nonprofit, powered by an influential network of the nation's leading business, nonprofit, foundation, and government leaders committed to reducing U.S. food waste- analysed 27 possible solutions to food loss and waste in the United States of America, grouped into three categories: prevention, recovery (redistribution) and recycling.

Table 2. *Food waste prevention solutions. Source: ReFED (2016)*

FOOD WASTE PREVENTION SOLUTIONS			
CATEGORY	SOLUTION NAME	DESCRIPTION	STAKEHOLDERS
Packaging, Product, & Portions	Standardized Date Labeling	Standardizing food label dates and instructions, including eliminating "sell by" dates, to reduce consumer confusion	Manufacturers, Retailers, Consumers
	Packaging Adjustments	Optimizing food packaging size and design to ensure complete consumption by consumers and avoid residual container waste	
	Spoilage Prevention Packaging	Using active intelligent packaging to prolong product freshness and slow down spoilage of perishable fruit and meat	
	Produce Specifications (Imperfect Produce)	Accepting and integrating the sale of off-grade produce (short shelf life, different size/ shape/ color), also known as "ugly" produce, for use in foodservice and restaurant preparation and for retail sale	Producers, Consumer-Facing Businesses
	Smaller Plates	Providing consumers with smaller plates in self-serve, all-you-can-eat dining settings to reduce consumer waste	Foodservice
	Trayless Dining	Eliminating tray dining in all-you-can-eat dining establishments to reduce consumer waste	
Operational & Supply Chain Efficiency	Waste Tracking & Analytics	Providing restaurants and prepared-food providers with data on wasteful practices to inform behavior and operational changes	Restaurants, Foodservice
	Cold Chain	Reducing product loss during shipment to retail	

FOOD WASTE PREVENTION SOLUTIONS			
CATEGORY	SOLUTION NAME	DESCRIPTION	STAKEHOLDERS
	Management	distribution centers by using direct shipments and cold-chain-certified carriers	Retailers
	Improved Inventory Management	Improvements in the ability of retail inventory management systems to track an average product's remaining shelf-life (time left to sell an item) and inform efforts to reduce days on hand (how long an item has gone unsold)	
	Secondary Resellers	Businesses that purchase unwanted processed food and produce direct from manufacturers/distributors for discounted retail sale to consumers	
	Manufacturing Line Optimization	Identifying opportunities to reduce food waste from manufacturing/ processing operations and product line changeovers	Manufacturers
Consumer Education	Consumer Education Campaigns	Conducting large-scale consumer advocacy campaigns to raise awareness of food waste and educate consumers about ways to save money and reduce wasted food	Consumers, Consumer-Facing Businesses

Table 3. *Food waste recovery solutions. Source: ReFED (2016)*

FOOD WASTE RECOVERY SOLUTIONS			
CATEGORY	SOLUTION NAME	DESCRIPTION	STAKEHOLDERS
Donation Infrastructure	Donation Matching Software	Using a technology platform to connect individual food donors with recipient organizations to reach smaller-scale food donations	Farms, Consumer-Facing Businesses, Food Recovery Organizations
	Donation Storage & Handling	Expanding temperature-controlled food distribution infrastructure (e.g. refrigeration, warehouses) and labour availability to handle (e.g. process, package) additional donation volumes	
	Donation Transportation	Providing small-scale transportation infrastructure for local recovery as well as long-haul transport capabilities	
	Value-Added Processing	Extending the usable life of donated foods through processing methods such as making soups, sauces, or other value-added products	
Donation Policy	Donation Liability Education	Educating potential food donors on donation liability laws	
	Standardized Donation Regulation	Standardizing local and state health department regulations for safe handling and donation of food through federal policy	
	Donation Tax Incentives	Expanding federal tax benefits for food donations to all businesses and simplifying donation reporting for tax deductions	

Table 4. *Food waste recycling solutions. Source: ReFED (2016)*

FOOD WASTE RECYLING SOLUTIONS			
CATEGORY	SOLUTION NAME	DESCRIPTION	STAKEHOLDERS
Energy & Digestate	Centralized Anaerobic Digestion (AD)	A series of biological processes in which microorganisms break down biodegradable material in the absence of oxygen resulting in two end products: biogas and digestate. There are many different AD technologies, including wet and dry versions, the latter being generally better suited for food waste mixed with yard waste.	Municipalities, Manufacturers, Retailers
	Water Resource Recovery Facility (WRRF) with AD	Delivering waste by truck or through existing sink disposal pipes to a municipal WRRF, where it is treated with anaerobic digestion; the biosolids can be applied to land for beneficial reuse	WRRF, Retailers, Municipalities, Restaurants, Consumers
On-Site Business Processing Solutions	In-Vessel Composting	Composting at small scale at institutions or businesses with heat and mechanical power to compost relatively quickly (less than one month versus more than two months for windrow composting)	Restaurants, Foodservice
	Commercial Greywater	An on-site treatment technology, greywater aerobic digesters use combinations of nutrients or enzymes and bacteria to break food organics down until soluble, where it is flushed into the sewage system.	
Agricultural Products	Community Composting	Transporting food from homes by truck, car, or bicycle to small, community, or neighbourhood-level compost facilities that process 2,500 tons per year on average	Restaurants, Consumers
	Centralized Composting	Transporting waste to a centralized facility where it decomposes into compost	Municipalities, Retailers, Restaurants, Foodservice, Consumers
	Animal Feed	Feeding food waste to animals after it is heat-treated and dehydrated and either mixed with dry feed or directly fed	Manufacturers, Consumer-Facing Businesses
	Home Composting	Keeping a small bin or pile for on-site waste at residential buildings to be managed locally; also known as “backyard composting”	Consumers

2. Methods

In research, we map priority stakeholder actions (farmers, manufacturers, restaurants/ foodservice, grocery retailers, state and local governments, foundations) according to the food waste hierarchy: prevention, recovery (redistribution) and recycling. Due to the novelty of the situation, we gather information via online. While our number one concern is for the health of those affected by COVID-19 and fulfil those restrictions which help to lessen the spread of the pandemic, several institutions, businesses call the attention to the food waste concern of the current situation like UN FAO (*“FAO offers 7 food tips to deal with the COVID19 crisis and answers on its impact on food and agriculture”*, 25 March 2020), ReFED (“Food waste resources during the COVID-19 pandemic”, 20 March 2020) and others take actions. Our hypothesis is that current actions put emphasis on consumer education, donation infrastructure and modified business solutions.

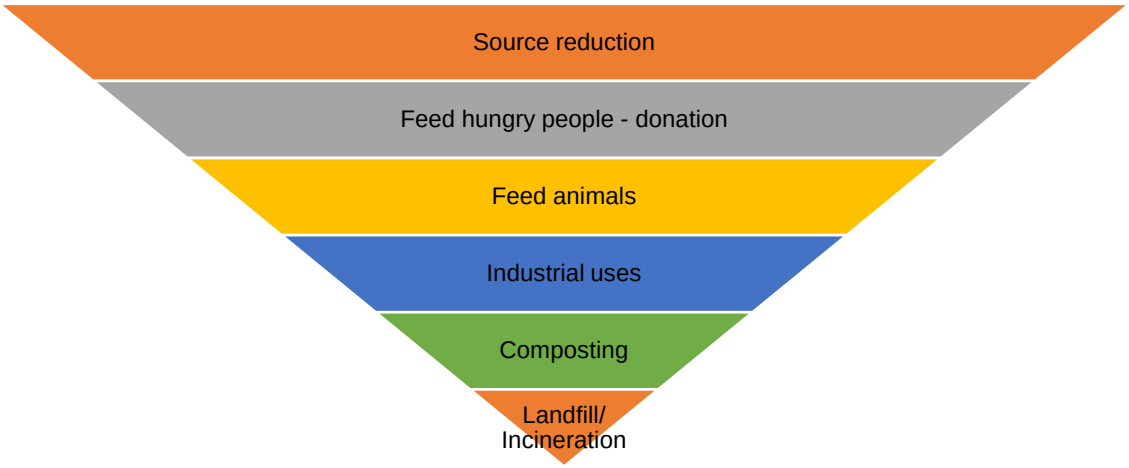

***Figure 4**. Food recovery hierarchy. Source: European Court of Auditors, 2016*

We assume, that due to the current situation there will be a shift from widespread-solutions to ones which are tailored for emergencies decreasing contingent risk in the management of Food Supply Chains. Our desktop research relies on the following sources:

- Novel Coronavirus (COVID-19) file of UN FAO called "Keeping food and agricultural systems alive - Analyses and solutions in a period of crises - COVID-19 Pandemic" (available at: *http://www.fao.org/2019-ncov/analysis/en/*)
- Fapda - Food And Agriculture Policy Decision Analysis Tool of UN FAO designed for search for policy measures and urgent actions (available at: *http://www.fao.org/in-action/fapda/tool/index.html#main.html*)
- Environment section of The Guardian (*https://www.theguardian.com/environment*)
- Thematic research by search engines.

3. Results and Discussion

***Table 5.** Cases for food loss and waste solutions during COVID-19 pandemic. Source: own compilation*

Category	Solution	Project owner/ disseminator	Description	Stakeholders	Region
Food waste prevention					
Saving harvest	Recruitment	Country Land and Business Association (CLA)	"Land army" to be recruited from people put out of work by the crisis in order to avoid leave crops rotting in the fields.	Farmers, Manufacturing, Retailers, Consumers, Food service	UK
		Scottish fruit farmers	Students and laid-off bar and restaurant workers given jobs as pickers after urgent appeal - Scottish fruit farmers have solved a recruitment crisis that could have resulted in this year's harvest of strawberries, blueberries and raspberries being destroyed.	Students, Laid-off bar and restaurant workers, Farmers, Manufacturing, Retailers, Consumers, Food service	Scotland
	Delaying harvest	Wexford Strawberries	Wexford Strawberries (providing "Ireland's tastiest, juiciest Sunny Strawberry from Wexford the heart of the Sunny South East" according to its official website: www.wexfordstrawberries.ie	Farmers, Manufacturing, Retailers, Consumers, Food service	Ireland

Category	Solution	Project owner/ disseminator	Description	Stakeholders	Region
			) is buying time by ventilating tunnels and removing their fleeces to lower temperatures and slow ripening in belief to have enough time for recruiting workers.		
Saving harvest	Harvest by volunteers	Asparagus harvest in Brandenburg	According to Guardian online hundreds of people have volunteered to help bring in the asparagus harvest in Brandenburg, the state surrounding Berlin.	Volunteers, Farmers, Manufacturing , Retailers, Consumers, Food service	Germany
	Online Platform	Bundesministerium für Ernährung und Landwirtschaft (Federal Ministry of Food and Agriculture, Germany)	"The Land Helps" platform (Das Land hilft at daslandhilft.de) helps for matching workers and farms in Germany.	Workers, Farmers, Manufacturing , Retailers, Consumers, Food service	Germany
		Alibaba	Chinese e-commerce platforms boost sales of unsold agricultural products by offering funds and technical support to link farmers to consumers while avoiding the physical contacts of going to markets.	Farmers, Retailers, Consumers	China
Operational & Supply Chain Efficiency	Manufacturing Line Optimization	UN FAO	Emergency mode production (e.g., physical distancing on the processing floor) to reduce food loss and waste while ensuring health safety	Manufacturing , Retailers, Consumers, Food service	World
	Free food	Milans' Pizza	As the Reuters (online) says with lots of ingredients stocked up, Varga quickly changed his plans and joined a growing number of Hungarians who have responded to the crisis with acts of kindness. He is now delivering free pizzas to the elderly who have to self-isolate in their homes.	Household	Hungary
	Touchless home-delivery and takeaway	WeLoveBudapest.com	Budapest restaurants offering home delivery and takeaway	Households	Hungary
	Education	Leanpath Inc.	The company offers waste prevention guides for restaurants and other facilities to educate them on food preservation techniques.	Manufacturing , Retailers, Food service	America, Australia, Europa
	'Vegetable Basket' policies	Chinese state	The Chinese state, based on their 1980s project, adopted 'Vegetable Basket' policies. With its help, they were able to supply the epicentre of the outbreak with fresh produce and vegetable from 9 different provinces, thus regulating the level of both demand and supply.	Farmers, Retailers, Consumers	China

Category	Solution	Project owner/ disseminator	Description	Stakeholders	Region
Operational & Supply Chain Efficiency	Drive-in farmers market	Farmers' market in Dunakeszi, Hungary	The farmers' market nearby the Hungarian Capital has decided to introduce the Drive-in mode for product delivery. The goods boxed are constituted in advance by the farmers and the consumers could pick up their orders just by drive-in. The way could enable less contacts between the clients and farmers.	Farmers, Consumers	Hungary
Packaging, Product, &Portions	Packaging Adjustments	TESCO PLC	Removing multi-buy promotions	Consumers	World
	Limit sales of food	Tesco, Sainsbury's and Asda in the UK	Tesco, Sainsbury's and Asda limit sales of food and other groceries – usually customers will only be permitted to buy up to three of any one product	Consumers	UK
		Spar Hungary	Spar Hungary sets 10-pieces-limit for flour, oil, rice and yeast, meaning customers could only buy 10 pieces at once	Consumers	UK
Consumer Education	Consumer Education Campaigns	TESCO PLC	Tesco sets wide limit of 3 items per customer on every product line and encourages consumers to buy only what they need	Consumers	World
		The Hungarian Dietetic Association	Shopping list for 2-weeks-long quarantine per capita	Households, consumers	Hungary
		American Red Cross	Keeping supply of food for two weeks	Households, consumers	US
		City of Arcata, California: Save the Food community	The community based resources, like a website with guidelines offer education on how to store the excess products the citizens bought.	Households, consumers	US
Food waste recovery					
Donation Infrastructure	Financial aid	Ministry of Agriculture through Dutch "calamity fund"	Financial help of EUR 4 million since a number of food banks are facing problems ranging from a lack of experienced staff, insufficient supply of food, but also locations that are no longer suitable for issuing food packages due to the Corona virus.	Food banks, Consumers	The Netherlands
		Government of the United Kingdom	Food redistribution organisations across England will benefit from £3.25 million of government funding to help them cut food waste and redistribute up to 14,000 tonnes of surplus stock during the coronavirus outbreak. (gov.uk)	Food redistribution organisations, Consumers	UK

Category	Solution	Project owner/ disseminator	Description	Stakeholders	Region
Donation Infrastructure	Food boxes (national service)	Government of the United Kingdom in partnership with the grocery industry, local government and local resilience forums	The first food boxes have been delivered to those vulnerable people being shielded from coronavirus as the government moved to support those most in need, Communities Secretary Robert Jenrick announced today (29 March 2020).	Local authority hubs, people	UK
	Donation matching	Food Recovery Network	Food Recovery Network has advocated food donation by offering to connect institutions who have surplus food with food banks.	Food service, Food recovery organizations	US
	Donation matching	Horticulture New Zealand, Fair Food NZ	The nationwide organization Horticulture New Zealand advocates for food growers to connect with Fair Food NZ, a food charity organization to be able to put their already harvested produce to good use and supply those in need of fresh food.	Farmers, Food recovery organizations	New Zealand
	Online platform	FeedKC.us, Replate, 412 Food Rescue	Online apps are created to match the offerings of restaurants and catering companies with drivers, who can deliver them to food banks.	Food service, Food recovery organizations	US
	Donation handling and transport	Herbfarm restaurant	Woodinville, Washington based farm-to-table restaurant shifted production to supply medical workers with boxed meals, thus keeping up production, retaining workers and still buying produce from farmers.	Farmers, Food service, Consumers	US
Donation Policy	Donation Liability Education	Feeding America	US based organisation educates partners about legal aspects in force regarding food donation.	Organizations, Manufacturers, Retailers, Food service, Food recovery organizations	US
		US government	The US government promotes food donation by standardizing process requirements based on an Act signed in 1996.	Organizations, Manufacturers, Retailers, Food service, Food recovery organizations	US
	Donation Tax Incentives	US government	The US government encourages companies to donate excess food by offering special federal tax incentives to them.	Organizations, Manufacturers, Retailers, Food service, Food recovery organizations	US

4. Conclusions

Based on the above, the authors argue that convergent scenarios are the most desirable possible outcome, and governments and stakeholder authorities should act in order to dampen shocks to ensure that the path towards a new equilibrium can begin to be treated.

Divergent scenarios bear the threat that agriculturalists are forced to abandon production of certain highly fluctuating crops, and switch to more predictable ones, possibly those listed under the convergent scenarios. However, as this transition itself may cause distortions in the convergent scenarios, this must be managed with due caution. Thus, the authors posit that some degree of administrative supervision and government intervention may be required in all three scenarios, in order to ensure supply and price stability, and to respect production quotas. With both divergent scenarios, it would be important to manage the price fluctuations before they even begin to take their toll, insofar as is legally possible.

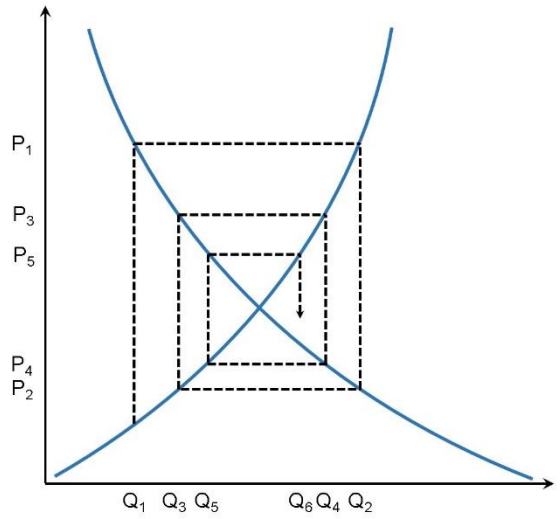

***Figure 3**. Káldor's cobweb model for convergent case*

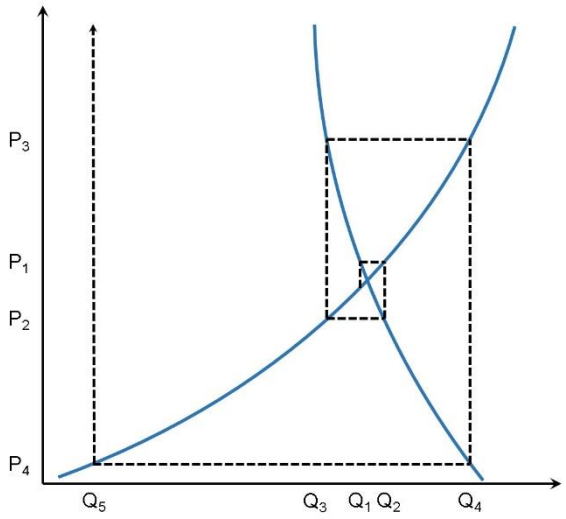

***Figure 4**. Farmers' answer to price fluctuation*

The consequences of rapid price fluctuations could be devastating to agriculturalists. It can be seen in both Figure 3 and Figure 4 that due to price fluctuations between cycles, farmers would be reducing the size of the crop in every alternate period, in an effort to minimise losses and drive prices higher. If they are sizeable enough to influence the prices, and are thus capable of driving them up, price instability ensues and the system veers out of control without governmental intervention. However, if they are too small to have any measurable impact on prices, it is likely that they will switch early to a more stable and predictable crop, i.e. from those in the rapidly divergent scenarios to those in the divergent, or even the convergent scenario. Those agents of considerable size, and in turn, a significant influence on prices are perhaps the greatest liability here, as their decisions will impact large shares of the aggregate quantities produced. If a number of agents adopt the same strategy simultaneously, they may aggravate the problem, causing the supply curves to slope up, and thus causing demand curves to become steeper, thus likely making shortages and oversupplies greater. It is important to consider whether agriculturalists set their targets synchronously or asynchronously to each other. If out of, say, mutual envy, they copy each other's strategies with one cycle of delay, there may be no significant changes in price nor quantity on the markets, as aggregate supplies could be expected to remain largely the same, thus a dampening in the oscillation may begin. However, individual farmers may yet choose to abandon production and switch to a more stable crop at any point when they can no longer afford to keep trying to produce crops in the rapidly divergent case, thus causing further smaller deviations in the dampened oscillation.

These switches will be encouraged by low associated costs (as agriculturalists' holdings, i.e. land, may already be suitable for the production of alternative crops or a multitude of them, and their equipment already suited to tend to diverse crops), and discouraged by any legal or biological limitations.

In this assessment, only crops with a cycle of one year or shorter (i.e. where farmers can relatively quickly respond to changes) are considered. Crucially, fruit-bearing trees are not considered, because though supply can be quickly reduced, it is slow to

increase once again. Farmers with fruit orchards would probably aim to weather the storm of disruptions, rather than act on the short term, in order to prevent medium to long-term damage. Fruit bearing trees would probably follow a convergent path. Nevertheless, if they are unable to generate an income from other sources, they may have to rely on government assistance.

Governments could resort to direct or indirect price controls (including setting minimum and maximum prices), tax reductions (such as temporary VAT recategorisation), setting quantitative targets (minimum and maximum quotas, thus effectively influencing prices), and could also dampen shocks by facilitating access to preservation and storage (e.g. tax breaks, or even discretionary grants or lump-sum payments to farmers to help them pay for processing, distilling and freezing). However, the extent of government involvement is probably desirable to be kept to the extent, both in terms of means and in duration, such that divergent trajectories are turned convergent.

The timing of government action is crucial, however. Figures 5 demonstrates the effect of immediate government action (taking place immediately after the first effects of the shock are observed), with more moderate external involvement (shown by a relatively small reduction in the slope of the curves). As it can be seen from the figure, prompt action triggers a prompt dampening of the oscillation, and a return to the previous equilibrium can begin sooner. Figure 6 demonstrates the effect of delayed government action (taking effect in the third consecutive cycle), with a more serious involvement (shown by a rather large reduction in the slope of the curves). From this image, it is obvious that delayed action will require more substantial government involvement, and a return to the previous equilibrium begins later and is more costly.

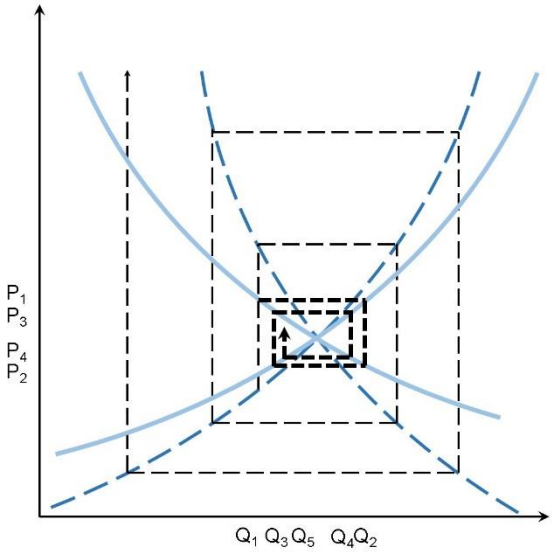

***Figure 5**. The effect of immediate government action*

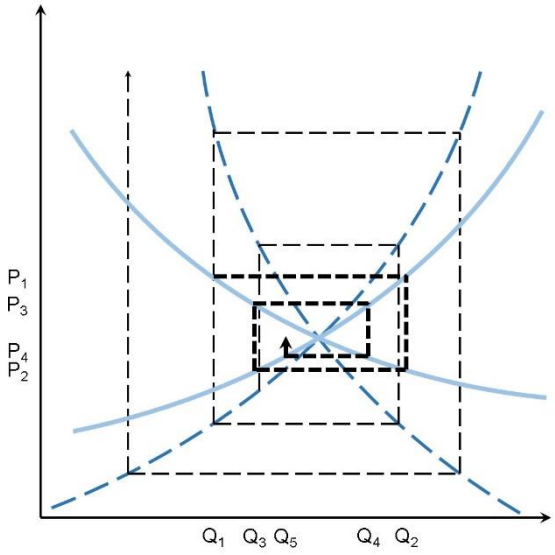

***Figure 6**. The effect of delayed government action*

Governments must aim to find the most cost-effective means of overcoming these hurdles, and must actively seek synergies between different goals, such as supporting the recently unemployed and also the agricultural sector. In particular, where supply shortages are looming as a consequence of the prompt unemployment of temporary workers, governments should support agricultural businesses by co-financing wages of seasonal workers. Good approaches and good practices from market agents, such as the temporary enlisting of recently unemployed workers from all other sectors of the economy should be pursued. Furthermore, should other problems hinder normal production levels (such as an absence of adequate protective equipment or disrupted access to logistics), governments must consider helping through these means also. Furthermore, governments must remain responsive to local problems and needs, which cannot be done effectively, nor cost-efficiently from the top down only. Lower-level governments must be given adequate powers and access to financing in order to quickly respond to disruptions. Both on the short run and on the long run, territorial strategic planning will be required to not only manage supply and demand disruptions, but also, to reduce food waste and to transition to a more sustainable local production.

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The social representation of sustainable food consumption and the role of SFSCs in the way towards sustainability

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Abstract

The global food system faces several challenges concerning ecological sustainability, and robustness in the face of shocks and global change (EC, 2019). We already know how to be sustainable; we are familiar with the planetary boundaries and future scenarios, and we have developed strategies (such as Sustainable Development Goals of the United Nations) based on vast scientific evidence. The necessary technology is present, sustainable diets are calculated. Still, the key and often missing element remains the consumer when we aim for real success in holistic change. What encourages some of them to make additional effort intending to act in a sustainable and responsible way? Why do they believe in one hazard, like GMO and not in the other, like health issues due to overconsumption of meat? The attention of this study is directed, on one hand, towards a special approach: social representation theory (Moscovici, 1961) examining what sustainable consumption means for end-users. On the other hand, we turn towards the farmers, and with field research, we examine how local farmers contribute to sustainable food production and what is the role of short food supply chains (SFSCs) in sustainable food systems. As we better understand the values and meanings of the food chain participants we get closer to the ideal tools and means to innovate resilient and sustainable food systems, what is the faraway objective. Social-psychological studies have unexploited potential to enrich and contribute to the studies of sustainability. Social representations are systems of social influence and communication that constitute the social realities of society. Turning back our reasoning to sustainable food consumption it might be interesting to see what given concepts mean to the consumers we try to incentive to act according to our understanding of the given concepts. In this study we assume that these understandings differ indeed, and for the sufficient incentivisation of consumers towards sustainable food consumption and general behaviour; a better understanding of their reality brings us closer. Also, examining the local farmers we can compare their representations with the consumers, and see if their practices correspond with the expectations of consumers. An altered version of the associative network technique (de Rosa, 2002); a free association game has been used, and 3 different groups participated: local food consumers, local farmers, and a control group of consumers. The local farmers markets (mostly also falling into the category of SFSCs) where the producers and consumers were included in the research were situated in the Balaton Upland, Hungary; while the control group of consumers was collected randomly. The free association research is still in progress, but some concepts representing a strong relation with the concept of sustainable consumption are already emerging, like local, rural, health, green, plastic, bio, vegetarian, chemical, food waste. The suggestions of the initial data and this exploratory research will be supported by word categorisation and analysis as well as with SPSS data analysis, where we hope for exploring connections between the personal characteristics and sustainable consumption concept of the consumers and the comparison with the local producers. This research has been supported by the European Union and Hungary and co-financed by the European Social Fund through the project EFOP-3.6.2-16-2017-00017, titled „Sustainable, intelligent and inclusive regional and city models", and by the ÚNKP-19-2 New National Excellence Program of the Ministry for Innovation and Technology.

Keywords: sustainable food consumption, sustainable food production, social representation theory, local economic development, short food supply chain

1. Introduction

What potential does local economic development have in sustainable development and why is sustainable food consumption is so important? Local economic development practically is the process where the local economic capacity is expanding to raise the life quality of the local people and its economic future (Gwen et al., 2006). The research community is quite divided concerning the dilemma if short food supply chains (SFSCs) and Local Economic Development (LED) would provide the most sustainable tools concerning food system. Here we argue that solutions are always region and food type-specific and that we cannot generalise but must examine the different situations with field research and talking to the stakeholders is inevitable. A forceful local economy requires good practices and collaboration to adapt and improve their circumstances (Gwen et al., 2006). Even though local is not always better, the more widespread use of the classical tools provided by LED would bring us closer to a more appropriate and healthier food system according to our experience in the Balaton Upland. We assumed that the concepts in connection with "local" are already in connection with sustainable food consumption in the minds of the consumers and that values evoked about sustainable food consumption can be supported by the tools of local economic development. The key to LED success is the local community and people, and the better we understand the consumers and farmers the more successful the incentivisation process can be. The most known tool of LED is local food production and its sales and promotion. The first and most important role of this area is serving the local people's need and supply, therefore understanding them better is inevitable. The local food development requires a strong focus on organizing fluent and effective local supply chain (Czene et al., 2010).Besides understanding what the sustainable food consumption means for consumers, we also wanted to examine what the local producers think about sustainable food consumption (and production of course) and to gain insight into their environment and current situation. As we live through now the vast changes the global epidemic COVID-19 brought to our everyday lives, we extended our research and asked the farmers how do they cope with the situation and by understanding the current special environment and changes, we could better handle the upcoming crises and new challenges due to emerging risks in the future, as small and medium-size organisations can be quite vulnerable in these situations, while being key stakeholders in sustainable food systems. Also, we aim to investigate the role of health in food systems and general food sustainability.

Food system sustainability, status quo and future prospects

The economic force of the food industry is unquestionable, and unfortunately, economic progress has been accompanied by environmental degradation, endangering the very systems on which our future development and our very survival depend on (ECOSOC, 2019). Food consumption is growing in general and expected to reach 3540 Kcal/person in 2050 (Alexandratos and Bruinsma, 2012) accompanied by rapid population growth, therefore we see that we have to produce more food in the future, keeping in mind that food scarcity and malnutrition is present in many regions at the moment (a worldwide estimated 821 million people – approximately 1 in 9 people–were undernourished in 2017, rising from the already distressing 784 million in 2015 (ECOSOC, 2019). In a world where avoidable food waste coexists with hunger, it also becomes a question of social justice since we could increase the food access for the undernourished (Britz et al., 2019). Our consumption patterns – besides containing too much of processed foods, foods high in sugar and fat – shifted towards a diet high in animal-based products and low in plants, but the former is generally less calorie-efficient, more resource-intensive and emit more greenhouse gases (West et al., 2014), and animal rights are often violated when we try to increase production.

Food waste in the developed areas has taken on such major proportions that mitigating its negative effects is a top priority in the Europan Commission's policy and strategy, no wonder, since the associated costs of food waste in the EU is estimated at 143 billion Euros (Stenmarck et al., 2016). Overexploitation of resources is unavoidable to feed the growing population with the current not-as-sustainable technology, considering that the food sector accounts for around 30 % of the world's total energy consumption and accounts for around 22 % of total Greenhouse Gas emissions (Suh et al., 2006; ECOSOC, 2019). According to Herbert Stein, "If something cannot go on forever, it will stop". We see that the food system already face issues and with the rising demand the social injustice, economic loss and degradation of the environment will grow, and strengthening food system sustainability is key. When we do so, all the three pillars of the sustainability equation should be taken into account, as they are fundamentally interrelated (Bell and Morse, 2012), and it can be argued that solutions that ignore one or more of these dimensions fail in terms of being sustainable. In the developed areas – keeping in mind all these

pillars – the end-users should be involved and understood better, as they have the power to shape the future trends, as well as their unsustainable consumption behaviour, is one of the root causes of the unsustainability of the system.

Local economic development and SFSCs

Considering the classical tools of LED, the local product and local production might contribute to the employment, quality of life, cultural richness, trust and social capital (therefore have the potential to strengthen the often neglected social pillar of sustainability).The most important elements of LED are the improvement and empowerment of the local community and the role of social capital, which are significant in the social and economic life of the settlements. Different forms of interpersonal and institutional trust and norms of cooperation are transformed into social networks (Füzér, 2016).With the help of these networks a given field can become sustainable and successful. From this approach, the main pillar of the local economy could be a strong community. Putman argues there is a correlation between social capital and economic development, from the theoretical point of view (Putnam, 1993). In our previous field researches, we have already found this kind of correlation between the settlements and among their citizens: where lots of NGO's and strong community with lots of activities were found, we could explore more initiations with strong stakeholders and engaged inhabitants related to the local value creation and protection.

For some, local means small, personal, human. When food is produced by big food companies outside of our towns, it is easy to struggle to reconcile the sense of personal ethics with our perceptions of the institutions that manufacture our food. As a result, we tend to measure our feelings by the distance between the producers and our plates. Local is not deterministically more sustainable. Global distribution can indeed be more cost-effective than forcing growth in unnatural environments. Staying on the ground of reality, usually, we do not have the problem that there is too much local food consumed that could have been produced in a more sustainable way; but that we have no connection with food any more, children have many misbelieves about food, and the average food miles are getting higher and higher.We should realise the many positive aspects what the local food production bring to the regions, to people's lives and that it can contribute to social and environmental sustainability in a way that big-scale production could hardly do so. Local food also means jobs nearby, nutrition from homeland, cultural identity, and environmental integrity. As "low perceived availability of sustainable products explains why for some consumers intentions to buy remain low, although their attitudes might be positive" (Vermeir and Verbeke, 2006); the perceived availability of these products could be strengthened on these local markets due to the "transparent" and "short food supply chain" nature of these contact points.

Direct-to-consumer sales require a lot of effort by the farmer if they try alone. Equipment, time, besides the risk that is necessary to their core activity: producing the food. If the producer carries the food to the local market, trucks are often partially filled; consuming energy for a high cost per calorie, therefore innovation supporting the unification, cooperation of local farmers should strengthen in the future – like the well-functioning system of Leader organisations.

Short food supply chains and sustainability

What is more important, the distance between the producer and our plate or the number of intermediate actors? In the concept of SFSC, "short" might both refer to social and physical distance. Besides the unequivocal meaning of physical: when we talk about the social distance, short distance refers to the possibility for interaction and direct information exchange between the consumer and producer, as there are a very few or no intermediates involved. This information exchange can assure the consumer about not just the origin, but production methods, values of the farmer, ethics and identity; and trust can be easily built between the partners. 'Rewired' food system should reconnect producers and consumers to the biosphere while also enhancing the transparency between them (Gordon et al., 2017). Also, according to Galli and Brunori, short food supply chains can act as drivers of changes, and also as a method to increase sustainability (in all dimensions), trust, equality and growth (Galli and Brunori, 2013).This study does not aim to examine holistically the challenging topic of food system sustainability but nevertheless would like to start the train of thought drawing attention to its importance and actuality. The better we see the values, drives and understandings of the food chain participants we get closer to the ideal tools and means to develop and innovate resilient and sustainable food systems, especially considering emerging risks and unpredictable

future situations, like the issues COVID-19 brought to our lives in 2020. For this reason, a couple of thoughts should be given to the food system sustainability and related issues.

The COVID-19 epidemic

The first confirmed patient was registered for COVID-19 in Hungary on 4th March 2020. Beforehand the government established the task force on 31st January, to control the situation and for public bodies harmonisation (Hungarian Bulletin, 2020). The government decided to start distant learning on Universities relatively fast, 1 week after the first registered patient appeared. A couple days later, on the 16th March primary and secondary schools also have been switched to remote education and all the events over 500 participants – outdoor – and 100 participants – indoor – is cancelled (Coronavirus official, 2020a, 2020b; Index, 2020). Next to distant learning the government also reset the border control and all the incoming travellers must have been stayed in 14 days voluntary quarantine to avoid further infection (Coronavirus official, 2020c).On 19th March a government decree recorded that those economic areas that are most concerned by the epidemic exempt from wages tax duties until the end of June (Pwc, 2020).

How can producers adapt to the changes due to the epidemic?

Even though the government has not announced statutory rule specifically for farmers, the National Public Health Centre stated some suggestions to provide pieces of evidence for them. The farmers are advised to separate products from the money of exchange, the staff must be healthy, they should separate themselves from each other at least 1.5-2 meters far and of course, must provide the same for consumers. Frequent washing and sterilization of hands and regular airing in closed areas are also strongly recommended (Agrárszektor, 2019). Parallel with the centralised suggestions the producers started to adapt the situation therefore unique solutions instantly appeared e.g. Dunakeszi local market where the customers pre-ordering their shopping list then they appear on the market at a given appointment and they can take their ordered product directly to their car (Sokszínűvidék, 2020). Most of the farmers introduced new activities to their operation such as increased sanitation or distance takeover (54%). However smart ideas can delay the decrease in traffic, the producers can experience up to 50% fewer visitors on local markets and in shops (Magyarmezogazdaság, 2020).

2. Methods

The attention of this study is directed, on one hand, towards a special approach: social representation theory (Moscovici, 1961) targeting the initial question: what sustainable consumption means for end-users? On the other hand, we turn towards the farmers, and with field research, we examine how local farmers contribute to sustainable food production and what is the role of SFSCs in sustainable food systems. The free association games started in September 2019 and the database has been closed on the 04.12.2019 with 255 respondents, meaning 1275 associations, mostly including consumers from the central part of Hungary. We also examined the farmers in the Balaton Upland region of Hungary, where several field trips supported the research, the first in Balatonalmádi farmers market, on the 20-21th of September 2019, the second in the 6th Bakony Expo on the 8-11th of November 2019, and further examination in April 2020, when we also asked the involved 22 farmers about the changes COVID-19 brought to their lives.

Free association game

An altered version of the associative network technique (de Rosa, 2002) has been used; a free association game. In general, this game is an association exercise, and various ways of this game exist. The players say the first things they think about when experiencing something, like in our case: when they hear the stimulus word (evoking 5 expressions, also indicating if they are positive, negative, neutral (polarity) and putting them in order based on importance. According to Joffe and Elsey, if we directly ask a question about attitudes and behaviours, answers are unlikely to reflect how people see the issue in its full reality and complexity, but the free association technique can offer a window into implicit content (Joffe and Elsey, 2014). This technique has been already utilized in many practical areas, such as exploring the social representation of sustainability (Techio, Conclaves and Costa, 2016). After the data was cleaned and synonyms were collected, the grouping has been

conducted based on the meaning of words, and they were divided into 26 groups keeping in mind nit to have overlapped. Furthermore, they were examined and grouped based on what which pillar of sustainability they supported. Basic indicators were calculated, following the recommendations of the previous studies (de Rosa, 2002; Orosz, 2008), amongst others: rank, frequency, the order of evocation, the order of importance, index of polarity and index of neutrality.

Field trip and online questionnaire

In the field trips in Bakony expo and Balatonalmádi, we observed the behaviour of the local farmers regarding sustainability, and asked them about what they think of their consumers' point of view regarding the sustainability of food consumption and production. Due to the epidemic, we must have been had to redesign the method of data collection for the further investigations, therefore we decided to ask local farmers and producers via online questionnaire in April 2020 through Éltető Balaton Upland Association, which is a trusted channel between local farmers and, producers and our research team. In the questionnaire, we prepared closed questions about the farmers' current food production sustainability, and willingness to raise their sustainability regarding food production or how their customers are thinking about the importance of sustainable food production. Multiple-choice questions were asked about their current sustainable activities and those potential activities they think they can increase their sustainable production. Local farmers mostly work independently from each other; therefore we prepared more open questions to collect individual answers which can bring a higher quality of response beside the fact that it was collected through an online channel. We asked them about the reason if and why they want or do not want to improve their sustainable activity and about those values they are present in their communication toward their consumers.

Software utilised

The results of the free association game were collected with Microsoft Excel Spreadsheet program, and basic index calculations and cross tables were created there. IBM SPSS Statistics software was also used for further calculations. The results about the field trips were qualitative observation notes and interview documents, used with Microsoft Word. For the online questionnaires, Google Form was used.

3. Results and Discussion

Indicators

Rank, OE and OI

Frequency (f) counts mentions of a given word. From the collected 1275 associations the most typically evoked concepts in connection with the expression 'sustainable food consumption' are 'bio' (87) and 'health (76). The order of evocation (OE) can be used as an indicator of prototypic accessibility. Associative speed not only indicates the strength of an associative link and thereby its salience, but also of its accessibility in terms of a greater prototypical agreement (i.e. the most commonly associated word is not necessarily the most important one for a subject, but can be simply the most socially shared one (de Rosa, 2002). To look back at the associations and classify each word by order of importance (OI) is a double level evaluative task for the player, implying a cognitive process of a more rational nature, compared to the higher projective nature and higher speed which characterise the order of elicitation (de Rosa, 2002).Even though 'bio' was mentioned 87 times, only 5 times (5.75%) was it chosen as the most important. However, the expression 'health' was chosen 36 times as the most important expression (47.36%), therefore we see that 'bio' can be the most often evocated expression, it's importance is slight. Other words often chosen as most important were: 'environmental protection' (11), 'responsible' (9) and 'conscious' (9). Considering the evocation order, 'bio' was mentioned first 23 times (32.53%), and 'health' was mentioned 17 times as first (22.37%).

Table 1: *Most frequently mentioned words, percentage, polarity, importance and rank, self-edited*

num.	Expression	Frequency	Percentage of all	Percentage of more mentioned	Polarity	Importance	Rank
1	bio	87	6,82%	7,12%	0,69	3,70	2,94
2	health	76	5,96%	6,22%	0,92	1,97	2,88
3	food waste	28	2,20%	2,29%	-0,93	2,79	2,25
4	vegetables	27	2,12%	2,21%	0,59	3,15	3,15
5	conscious	24	1,88%	1,96%	0,92	2,46	3,21
6	local product /	22	1,73%	1,80%	0,73	3,23	2,45
7	GMO	19	1,49%	1,55%	-0,35	3,88	3,59
8	affordable	19	1,49%	1,55%	0,84	3,21	2,74
9	quality	18	1,41%	1,47%	1,00	2,33	3,17
10	no food waste	18	1,41%	1,47%	0,94	2,06	2,72
11	vegetarian	18	1,41%	1,47%	-0,17	3,78	2,78
12	hunger	17	1,33%	1,39%	-0,88	2,35	3,24
13	vegan	15	1,18%	1,23%	0,21	3,57	2,00
14	no packaging	14	1,10%	1,15%	0,86	3,21	3,29
15	domestic	14	1,10%	1,15%	0,79	2,86	3,57
16	environmental protection	14	1,10%	1,15%	0,93	2,33	3,17
17	environmentally	13	1,02%	1,06%	0,85	2,46	1,85
18	green	13	1,02%	1,06%	0,54	3,15	2,85
19	home made	12	0,94%	0,98%	0,92	2,50	2,75
20	meat	11	0,86%	0,90%	-0,55	3,27	2,36
21	water	11	0,86%	0,90%	0,36	1,91	3,36
22	fruit	10	0,78%	0,82%	1,00	2,40	3,20
23	agriculture	10	0,78%	0,82%	0,70	3,60	2,80
24	plastic	10	0,78%	0,82%	-0,40	3,30	3,00
25	plant	10	0,78%	0,82%	0,90	3,10	2,80
26	market	10	0,78%	0,82%	0,90	3,20	3,00

Index of polarity and neutrality (de Rosa, 2002)

Subjects were asked to attribute a polarity to each word, using positive, negative or neutral values receptively. In order to calculate the polarity on the basis of the total number of words associated with each subject, two specific indexes have been utilized: Index of polarity (P): a synthetic measurement of evaluation and attitude implicit in the representational field.

Equation 1: Index of polarity (P), self-edited based on (de Rosa, 2002)

$$(P) = [\,(N° \text{ of } `+' \text{ words}) - (N° \text{ of } `-' \text{ words})\,] \,/\, N° \text{ of total words associated}$$

(P) ranges between (-1 ;1).

If (P) is between -1 and -0.5 most words are connotated negatively. If (P) is between -0.4 and +0.4 positive and negative words tend to be equal. If (P) is between +0.4 and +1, most words are connotated positively. The polarity index of sustainable food consumption is 0.427 only slightly positive, what must be due to the fact that people often think of the unsustainable food consumption, for example mentioning hunger, animal suffering, pollution and careless consumerism.

Index of neutrality (N): neutrality works as a control measurement, assuming that high positive polarity corresponds to lack of neutrality and vice versa.

Equation 2: Index of neutrality (N) self-edited based on (de Rosa, 2002)

$$(N) = [\,(N° \text{ of } `0' \text{ words}) - (N° \text{ of } `+' \text{ words} + N° \text{ of } `-' \text{ words})\,] \,/\, N° \text{ of total words associated}$$

(N) ranges between (-1 ;1).

If (N) is between -1 and -0.5 few words are connotated neutrally. If (N) is between -0.4 and +0.4 neutral words tend to equal to the sum of positive and negative words. If (N) is between +0.4 and +1 most words are connotated neutrally, and there is a high neutrality.As the neutrality index is very low, -0.704, we see that only a few words are connotated neutrally, and people have strong opinion on the issue of sustainable food consumption as this concept evoke expressions with emotional component.

SPSS Calculations

OE,OI and Polarity

It was examined whether there is really a difference between the evocation order (OE) and order of importance (OI), as literature suggested. For this purpose a non-parametric rank correlations was used: Spearman's (rho) rank correlation to measure the strength of the relationship between these two variables considering our data.

Table 2: *Spearman's rho for OE OI and polarity (SPSS), self-edited*

Correlations

			OE	OI	polarity
Spearman's rho	OE	Correlation Coefficient	1,000	,178**	-,080**
		Sig. (2-tailed)	.	,000	,004
		N	1275	1275	1275
	OI	Correlation Coefficient	**,178****	1,000	**-,256****
		Sig. (2-tailed)	,000	.	,000
		N	1275	1275	1275
	polarity	Correlation Coefficient	**-,080****	-,256**	1,000
		Sig. (2-tailed)	,004	,000	.
		N	1275	1275	1275

**. Correlation is significant at the 0.01 level (2-tailed).

The model is significant (r <0.05) and the correlation co-efficient is 0.178, meaning that there is only a weak connection between evocation order and importance order, therefore the assumption according to which there is a difference between OI and OE is true.

It was also assumed that the expressions holding some emotional charge will have connection with OI or OE. For this purpose the application of Spearman's (rho) rank correlation had to be considered as only variables that are either ordinal, interval or ratio can be applied. Polarity can take the values: -1, 0 and 1, therefore Spearman can be applied (values have been transposed). There is a minor connection between polarity and OI (-0.256), therefore presumably expressions having some emotional charge have connection with the OI, but OE was quite independent from polarity (-0.080).

Age and Polarity

It was assumed that there is a connection between the age and the polarity (if positive, neutral or negative associations the individuals evoke when hearing the stimulus). For this purpose a Pearson correlation was applied as both variables were metric and also the technique allows us to examine both relationship and strength.

Table 3*: Pearson correlation for age and polarity (SPSS), self-edited*

Correlations

		age	Polarity
age	Pearson Correlation	1	**-,096****
	Sig. (2-tailed)		,001
	N	1275	1275
polarity	Pearson Correlation	-,096**	1
	Sig. (2-tailed)	,001	
	N	1275	1275

**. Correlation is significant at the 0.01 level (2-tailed).

As r<0.05, the correlation is significant. The Pearson's correlation coefficient between age and polarity is -0.096, the two variables are close to be independent from each other, the correlation is negligible.

Gender and sustainability pillar

Is there a connection between the gender and what sustainability pillar the evoked words belong to? With the Chi-square test these two variables were compared in a contingency table to see if they are related.

***Table 4**: Pearson Chi-Square for gender and sustainability pillar (SPSS), self-edited*

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	11,486[a]	5	,043
Likelihood Ratio	11,112	5	,049
Linear-by-Linear Association	,384	1	,536
N of Valid Cases	1220		

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 16,51.

As p=0,043 our results are statistically significant, gender is not independent from sustainability pillar (which evoked word belong to).

***Table 5:** Cramer's V for gender and sustainability measures*

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	,097	,043
	Cramer's V	**,097**	**,043**
N of Valid Cases		1220	

Phi and Cramer's V are both tests of the strength of association. We can see that the strength of association between the variables is weak, but gender has an effect on what sustainability pillar the evoked words belong to.

Field trip and questionnaire

Besides the data collected in 2019 in Balatonalmádi and Bakonyexpo, we have collected 22 answers from farmers who operate or take part in Balaton Upland's local food supply chain. All of them stated that they are producing food in a sustainable way. To clarify this we collected what kind of sustainable activities they do and we can say that the most common answers are that they are producing their product without preservatives and additives (81.8%), producing healthy food (81.8%), by using natural raw materials (77.3%) and employ local residents (68.2%). Behind the most common activities, we can conclude that more than the half of the respondents said that they are selling their products locally which cause lower transportation cost (63.6%), using biodegradable or no chemicals (63.6%), using local services and products as raw material (63.6%), actively take part in community's life by organizing and supporting local events (59.1%) and reuse by-products (59.1%). All together the respondents have chosen more, than 8 option on average out of the 12 in the multiple-choice question. After all, we asked them to think about if they can do further about being even more sustainable and still 77.2% of the total respondents thought that yes, they could do better in sustainable food production. The most commonly mentioned reasons are environment protection, renewable energy usage (solar panels, bio energy, recycled packaging etc.) but thinking of the future and the next generations' wellbeing also appeared among the answers. Those who still think they can do even more about sustainable food production answered that better recycling and environmentally friendly package (45.5%), lower energy usage or renewable energy usage in processing (45.5%) and decreased transportation cost (31.8%) would be a good next step.

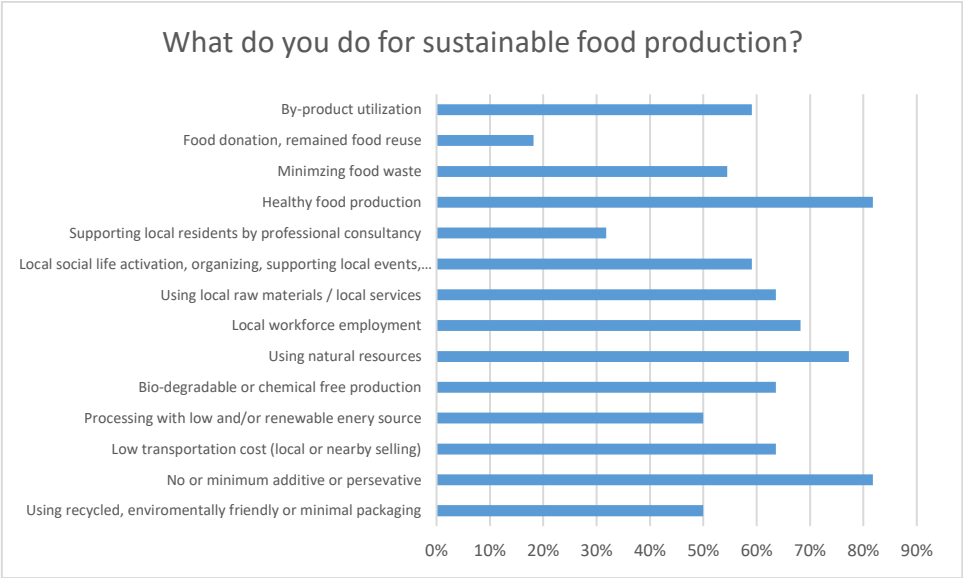

***Figure 1**: Local farmers answers for current sustainable activities*

Next to sustainability activities we also wanted to examine the farmers' communication about their values toward customers. Among the most commonly mentioned values 'bio/eco/natural/health' expressions appeared altogether 12 times, 'chemical-free' expression appeared9 times, 'local/rural/own/' and its synonyms appeared also 9 times, the expression of 'sustainability' and 'quality' appeared just 1-1 times among the answers. Next to their communication, we asked them to share their experience if the customers feel important to be sustainable as a local producer and 68.2% said yes, it is important. The most common sign is that the customers sharing their opinion with the producer, asking for reusable package or denying plastic bag, they are coming back to shop again and asking information about sustainable technologies and the production process itself. Therefore, we can conclude that those farmers and local producers who are focusing on their sustainable food production and energy usage can generate profit by satisfied customers.

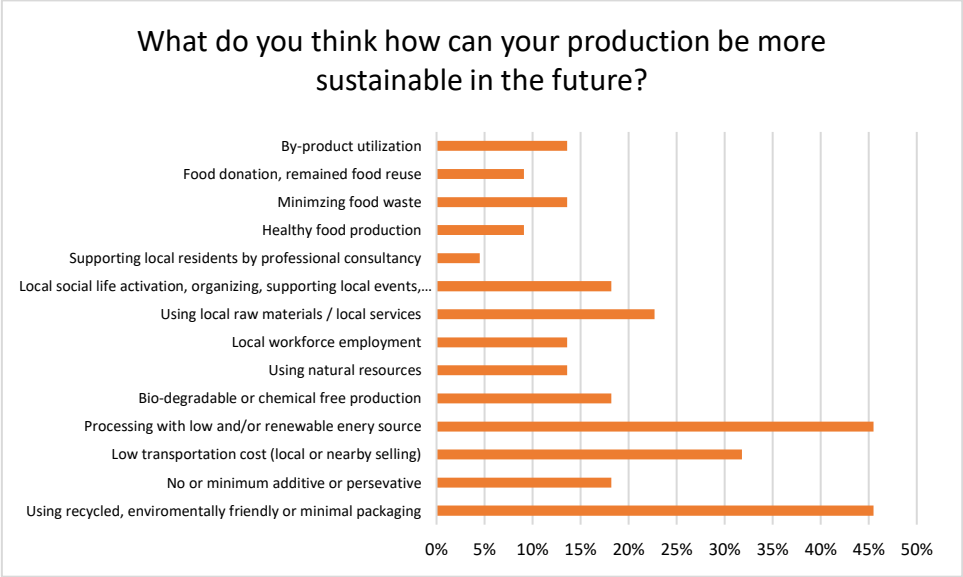

***Figure 2**: Local farmers answers for possible sustainable activities for the future*

Governmental limitation caused difficulties due to COVID-19

As we examined in Balaton Upland producers (N=22) the main issues during the epidemic are the followings: uncertainty (82%), masks and disinfectants procurement is difficult (36%), scope of activities has changed (22%), personal work is

stalling due to curfew (22%). Furthermore, 59% of the asked producers face huge difficulties with sales mainly due to decreased or stopped demand which directly leads toward minimum or zero income. Regarding the local markets those farmers who have been regularly visiting markets facing decreased number of customers and mentioned that they are not visiting anymore the marketplaces until the end of curfew.

4. Conclusions and lessons learnt

Sustainability in practice at local farmers

Taking into account the social representation of sustainable food consumption, the evoked words were either with negative or positive polarity, and neutral expressions were rarely evoked by the participant consumers, therefore we see that this is a high topic and people bond with it together expressions with emotional charge behind. We can also state that the local farmers in the Balaton Upland have high focus on sustainable production and operation altogether, both based on our observation in the field trips as well as on the answers of the online questionnaire. We see that the observed sample have reported 8.2 out of the 14 listed activities listed on average. This high number means that they are focusing on more areas side by side; it seems to be not just a side-effect but a significant part of their operation. Sustainability contains different understanding among the respondents therefore further details are shared under the following chapters.

Food product packaging is still in the spotlight

Asking the producers about their sustainability measures, quite often the first arising topic is in connection with the packaging – what also appeared in the representations (‘no packaging ‘(14), ‘plastic’ (10)). As we mentioned previously, producers have a common feedback from customers that reusable packaging and denying plastic bag is a common and expected practice. We can also conclude that most of the examined producers are highly aware about sustainable food production still not mentioned packaging among the most common activities. However, they think it is an important part of the sustainable operation since almost half of them stated that they should improve their sustainable production by better recycling and environmentally friendly package.

Characteristics affecting representation

It was assumed, that demographic characteristics will be in connection with the representations. We examined whether age and polarity will have some connection, but as the Pearson’s correlation coefficient between age and polarity is -0.096, we can conclude that age does not really matter in what kind of “charge” the associated words have when we consider sustainable food consumption, or at least not with N=1275. Furthermore, other demographic data were neither significantly linked to the representations. Characteristics that were not asked could be responsible for the representation differences, or extending the sample size would bring the causative factors to the surface. For better coverage of the social representation of the sustainable food consumption, it would be favourable to continue the research and reach better representativeness. Also, it is advisable for usable results to attain saturation , as it occurs when adding new data to the existing ones does not result in new information or perspectives.

Cultural – social sustainability better enforced locally

Considering the classical tools of LED, the local product and local production might contribute to the employment, quality of life, cultural richness, trust and social capital. More than the half of the farmers said that they actively take part in community’s life by organizing and supporting local events, which means that they have an important role in social life and local resident’s employment high rate confirming the strong community spirit. We can also state that professional consultancy is not a commonly practiced activity, so they are focusing more on community building than technical

knowledge sharing. According to Smith, alternative agri-food movements and other creative alternatives to mainstream agriculture, like organic (bio) food, Fair Trade, and the local food have been educating the public about sustainable food systems (Smith, 2013), increasing public awareness about the environmental and social impacts of the food systems and motivating social change (Feenstra, 2002). This is also confirmed by our research, as mentioning these movements frequently popped up in the minds of the consumers considering sustainable food consumption, having the possibility to alter the relationship between food consumers, and food producers. These movements offer practical, easy-to-understand and tangible solutions by establishing alternative food systems that reduce food miles, increase farmer cooperation and promote ecological farming practices (Lyson, 2004).

Environmental sustainability is still in the forefront

Several studies (Matos et al., 2012; Ramos and Kawamura, 2009) came to the conclusion that the socially shared knowledge is especially associated with the environmental dimension of sustainability; though some studies already suggest a transformation in the representation of sustainability concerning issues in association with awareness, responsibility, balance, and concern for the future (Techio, Conclaves and Costa, 2016). According to the findings of this study, the environmental pillar of sustainability is highly represented considering sustainable food consumption, as we have seen the dominance of the environmental pillar, but also considering the often mentioned words, we presume that this dominance is valid: ‘environmental protection’(14), ‘environmentally conscious’(13), ‘green’ (13), ‘no packaging’ (14), ‘plastic’ (10). According to the research conducted amongst the farmers, the most practised sustainable activities are producing their product without preservatives and additives, producing healthy food and natural raw materials, and employ residents. We can say that beyond the existing environmentally-friendly actions they also need to improve environmentally friendly or minimal packaging system and alternative energy sources or less energy usage of production is still need to be developed, which can be counted as expensive developments.

Food waste was a really important term in the representations, if we consider ‘food waste’ (28) and no food waste (18) as one, it would be the third most frequently evoked expression about sustainable food consumption, therefore the producers should strive for not just achieving prevention of waste and reuse, but also communicate it. Leftover food donation and reuse appeared just at 18,2% of the response of the farmers, and we also can see that the willingness to focus on this part is also relatively low, so it is not in the focus of local producers if we are thinking about sustainable development. Either we are thinking about food waste or a conscious food supply system.

Bio (organic), preservatives and additives

The producer's communication about sustainable values toward customers is focusing the most on ‘bio/eco/natural/health’, ‘chemical-free’, ‘local/rural/own/’ and its synonyms. The highest rate on sustainable food production already existed activities is producing their product without preservatives and additives and producing healthy food and using natural raw materials which means that the sustainable food consumption mainly means these activities for local producers. We can conclude that customers and producers have common importance and understanding of association in this field. In the representations we see a negative judgement of additives and preservatives (‘chemical’ (9) was every time judged to be negative, and ‘chemical-free’ (9) was a positive thing (P=0.78) as well as ‘additive-free’ (6) (P=1) according to the respondents); while natural, free and bio (87) represent positivity for them.

The importance of Health

We argue that health is the keyword for sustainable food consumption. Attention should be directed towards the order of importance, since ‘bio’ (87) was only 5 times (5.75%) chosen as the most important, while the expression ‘health’ (76) was chosen 36 times as the most important expression (47.36%) (Average OI=1.97), therefore we see that ‘bio’ can be more often evocated expression, its compared importance is slight. Experiencing the current changes, the COVID-19 virus brought

to our lives, many realise the importance of health – not just in the food system – but in life generally. The sustainable food system cannot exist without health – besides the health of humans: animal, soil and plant health are crucial. Looking from the epidemiology point of view, several modern diseases are zoonotic ones, such as Ebola, and according to the Centers for Disease Control and Prevention more than 6 out of every 10 known infectious diseases in people can be spread from animals, and 3 out of every 4 new or emerging infectious diseases in people come from animals (CDC, 2020). These diseases can occur due to many issues, including the unhealthy animal husbandry, not appropriate circumstances and unnatural practices (feeding pigs with pork for example). We can conclude that farmers take way more effort for sustainable development and health then they still want to improve if we look the number of existing activities (181) comparing to the wished number of activities (62). They have a high focus on additive-free or minimization and healthy food production, even though the highest need is for package minimization or a more environmentally friendly solution with renewable energy resource or energy minimization.

The food system is like a cobweb, and the health of one actor influences everyone and everything at the end. Health has an immense impact on the economy as well besides the social and environmental pillars of sustainability. In the upcoming years, it would be worth to examine if emerging risks strengthen the importance of health or not, and how they will affect the consumer behaviour regarding consciousness, altruism and efforts for sustainable behaviour.

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Where to stay while travelling?

Sustainable and ecofriendly accommodation

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Abstract

The United Nation created the World Tourism Organization, which implemented all the Sustainable Development Goals into the tourism industry and have not only goals to achieve but actively supports organizations and enterprises in practice. By focusing on Europe, there are many different ecolabels for example, which can give a certificate to hotels and tourism accommodation. I compared the European, the Scandinavian and the Austrian Ecolabel and as my result I can say that the main goals are the same: less water, electricity consumption and produced waste, but there are differences in details regarding some fields like training employees for example.

In my work besides international guidelines, I present specific hotel(chain) examples of the EU, Austrian and Scandinavian eco-labelled hotels, supplemented by some hotels' own perceptions and experiences, which data is available on their websites and I also have some information as a result of questionnaire responses. My most important researched chain is Scandic Hotels, which exemplarily monitors and develops its hotel members for sustainability and economic growth at the same time.

While analysing the Hungarian situation, I visited dr. Vilma Éri, Lead Certification Director of the Eco-labelled Product and European Eco-label, who shared with me the draft certification for Hungarian restaurants. In addition to this analysis, I also studied the Green Hotel Certification established by the Association of Hungarian Hotels and Restaurants, examining the composition of successful applicants. In addition to the eco-labels and official international initiatives, I also found it interesting to introduce Ecobnbs activities, which is an alternative, eco-friendly accommodation-advertising start-up company. The Italian-based accommodation search website is a platform, where you can choose from eco-labelled accommodation only, the conscious tourist can select the environmental requirements of the accommodation.

The motivation from the customers side is not as high as it could be in the future, my questionnaire results showed that young people would mostly choose eco-labelled accommodation if the renting price is not higher than in case of non-eco-labelled accommodation.

Keywords: tourism, accommodation, ecolabel, hotel, certification

1. Introduction

Where to stay while travelling? Can we make a conscious decision when choosing accommodation? In my research, I try to give answers to these questions, because putting environmental protection and sustainability into practice is one of the most important tasks of the 21st century. This also concerns every tourist, people working in tourism, government and NGO. In my age group most people have already been to many foreign countries, and by the time we got to college many of us has picked up travelling around the world as a hobby. However, the question arises what impact this drastic increase in tourist numbers will have on individual populations, wildlife and their natural habitat. Tourism can make a society richer by ensuring more workplace and orders to local farmers, but can also be harmful, if tourists and investors have no respect for locals. Environmentally responsible consumption and behavior is the responsibility of all tourists and lodgers. For the time being, most people hardly ever hear about various eco-friendly activities and initiatives, not to mention eco-labelled products and services. Thus, many people may find it remote, inaccessible, or too expensive to use - e.g. relaxing in environmentally friendly hotels and I try to counter this misconception.

Although the energy, water and gas consumption and waste production of each facility may seem small compared to the consumption of housing estates, office blocks, they can still play a significant role in polluting or protecting their environment. They also have a role to play in informing and forming their customer base.

All in all, the existing examples show, that the way of travelling could change in the coming years based on the number of eco-friendly and sustainable accommodation. Nowadays, the issue of climate change has a great impact of public opinion, which means that more and more people will care about consciousness and choose sustainable accommodation.

2. Methods

At the beginning of my study I my aim was to have an overview of the organizational and legal background of sustainable, ecofriendly tourism. By this I followed the big to small method, so I firstly visited the United Nations' website and the related documents, after that I read through the main goals and regulations of the tourism specific World Tourism Organization. In my study beside international rules and goals I focused on the practical side of this topic, so I choose ecolabels well known in Europe, which have criteria for tourism accommodation and some of their best practices. In my research, I also focused on the Hungarian case, so I personally interviewed dr. Vilma Éri, who developed the Hungarian Ecofriendly Product Certification to ensure the opportunity for restaurants as well.

I brought some examples for the different ecolabels, with the help of the accommodation's websites mainly. The biggest good example I introduce in my research is the chain called Scandic Hotels, who monitors the hotels sustainable development on the organizational level and introduces the results to the public in the form of reports on a yearly basis. I created a short survey to the member hotels of Scandic and I present one of the answers. An interesting startup best practice was Ecobnb, I will shortly introduce this company as well, and compare to the well-known Airbnb company, which may inspire the name of its green version.

While analyzing the Hungarian tourism industry I made a research on the growth of the Hungarian Green Hotels, for which the base was the list of certificated hotels on the website of the Association of the Hungarian Hotels and Restaurants. Additionally, the motivation behind choosing a certificated accommodation is an interesting factor, so I made a short survey among young Hungarian people about their knowledge and habits in connection with travelling.

3. Results and Discussion

a. Sustainability and tourism

In the recent decades, more and more can be heard about the concept of sustainability and about sustainable development, consumption, and the problems and opportunities they raise. One of the earliest formulators of sustainability was the Brundtland Commission, which in its scientific work published in 1987 defined sustainable development as "development that can meet the needs of the present without compromising the ability of future generations to meet their own needs. (Persányi, 1988). So not only should we focus on solving the problems we currently face, avoiding the dangers that threaten us, and increasing our own well-being, we are also responsible for the well-being of the next generation. The Earth where we live has finite natural resources, the overuse of which can lead to the disappearance of certain resources (eg depletion of raw material resources, depletion of drinking water resources).

This definition is based on three dimensions: the social dimension is a kind of objective, it is in the interests of all people to maintain the current quality and standard of life and to ensure a better and better life, secondly the economic dimension approaches the problem from the asset side and emphasizes the role of production and services, and at last ecological dimension examines the environmental factor, which we must always keep in mind in our decisions, and conscious attention to this is the method that helps to reduce the environmental impact of human actions. These three factors should be considered as a unit, interacting with each other, one should not be interpreted separately from the other, as they are closely related and a decision made from the perspective of one dimension will have consequences for the other two as well. (Valkó, 2003) As natural resources are limited, great emphasis must be placed on educating generations for sustainable consumption.

Adherence to this applies to industry, companies, governments as well as to individuals, "sustainability is not just a matter of politics and governance; but also individuals, families, businesses, non-governmental organizations must pursue goals and values, make their daily decisions in a way and engage in initiatives that can ensure the achievement of a sustainable society ". (Hun. National Council for Sustainable Development, 2013)

There are basically two approaches / strategies to solve the problems of sustainable consumption:

1) the efficiency strategy approaches from the producer's point of view, according to which the resource efficiency of production must be increased, thereby reducing the extent of the use of environmental resources,

2) the substitution strategy, on the other hand, places the weight of the responsibility on the consumer, sees the solution in the change of the "consumer standard" and the consumer attitude. (Valkó, 2003)

If we have a look at the relationship between sustainability strategies and tourism hospitality the question arises as to which strategy hotels, restaurants and tourist centers should follow. The answer is that both. After all, the efficiency of production in this case means the efficiency of the individual services (preparation, stock of tangible assets, advertising, labor demand, execution, etc.). However, the efficiency of the operation of a building is very similar to that of private households, they are placed in similar decision situations, e.g. regarding the procurement of food, the issue of selective collection of waste, or the selection of energy-efficient burners. From this point of view, as consumers, they have to make a conscious decision, and an extra responsibility of these facilities to draw the attention of their guests to environmental awareness, they also try to shape their attitude following their own good example.

Much depends on the attitude of the management of the given accommodation and, of course, on the financial situation, but nowadays there are countless opportunities for businesses (eg using EMAS, ISO 14001: 2015, etc.) to improve their energy, waste or emission efficiency, possibly social impact. also increasing their level of responsibility. Accommodations that also receive an award for their environmentally conscious activities may appear in a favorable light for tourists and investors (e.g. Green Hotel certification, Green Festival, EU Ecolabel certification, etc.), in addition, they can gain a competitive advantage over similar categories of non-certified facilities.

The Sustainable Development Goals also contain some tourism related point, which can be a guide to entrepreneurs in the tourism industry. One of these the 8/9 goal, which supports the development and implementation of the policies in tourism by 2030 to create jobs and promote local culture and products. In addition to concrete examples, it is important that all hotels, restaurants and their suppliers and partners strive to achieve the general goals to the best of their ability and ability during the development of their organizational system and the operation of their organization. To ensure all needed support on issues related to tourism United Nations founded the World Tourism Organization's (UNWTO) in 1975, which has its bases in Madrid, Spain. Currently, 156 countries are members of the organization, in 6 regions (for example Hungary joined when the UNWTO was founded). In order to comply with the principles of the UNWTO, it is constantly negotiating with each country and the necessary steps are being discussed at various conferences and events. Celebrities are also in favor of promoting the organization, e.g. on April 9, 2018, it was announced that Lionel Messi football player has become an Ambassador for Responsible Tourism at UNWTO. (UNWTO, 2019)

An important ethical basis of the organization is the collection of principles entitled Global Ethical Guidelines in Tourism, the principles of which were set in 1999. The 10 principles of the GCET (Global Code Ethics for Tourism) were adopted, of which Principle 3 describes tourism as an important element of sustainable development, the sub-points of which are as follows:

• All stakeholders in tourism development must protect the natural environment in order to achieve solid, continuous and sustainable economic growth in order to adequately meet the needs and aspirations of current and future generations.

• National, regional and local authorities should give priority to and encourage all forms of tourism development that help to save scarce and valuable resources, especially water and energy, and to avoid waste generation as much as possible.

• Surprisingly large spatial and spatial tourism and visitor crowds, especially during paid holidays and school holidays, and a better distribution of breaks could reduce their impact on the environment and increase the benefits of tourism for those who live there.

• The organization of tourism infrastructure and tourism activities should be designed in such a way that measures take into account environmental considerations, protect biodiversity and endangered species; stakeholders and professionals need to work in the most critical areas.

• Close-to-nature tourism and ecotourism, in particular, help to restore and improve tourism, provided that the natural heritage and the local population are respected and in line with the carrying capacity of the sites.

Adherence to and consideration of the principles in making decisions in any sector of tourism is essential, but the UNWTO offers not only a theoretical basis but also practical solutions, a notable example of which I will present in the next section.

Hotels Energy Efficiency Program is one of the organization's outstanding projects - in cooperation with the UN and EU Tourism and Energy Organizations - provides practical assistance to hotels and accommodation establishments in reducing their energy emissions. Hotel Energy Solution (HES) mainly offers information and technology assistance to Small and Medium Enterprises (SMEs), but businesses can also take part in various trainings on the subject. All companies wishing to join can view their current CO2 emissions online using the e-toolkit (a website whose calculator allows you to find out about CO2 emissions), which provides advice based on the results of the company, helping to increase its energy efficiency and reduce its carbon footprint. and their use leads to cost reduction and economic profit growth. (HES, 2018) Based on the HES and the e-toolkit, the applications of the Hungarian Green Hotel Certification are also evaluated.

b. Eco-labelled accommodation

Nowadays, there are a large number of different eco-labels and eco-friendly certifications in the world, the aim of which is to bring a given company (manufacturer, supplier, hotel, etc.) or product or service closer to consumers and potential customers. Proof of their social responsibility not only makes the company sympathetic, but they also gain an advantage over their competitors by using the eco-label. The eco-labels of the world are united by the so-called GEN (Global Ecolabelling Network), on whose website you can find existing certifications by product category and country. Currently, 27 countries / rating systems are members of the organization, including Japan, Austria, EU, Brazil, Ukraine, etc. (Hungary is only present as a member of the EU, our national environmentally friendly product classification is not included in the list). (GEN, 2019) Below, I highlight and compare 3 eco-labels (European Union, Scandinavian and Austrian) (especially in terms of qualification criteria in the field of tourism).

The EU Ecolabel has existed since 1992, as the European Union's eco-label. Many member states used this as a basis for creating their own national eco-labels, which is why it is of paramount importance for our country as well. Certification takes into account the entire life cycle of a given product or service: from its manufacture to its withdrawal from the market. It promotes the products of the circular economy and low-waste production, and seeks to encourage companies to produce products that are as durable as possible. Not only can companies rate their existing products, but the expectations and standards set by the EU Ecolabel can also serve as a guide when developing new products. The product and service catalog can be viewed separately on the official website, which is a great help for conscious customers when looking for environmentally friendly products. The categories of EU Ecolabel that can be applied for today are: paper products, cleaning products, DIY products, furniture, garden, household appliances, other household appliances, lubricants, floor coverings, electronic appliances, textiles and clothing, tourism. (European Commission, 2019)

The Austrian eco-label was established in 1990 at the initiative of the Ministry of Agriculture, Forestry, Environment and Water, with eligible categories: office paper and printing, household and cleaning, construction and housing, garden and green space, energy, financial products, mobility, shoes and textiles. , film production, tourism. The tourism part came into force in 1996. With its outstanding precision and detail in today's international eco-labeling practice, it is one of the most relevant rating systems in Europe. Its website distinguishes two distinct categories: products and tourism. The other 9 subcategories of the latter include event organization (as a service), venue colors, catering and gastronomy, as well as different types of accommodation: hotels, campsites, shelters, private housing expenses. To be awarded the eco-label, the applicant must meet a number of requirements, which include the implementation of the EU Ecolabel tourism regulations and the points of the Austrian national rules. The criteria are not mandatory requirements for all forms of operation, this can be seen in the table next to the criteria. (Das Österreichische Umweltzeichen, 2018)

Created in 1989, the Nordic Swan eco-label helps companies in the Nordic countries: Denmark, Sweden, Finland, Norway and Iceland to improve their environmental efficiency and commit themselves to sustainable development. The objective of the Ecolabel Fund is to help the negative impact of production and consumption processes on the environment through its work and to make it easier for customers to find environmentally friendly products and services. Today, the eco-label covers 60 product and service groups and more than 200 product types. (Nordic Swan Ecolabel, 2019)

The short introduction of the three ecolabels shows that they were founded shortly after each other thirty years ago. The European covers all the criteria for European countries, that is why its points are more general. The Scandinavian and Austrian are more country specific of course, and these are good examples how countries should create their own criteria. The main points should be the same, which are the followings:

• General management: a hotel can only operate in a sustainable way, if the leaders of it are engaged, they have to create a base for an environmental management system, organize trainings for the staff. Informing guests about ecofriendly behavior is also important. The continuous consumption monitoring gives feedback of the efficiency of the implementations.

• Energy: the consumption reduction is key for all eco-friendly accommodation, they have to build energy-efficient room and use energy-efficient water heating appliances, air conditioning and air-based heat pumps. (There are some labels which ban the use of air conditioning.) The lightning should be also energy-efficient, this can ensured by bigger windows (more natural light) and by energy-efficient light bulbs. To this section the followings can also be rewarded: temperature control, automatically turning off HVAC and lighting, purchasing electricity from a renewable energy supplier.

• Water: the use of effective water block accessories: bathroom faucet and shower, toilets and urinals are key by water consumption reduction, but the less washing can be also achieved by reusing towels and bedding (“hang up your towel”)

• Waste and sewage: waste reduction can be achived by waste prevention: food service waste reduction plan, not using disposable products, recycling and selective collection and shipment of waste.

• Eco-friendly cleaning materials: using eco-labelled cleaning materials not just support the environment, but also ensure the save work of the employees doing the cleaning.

• Purchasing food and other goods from local farmers, producers.

These are the most important sections of being eco-friendly, but the difference between a sustainable and an ecofriendly accommodation is the leaderships behavior towards employees, guests (for example creating wheelchair access places). Other Ecofriendly implementations can be: smoking ban in common areas and rooms (in some countries there are governmental regulations for this), promoting non-car, environmentally friendly transportation types like the use of public transport, collecting and reuse of rainwater.

c. Best practices: Scandic Hotels, Austria Trend, Ecobnb

Founded in 1963, the **Scandic** hotel chain is today the largest hotel operator in the northern region, with 70% of its revenue coming from business trips and conference services and 30% from private travel. It has member hotels in 6 countries, about 55,000 rooms available to guests in nearly 280 hotels. Scandic has nearly 16,000 registered members / guests. In 1993, Scandic set sustainability goals and this year was at the forefront of the hotel sector worldwide. The innovative basic idea for this was the “hang your towel” principle, meaning that if the guest still wants to use their towel, they will hang it on a hanger, from which room service will know that it does not need to be replaced. Nowadays, this is a common custom worldwide and it was started by Scandic. Since 1996, all its member hotels have been required to document and report on energy, chemical and water consumption, waste, and all hotels have an environmental manager and all employees have the opportunity to participate in various environmental trainings. This measure systematically reduced the environmental impact of hotels, resulting in their first Scandinavian eco-label being awarded in 1999. At the end of 2016, nearly 180 hotels were awarded the Scandinavian or European Union eco-label for being an eco-friendly hotel. Environmental protection and social responsibility also play a major

role at Scandic, which seeks to involve all member hotels and guest members in related projects. In 2001, an initiative called "Scandic in society" was set up, in the framework of which the company helps those in need in a number of ways, e.g. bedding is provided for homeless people living in tents.

Based on the reports, it can be seen that between 2016 and 2017, there was an absolutely positive change in the company's results: their hotels appeared in another 10 cities, so in 2017 more than 280 establishments belonged to the hotel chain. This 26% increase led to a 31% increase in the number of hotel rooms, which also justified an increase in the number of employees, where an 11% increase was observed. In 2018, much more moderate growth can already be observed. The number of affected cities did not change, but the chain had more than three hotels, and the number of employees also increased by 13% compared to 2017. The total number of rooms available for rent exceeded 57,000, which shows that the existing hotels have also been expanded. Overall, it is a dynamically and large-scale developing company. However, this fact also places more responsibility on leadership and management, as ever-expanding capacity makes it more difficult to manage and control activities to achieve sustainable goals. 4 main sustainability goals they want to achieve by 2020:

• diversity and inclusion: all employees start with equal opportunities, care is taken not to discriminate against anyone's gender, age, etc. Due to this, it is used to measure the annual employee satisfaction measurement

• health: this hotel chain is chosen by travelers who lead a healthy lifestyle and potential workers who seek harmony between work and private life

• CO2 emissions: the aim is to become the lowest CO2 emitting hotel chain in the northern region, with the goal of awarding an eco-label (typically the North Swan or the European Union eco-label) to hotels within one year of joining the hotel chain. It was met at 90% in 2017

waste management: the objective of reducing the amount of waste and increasing the proportion of recycled waste

In addition to the targets set by the directive, specific limit values have been set for certain environmental impacts that Scandic hotels as a whole must meet by 2020. When summarizing the data for 2016, 2017 and 2017 for five areas I highlighted (eco-labeled chemicals, CO2 emissions / hotel nights, water consumption / hotel nights, recycled waste, hotels using renewable energy), comparing them with the 2020 goals, it can be said that for recycled waste, the 10% increase from 69% in 2016 to 79% in 2017 has already reached the desired target (76%) and even exceeded it. In addition, the amount of CO2 emitted per hotel night fell by more than one kilo between the first two years studied, which, at 1.55 kg in 2017, also far exceeded expectations and exceeded the target of only 2.3 kg. A very strict value was set for eco-labeled chemicals: 95%. Although this ratio increased to 82% from 2016 to 2017 after an increase of 4%, it has not yet proved sufficient to reach the target, but with this growth rate it is likely to be reached by 2020, despite the fact that by 2018. year showed a barely perceptible decline of 1%. The fourth aspect examined was the amount of water consumption per hotel night, which was determined in cubic meters. There was no significant change between 2016 and 2017, a value of around 0.18 cubic meters was set, which is only 0.02 cubic meters from the target and the same unchanged characteristic based on the data for 2018, which is 0.19 cubic meters further away from the target. , but the value did not deteriorate greatly. However, the stagnation of the problem shows neither a good nor a bad trend, so the management would be worth examining in depth, otherwise they will not achieve the set goal. The last aspect examined was the proportion of hotels with renewable energy, for which the 2020 target is 100%, so all hotels should use renewable energy sources to operate. The value of 86% in 2016 is a great performance in itself, but in 2017, almost meeting the target, it was 99.7%. (Scandic Hotels Annual Report 2016, 2017) (Scandic Hotels Annual Report 2017, 2018) (Scandic Hotels Annual Report 2018, 2019)

One of my survey respondent boasts more than one eco-label: the Swan, the European Union eco-label and the Green Globe. He has also won numerous other awards before and since the Ecolabel. In its first year of operation, it won its first eco-label (the exact year was probably not given to avoid identification), suggesting that the hotel was created with a vision of sustainable operation in the first place. Their motivation for applying was stated as follows: "We place great emphasis on our responsibility

in the environmental field. Third-party environmental awards drive the environmental initiatives of all hotels." So the eco-label is about a milestone in the life of hotels, a glory to themselves and proof to the outside world that they do consider it important to reduce their impact on the environment. Although they say their costs have increased in implementing the innovations needed to meet the requirements of the eco-label, I believe it will pay off in the longer term. The purchase of energy-saving equipment, the transition to renewable energy or the more precise management of waste can also greatly increase the short-term costs of a hotel, but their introduction later on will reduce energy consumption, use less water, etc. likely to pay off. When identifying the area of greatest concern, my respondent highlighted in an interesting way that they had to meet all the listed aspects (energy saving, water consumption, waste management, management, cleaning products) and therefore had to change everything. After that, my question on which area had to implement the least innovation was answered in the field of energy. As he mentioned earlier that he had already been awarded in the first year of his handover, I can only conclude from this answer that all aspects had to be considered at the same time in the design. This issue is relevant for hotels where, after years of establishment, it has been possible to obtain the eco-label by changing and modernizing existing conditions. The eco-label is used in their marketing program, e.g. on the official website, social media platforms and guest gatherings. Nevertheless, they feel they have become more popular than their competitors. The hotel has its own eco-labeled restaurant and intends to reapply for the eco-label after it expires.

Austria Trend hotel group is another great example. This hotel chain has 28 members in Austria, Slovenia and Slovakia. It differentiates hotels into three categories: premium, comfort and "smart" ratings, according to the services they provide, so you can choose according to the needs of each guest. Common features of all three categories: Austrian experience breakfast, possibility of personalized pillows, premium room offer for greater comfort. On the homepage of the Austria Trend website, the main news includes a call that begins with the slogan: "Sleeping at Austria Trand is environmentally friendly." This statement expresses the hotel chain's pride in having 8 Austrian eco-labeled hotels. The logo of the Austrian eco-label is therefore largely displayed on the website, and with this, all qualified hotels are also searched for. (Austria Trend, 2019)

On the Italian-initiated accommodation search site **Ecobnb**, you can choose from accommodation that is specifically environmentally conscious for the traveler who wants to relax and take into account its impact on the environment. When the startup, which defines itself as a "sustainable tourism community", was launched in 2013, among other things, it won the support of the European Community in the Innovative Projects program. On the site, accommodation wishing to advertise itself as eco-friendly must meet at least five of the 10 requirements set by Ecobnb, which means that they have previously been recognized by international eco-labels or eco-tourism organizations. Thus, Ecobnb does not rate accommodations, but gathers what has already been declared sustainable into a well-managed platform. This is profitable for both the site and the accommodation, as Ecobnb does not have to deal with the evaluation, but it provides an important advertising platform for that accommodation and may even make it easier to assess its competitors with the help of the site. (Ecobnb, 2019)

d. Hungarian situation

Hungary does not have a separate ecolabel, but there is the Country-wide well known Hungarian Ecofriendly Product and Service mark, which was established in 1993 on the model of the European Union eco-label product qualification system and, after the accession to the EU in 2004, operates in Hungary in parallel. There is a separate legislation for the use of the well-known pedunculate oak trademark. Companies can apply for the environmentally friendly product certification continuously with any product and service marketed or produced in Hungary.

The eligible categories are the followings: paper products, cleaning products, packaging, building materials, household appliances, oil filters, beauty care, cleaning services, fire extinguishers, and since last year the restaurants and catering services can also apply for it. The tender is announced by the ministry responsible for the environment and in case of a successful tender, the given product may bear the trademark registered by the Hungarian Patent Office. The qualification can be awarded for a minimum of 1 and a maximum of 5 years after successful application. Users of EMAS or ISO 14001 will benefit from the application if they can justify the use of the eco-friendly scheme. (Hun. Ecofriendly Product and Sevice

Certification, 2018) During my work I had the opportunity to meet and talk in person with dr. With Vilma Éri, who is an employee of the Environmentally Friendly Product Nonprofit Ltd. and the Hermann Ottó Institute, as well as the senior certifier of the Environmentally Friendly Product and European Eco-label Certification Directorate and the director of the Institute of Environmental Science. Vilma Éri shared with me the expansion plan, which was not yet available to the general public, and which was freshly compiled by her, which was prepared for the qualification of catering establishments. The Herman Ottó Institute and the Hungarian Environmentally Friendly Product Certification have chosen the Scandinavian sample, the Nordic Swan Ecolabel, as the basis for the Hungarian eco-rating system for restaurants and catering establishments. (Éri, 2018)

The inclusion of a new service in the rating system - hospitality - is justified by a number of factors that are closely related. “Hospitality is handled by many businesses, and although the environmental impact of an individual store is not significant in itself, the combined burden is significant due to the number of stores. Service providers meeting the eco-label criteria may voluntarily reduce this burden through environmentally friendly measures.” (Éri, 2018) In addition, restaurants and catering establishments would often and often use eco-labeled products for everyday life.

Tourism was not included in the eligible categories before, but the Association of Hungarian Hotels and Restaurants has created an environmentally friendly rating for hotels. The Hungarian Hotels and Restaurants Association (from now one HHRA) was founded in 1968 with 17 hotels. Today, it boasts more than 500 members, including 400 hotels, 7 hotel chains, 30 restaurants, 20 educational institutions and more than 100 associate members. Since 1993, every two years, member hotels have had the opportunity to apply for an Environmental Green Certification, which they can wear for one year or, in exceptional cases, for 4 years or even forever (Evergreen Hotel). Hotels can start in two categories (except for 2015-16, when there was only one category): independent, independent hotel and hotel chain hotel category, the first 3 places will be awarded and successful applicants will also be listed. The most important aspects to consider for an applicant are: educating and informing employees and guests about environmental friendly behavior, using energy saving lightbulbs and devices, having an appropriate heat insulation, water saving devices, reusing rainwater, appropriate handling of waste, recycling and using reusable materials, using domestic products, organic food, from local producers, working in a green office, more natural light, plants, office supplies made of environmentally friendly materials. (HHRA Green Hotel Application Guide, 2018) The list of the winners of the Green Hotel Award is announced by HHRA on the HHRA website, separately for each application period (every two years). I examined the data of the last three periods (2015-16, 2017-18 and 2019-20) according to the following aspects: the development of the total number of successful applications, including the proportion of hotels in rural and Budapest, the possible influence of belonging to a chain and the issue of multiple successful applications.

It can be seen that in the last three periods the number of successful applicants has steadily increased from 2015-16 to 2017-18 by roughly 10%, while between 2017-18 and 2019-20 there has been an increase of almost 20% for the period immediately ahead in comparison. Based on this, it can be stated that there will be more and more entrants and more and more environmentally conscious hotels in Hungary, which is a positive trend. The development of the distribution of hotels in rural and Budapest is also interesting: in the period 2015-16, 10% more hotels in Budapest won the award than in rural areas. In the following year, the countryside lagged behind by 15%, but this not-so-large difference disappeared, and even the countryside took over the leadership in the most recent period, with 51% rural and 49% Budapest. At the beginning of my research, my basic assumption was that hotels based in Budapest have more opportunities to achieve their environmental goals, as all goods are available faster and closer than in the countryside, more people see in their marketing campaigns and more people stay in the capital on average, especially if foreign guests considered. According to the latest trend (from January to December 2018) announced by HHRA, in 2018 65.3% of foreign guest nights were realized in Budapest hotels, so the majority of foreign guests chose the capital. In contrast, only 10.5% of domestic guest nights could be attributed to the capital, which shows that an increasing proportion of Hungarians are looking for recreation in the countryside. The report also points out that “record results in 2018 are mainly due to strong domestic demand” (Tendency Report 2018, 2019) Overall, therefore, Budapest hotels are in a better position in terms of resources and finances, yet the development of rural tourism (thermal baths, sights, etc.) and the growing demand seem to make rural hotels profitable and many people use these profits to improve their sustainability.

I examined hotels belonging to a hotel chain whose at least 3 members won an award in the tender for the period 2019-20. Hotels that are members of a hotel chain define their goals and strategies largely in accordance with the chain's policies, so these award-winning hotels reveal something not only about themselves but also about the environmental policy of the chain they represent. In total, the 5 hotel chains listed include 31 hotels, with 16 hotels winning tenders in addition to these this year. Based on this, it can be seen that the hotels were represented in a very significant proportion by the larger chains: 66% of the winners came from them. The most significant members were Hunguest Hotels, with 11 Green Hotels, and Ibis Hotels with 8 award-winning members. It is interesting to note here that all Hungest Hotels Green members are rural hotels.

Based on the data for the period 2019-2020 we can see the proportion of hotels that were listed as second or even third successful applicants (for the 3 periods I examined). A staggering result was achieved: the highest proportion, 40%, was won by hotels that had also won in the previous two periods. The first-time winners represented 32%, while the second-successful applicants were represented in 28%, which shows that less than one-third of the applicants were new (or last successful more than 2 periods earlier). This result shows that award-winning hotels usually do not think for a single period, not for two years, but for the long term, so they re-apply for the award. It is also important to point out the fact that not all of the two-time winners were awarded in the immediately preceding period, some did in the 2015-16 period and then won the 2017-18 period again. (HHRA Green Hotels, 2019)

e. Research among young tourists

The certifications presented earlier, and the labelled accommodations, are all an integral part of eco-friendly, sustainable tourism, but they can only be important if people are aware of these opportunities. To assess this, I prepared an online questionnaire, the results of which are presented below.

The questions of the questionnaire can be divided into three questions:

1. General travel indicators (Where? By what vehicle? How often? At what accommodation?)

2. Environmental awareness questions (How important do you consider it to be conscious in everyday life? How well do you know different eco-labels?)

3. Questions about eco-friendly accommodation (What indicators do you consider important for eco-friendly accommodation? How well do you know this type of accommodation?)

More than hundred people completed the questionnaire, 77% of those surveyed in terms of demographics are in the 21-30 age group and 70% have completed (or are completing) at least a BSc university degree. The gender ratio is unequal, roughly 65% of women and 35% of men completed my questionnaire, the majority of respondents have a salary, typically having an average monthly net income of between 100 and 300 thousand Hungarian Forints.

1. I considered it important to examine the results of the travel-related questions because potential accommodation bookers will be those who travel frequently, and it can be stated that the environmental impact of those who travel less is much lower. 60% of my respondents travel once every six months, 18% annually, but about a fifth travel at least once a month, which means at least 12 trips a year. From this, it can be seen that travel has become a common program for the young age group. Interestingly, no respondent selected the category as a response less than a year ago, so everyone travels at least once a year.

The proportion of foreign and domestic trips is almost the same, with only 7% more people typically traveling abroad, which is most common among those who travel every six months. The most frequently used mode of transport during their travels became 45% by car, followed by 33% by plane, followed by public transport (bus, train, metro, tram). This result shows that comfort and speed are still more important today than reducing the impact on the environment. In addition, the high use of airplanes can, of course, also mean the popularity of locations that are not or only difficult to reach by other means of transport.

When choosing accommodation (one could fill in more than one filler), most of the respondents preferred apartment-type accommodation (almost 70%), followed by hotels with 45%, then hostels with 15%, with the few remaining acquaintances and friends. stayed. Interestingly, 78% of those traveling abroad stay in apartments the most.

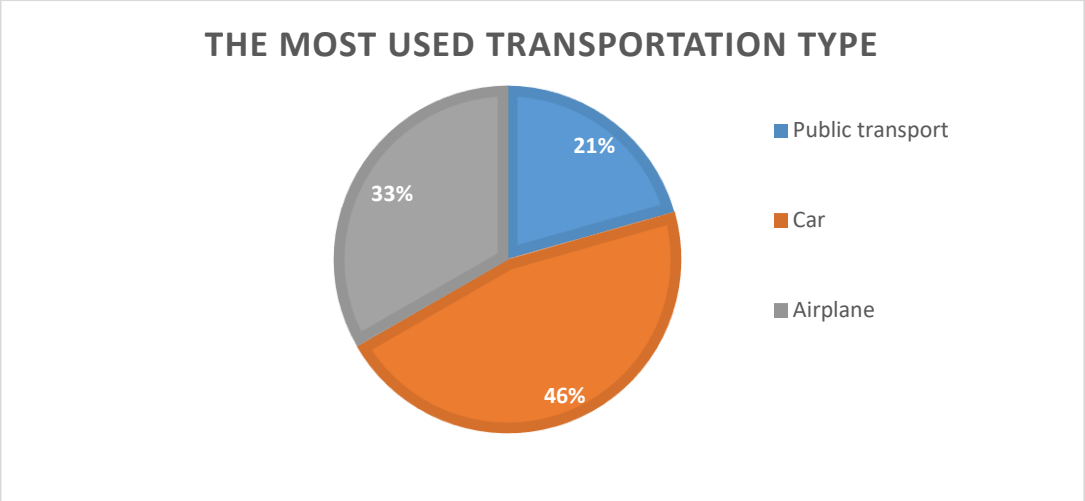

Figure 1 The chart of the most used transportation types in %, Based on own research

2. The awareness present in our daily habits can influence the decisions we make during our journey, which is why I found it important to map out this issue. My respondents had to indicate on a scale of one to five how important they consider environmentally conscious and sustainable consumption in everyday life, where the five meant that they considered it very important and the one that they did not consider it important at all. Positive feedback is that 44% of my respondents marked four ("I think important") and 38% marked five ("I think very important") in their response, so for the vast majority (84%), awareness is a key point in everyday decisions. . This result is somewhat contradicted by the result of summarizing the answers to my next question, which sought to assess the extent to which consumers know and choose domestic and international eco-labeled products / services. Of those who considered awareness important in everyday life, only 25% know and choose eco-labeled products, 31% have heard of them but do not know / do not know what they are good for, and what is most negative feedback is that 36% know but do not decide when making a purchase. In terms of all responses, one-fifth of respondents pay attention to eco-labeled products and 40% are familiar with eco-labels, yet do not decide based on this. In my opinion, a campaign for eco-labels and eco-shopping should focus on those who have either not heard of it or do not know what exactly eco-labels are good for, as they account for 40% of all.

3. According to my preliminary assumption, few people will be aware of eco-friendly accommodation options, and those who consider awareness important and / or know the eco-labels are more likely to know them. 60% of my respondents have not heard of either domestic or foreign rated accommodation, which unfortunately supports my assumption, but almost 20% have heard of both, which is an unexpected value. The work of the Responsible Gastrohero, which is becoming more and more popular in Hungary, is known to 24% of the respondents.

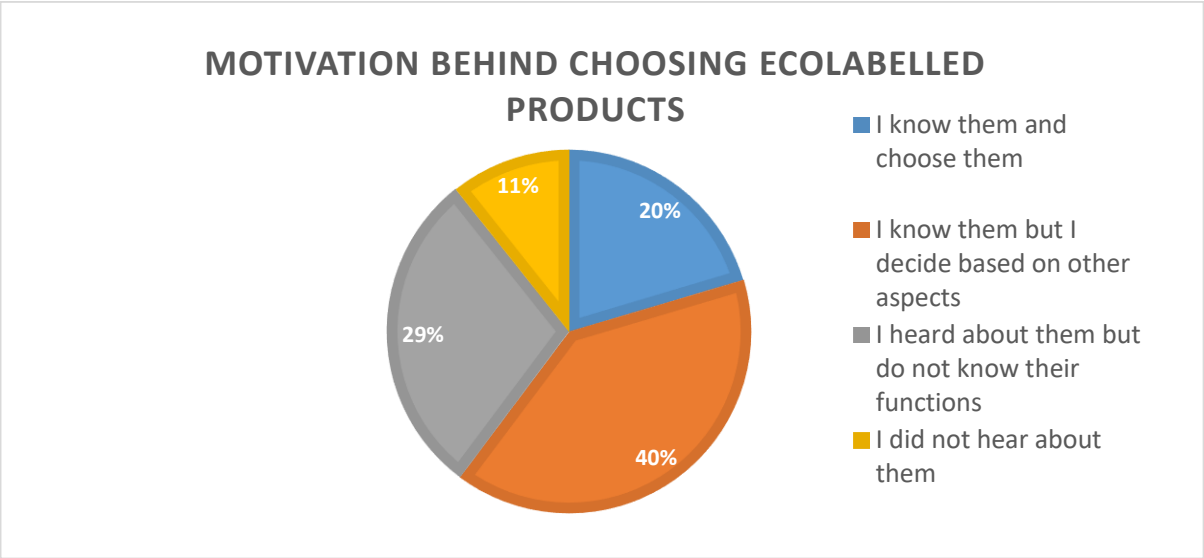

Figure 2 The motivation behind choosing ecolabelled products in %, Based on own research

In one of my questions, I was looking for the answer to the question of when someone would choose eco-friendly accommodation. The vast majority, 74.8% of respondents, would choose eco-friendly accommodation if it is not more expensive than other similar options, which is an economically understandable consideration, but it also seems that few would sacrifice for sustainability. Roughly 12% of my respondents, however, stated that they would definitely choose one the next time they choose accommodation (they were probably the first to hear about such options from me), which is a positive feedback.

I asked the respondents to indicate which of the 7 aspects I have listed may be the most important in their opinion for an eco-friendly accommodation. Energy saving comes first with 83 votes, followed by measures to reduce and select waste with 71 votes, and water saving and the purchase of food from local producers are tied for third. Several ratings rank these four characteristics as the most important, making it clear that people are aware of what the burden is on the environment.

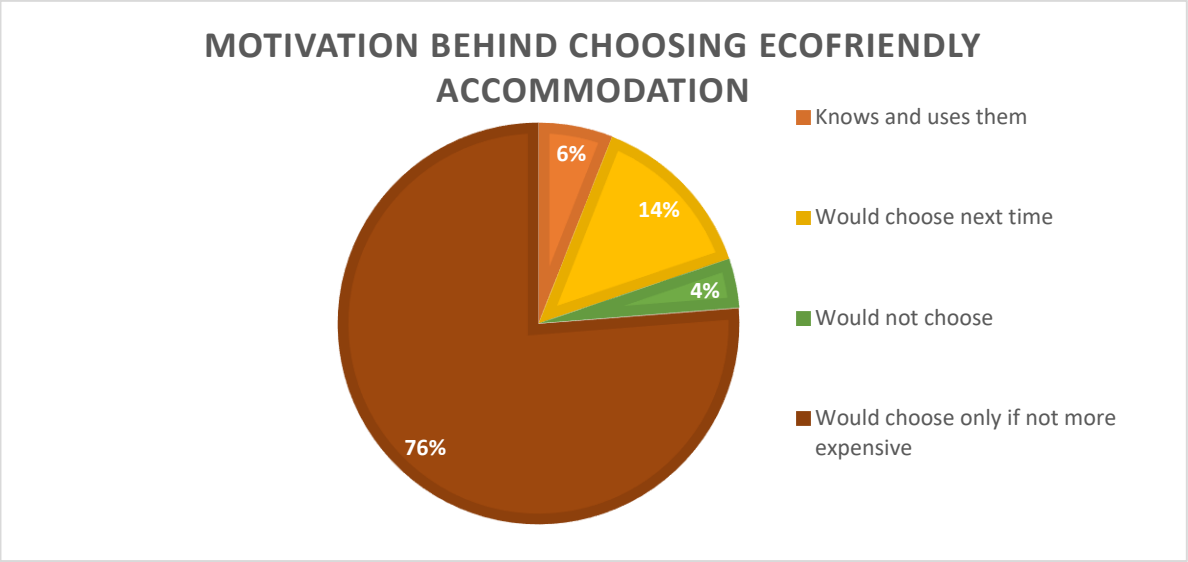

Figure 3 The motivation behind choosing ecofriendly accommodation, Based on own research

Summarizing the answers to the application form, it can be stated that a significant part of Hungarian young people regularly travel both domestically and abroad. As most people choose the comfort of apartments and hotels, they can be potential guests at the eco-friendly counterparts of these accommodations, but this is hampered by a lack of information, as most have not even

heard of such options. In addition, it is a positive result that less expensive eco-friendly accommodations are attractive to travelers, and again, when informed, they may realize that most of these options are in the same price range as their unrated counterparts.

Those who value awareness in everyday decisions also have little information about eco-labels and eco-friendly accommodation, which would need to be improved, but this also shows that people are unwilling to pursue eco-friendly solutions properly.

4. Conclusions

Through the examples I have presented, it can be seen that nowadays a stable foundation has been established in the field of sustainable accommodation, which, however, is still to be developed. Successfully applied certified hotels of foreign eco-labels are an example of domestic practice.

International cooperation in this field is implemented through UNWTO programs, assisting and guiding national initiatives. However, the role of eco-labels is also very important, as most sustainable hotels have reduced their environmental impact in line with the conditions they set. In my opinion, the number of "green" hotels will increase both abroad and domestically due to the growing climate anxiety, so sooner or later environmentally friendly operation may become a basic requirement for a place to stay. This, in turn - giving qualified accommodation to a competitive advantage - gives responsible hotels and apartments an economic advantage, which will encourage their not yet qualified competitors to acquire it as well.

Looking to the future, in addition to other alternative solutions, an important step for the Hungarian market is the introduction of the official eco-certification for restaurants, which may later be extended to accommodation.

Most people would be open to environmentally friendly solutions, but due to incorrect or incomplete information, few people choose eco-labelled products and services and accommodation. With a greater emphasis on informing people, this would, in my view, be remedied. Nowadays, it is not possible to tell people not to travel, not to be tourists (as this would be the most environmentally friendly solution), but it is possible to tell how conscious tourists can be conscious, what type of transport or accommodation to choose, which can reduce their environmental impact.

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Agriculture and Sustainability

Agricultural Efficiency in Myanmar

Efficiency differences and drivers behind them in Myanmar's state and regions

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Abstract

Efficiency in agricultural production is crucial for developing countries. This statement is particularly true for Myanmar, where more than two-thirds of the population relies on agriculture for their livelihoods. By using a set of four surveys collected by the World Food Program during the period 2012-2015, this paper measures agricultural efficiency in Myanmar's states and regions using both a Stochastic Frontier Analysis (SFA) and a Data Envelopment Analysis (DEA), while controlling for geographical conditions. The results show that areas that are the traditional focus of agricultural policies (Shan State and the Ayeyarwady river basin) are highly inefficient. To understand this result, the paper analyses how differences in efficiency relate to which source of capital is available for the farmers, ownership of assets, and crop diversification. This analysis sheds light on the role of monitoring, credit constraints, property rights, and the production of market-oriented crops. Finally, the paper analyses the prevailing conditions in individual regions and states and discusses policy opportunities to increase efficiency in the different administrative units.

Keywords: Myanmar, agriculture, efficiency, DEA, SFA

1. Introduction

In 2011, Myanmar shifted from a military regime to a civilian-led government and started its liberalization process to join the global economy. The agricultural sector changed production defined by the government to production decisions taken at the farmer level. Institutions and legislation on land tenure have changed to encourage privatization and exports. Under this new paradigm, efficiency, understood as the capacity of the farmers to maximize their output given a set of inputs, becomes a central indicator to measure agricultural performance and guide the design of public policies. However, due to the large variety of agricultural products, most of the studies of Myanmar have focused on single products (Aung, 2012; LIFT L. , 2019).

Different techniques have evolved to develop broader analysis, that can cover multiple sources of inputs and outputs to measure the efficiency of large agricultural areas (Hossain, Kamil, Baten, & Mustafa, 2012; Toma, Dobre, Dona, & Cofas, 2015; Liu, Zhang, He, & Li, 2015). Nevertheless, a common assumption on these papers is that all farmers have the same type of asset ownership. This assumption helps to highlight some of the technical elements associated with production inefficiencies, but it shadows important concepts related to the context where production takes place. To illustrate this point, consider agricultural output as a function of assets such as land, capital, and labour. For the case of assets, it is known that ownership share may impact how the farmers use them. In that aspect, authors such as Baland and Platteau (2007) have shown that community structures and social norms have a direct effect on the coordination and adequate use of common resources. Thus, the incentives to use a community power tillers and water pumps are different from the incentives of using the same tool but fully owned by the farmer. Furthermore, if the capital is accessed via debt, principal-agent problems can emerge depending on the monitoring capacity of the debtor, and on the regularity of interaction between the debtor and the borrower (Coleman, 1988; Coate & Ravallion, 1993; Udry, 1994). Hence, how inputs are used strongly depends on these tenure and acquisition characteristics, that, at the same time, rely strongly on the social norms and institutions.

The recent and gradual liberalization of the Myanmar economy has caused substantial heterogeneity in the country, where traditional institutions and social norms clash with market forces. Therefore, using agricultural information from Myanmar after liberalization and integrating it with the new techniques to measure efficiency, this paper expands the literature on agricultural economics in Myanmar in two aspects. First, it is the first study that covers the whole country and can make the efficiency measure comparable across states and regions. Second, it goes beyond the technical analysis and shed light on how access to capital, ownership of assets, and crop selection are associated with farmers' efficiency. Thereby, this paper identifies the main causes of inefficiencies in the different administrative units of the country and recommend ways to improve.

2. Methods

This section describes the methodology used to identify the farmers' efficiency and the factors that drive efficiency. The section is divided into two parts, where the first part describes the data sources used during the process, and the second part explains the technical procedures.

Data

The paper relies on two sets of data sources: one on the farm information and another on the geographical conditions that can affect the farm production efficiency.

The first data source, outlining farm information, comes from a set of four surveys, under the name of Food Security Surveys (FSS) produced by the World Food Program during the period 2012-2015. These surveys interview 27000 rural households across Myanmar. The households were randomly selected and stratified at the village tract level (a village tract is an administrative unit in smaller than townships). Table 1 presents the number of households used for the study after rural households that are not dedicated to farming activities and registers with a large number of missing values were removed.

Table 1. *Sample Size Statistics*

		Sample Size	
States and Regions	Total Townships	Townships in the sample	Farmers
Ayeyarwady	26	26	182
Bago (East)	14	12	63
Bago (West)	14	14	116
Chin	9	8	107
Kachin	18	13	193
Kayah	7	6	258
Kayin	7	5	159
Magway	25	22	252
Mandalay	28	16	169
Mon	10	9	79
Rakhine	17	15	217
Sagaing	37	36	865
Shan (East)	15	8	162
Shan (North)	45	16	64
Shan (West)	21	19	192
Tanintharyi	10	10	79
Yangon	47	11	102
Total	350	246	3259

Table 1 shows that the only division missing the data is Nay Pyi Taw, the country's administrative capital. The reason is that the region is young (established in 2005), and its productive structures are focused on the support of the government structures. The two mid-columns of table 1 show that the sample covered a large share of townships in most states/regions except for some that are impacted by conflict (Rakhine, Shan and Kachin) and highly urbanized areas (Yangon and Mandalay), that for those conditions are not relevant for this study.

It is worth noting that the four surveys that comprise this set of data from the World Food Program have some variations on the number of questions used. However, this paper used only common questions from the following sections: household income, expenditures, credits and debts, livestock and other assets, and agricultural production.

The second set of data sources is compiled from multiple places and aims to capture the geographical factors that affect agriculture. Out of this group, the first variables are temperature and precipitation. These variables were estimated by The Asia Foundation for the project Township Development Indicators (TDI) database using WorldClim Global Data (v1.4). Then, two variables were created to approximate access to water sources. For this purpose, Landsat 7 and 8 images, downloaded via Google Earth Engine, were used to calculate two different indices: $NWDI_{(Green,\ NIR)}$ and $NWDI_{(Green,\ SWIRI)}$. To construct these variables, all Landsat available images were collected for the period 2012-2017. Then, by year, all the rasters were merged into a single raster where the band calculates the average value of the corresponding bands of the rasters from the same year. Then, using the processes suggested in Mcfeeters (1996) and Xu (2006), the indices were calculated for each year. Finally, the six values of each index (one per year during the study period) were averaged at the village track level (administrative unit that is smaller than the township). Finally, two variables were created to estimate the elevation and the slope of the farmland. For this purpose, SRTM Digital Elevation Data V.4 was downloaded via Google Earth Engine. Then, using the elevation, the slope was estimated using ArcGis 10.5 default protocols.

Methodology

This paper processes the data in two different stages. The first stage estimates the production inefficiencies, and the second stage investigates which factors can explain them.

In general terms, production (in)efficiency is related to how distant a production unit (in this case, a farmer) is from the production frontier (i.e., if the farmer can use its inputs at its full potential, how much more can it produce). However, due to the diversity of inputs and outputs, there is no definite answer in the best way to estimate the production frontier.

The two most popular methods for the estimation of the frontier are the Stochastic Frontier Analysis (SFA) and the Data Envelopment Analysis (DEA) (Coelli, 1995) . The methods have different drawbacks and advantages, which make them complementary to each other. Due to the strengths and weaknesses of each method, this paper analyses agricultural efficiency using both methods, similar to the strategy followed by authors such as Sharma et al., (1997), Tingley et al., (2005), and Theodoridis et al., (2008). Following the notation of Aigner, Lovell, and Schmidt (1977), SFA is stated in equation 1

$$y_i = X_i\beta + v_i - u_i \; such \; that \; v_i \sim N(0, \sigma_v^2), u_i \sim \mathcal{F} \quad (1)$$

where i is the production unit, y_i and X_i are the production outcome and a vector of production inputs (adequately transformed), v is a normal error, and u is the inefficiency term that is driven by a distribution $\mathcal{F}$ that has positive support[1]. The main advantage of this technique is that it estimates the parameters of the production frontier on a given functional form. Hence, based on the estimated values, it is possible to distinguish effects from additional inputs to general data noise that is captured in the first stochastic term v_i. The main drawback is that the same production function is shared by all the farmers. Since farmers produce different types of crops, the method fails to capture that specific input mixes can be beneficial for production, depending on the crops produced. Given the available information, Table 2 displays the different inputs that are considered for the analysis.

[1] After different experiments, a truncated normal is chosen due to its data adjustment.

Table 2. *Average values of the input variables*

	Agricultural expenses (log)	**Available land area**	**Livestock assets**	**Tool Assets**	**Precipitation**
Calculation	Directly identified in FSS	Directly identified in FSS	First principal component, of the set that included the livestock assets reported in SFF	First principal component, of the set that included the tool (categories 1 to 12) assets reported in SFF	Directly identified in FSS
Unit	MMK_log	Acres	Dimensionless	Dimensionless	Inches
Ayeyarwady	12.70	10.54	-0.08	1.35	243.21
Bago East	12.75	13.21	0.30	1.52	274.22
Bago West	12.28	9.71	0.21	1.57	155.60
Chin	10.11	2.16	-0.30	-0.81	217.15
Kachin	12.00	4.82	0.72	0.67	202.96
Kayah	11.24	4.14	0.15	0.41	120.39
Kayin	10.81	5.27	-0.01	-0.07	271.25
Magway	11.32	6.70	0.71	1.00	97.06
Mandalay	11.79	7.63	0.26	0.64	83.18
Mon	12.28	8.08	-0.23	0.47	433.86
Rakhine	11.36	4.83	0.36	-0.14	377.43
Sagaing	11.74	5.79	0.60	1.27	155.93
Shan East	10.15	2.64	0.81	0.63	137.07
Shan North	11.39	4.83	0.19	0.60	155.75
Shan West	11.37	3.93	0.37	0.72	151.57
Tanintharyi	11.32	6.45	-0.35	-0.32	327.13
Yangon	12.75	13.91	0.11	1.82	267.73

Table 2 (continued). *Average values of the input variables*

	Temperature	**Slope**	**Elevation**	$NWDI_{(Green,NIR)}$	$NWDI_{(Green,SWIRII)}$
Calculation	Explained in section Data	Explained in section Data	Explained in section Data	Explained in section Data	Explained in section Data
Unit	Degree Celsius	Degree	Meters	Dimensionless	Dimensionless
Ayeyarwady	26.82	0.82	20.39	-2.75	0.08
Bago East	26.75	1.19	42.82	-1.98	0.10
Bago West	26.99	1.13	46.61	-1.73	0.10
Chin	20.71	20.44	1040.20	-4.00	0.11
Kachin	20.94	12.59	831.43	-3.84	0.10
Kayah	22.92	11.45	919.88	-2.59	0.11
Kayin	26.06	6.62	213.70	-3.38	0.11
Magway	26.42	3.80	190.56	-1.91	0.10
Mandalay	26.33	2.32	256.43	-1.33	0.10
Mon	26.70	2.85	58.94	-2.64	0.10
Rakhine	25.42	6.36	4340.87	-3.40	0.09
Sagaing	24.08	6.39	338.80	-2.90	0.10
Shan East	21.56	15.52	1088.69	-3.93	0.11
Shan North	19.84	11.76	1036.36	-3.17	0.11
Shan West	20.63	9.75	1127.26	-2.68	0.11
Tanintharyi	26.05	7.68	124.08	-4.21	0.10
Yangon	27.05	0.83	12.54	-1.93	0.08

The following exercises use, as output variable, the logarithm of the income of the household as the output of the frontier and ten input factors, four of them are determined by the farmer (agricultural expenditure, livestock assets, tool assets, available land area) and the remaining six are given by the environmental conditions which are divided in topographic characteristics (elevation and slope), hydrographic characteristics (precipitation, $NWDI_{(Green,\ NIR)}$, and $NWDI_{(Green,\ SWIRI)}$), and weather characteristics (temperature). Thus, the first group of variables is referred to as farmer variables, while the second group is denominated environmental variables. It is worth noting that livestock assets and tool assets were constructed from the list of variables associated with the assets of each type owned by the farmer. This decision was taken to create a uniform measurement that weights the various types of assets according to their covariance structure. Finally, due to the need of the production function specification, different functional forms were tested. Out of these exercises, the best functional form was obtained when the quadratic terms of the environmental variables were included. Table 3 displays the estimated coefficients of SFA regression.

Table 3. *SFA Regression*

Income Logarithm	Coefficient	Std. Error	z	P>z	[95% Confidence Interval]	
		Frontier				
Livestock assets	0.012836	0.012466	1.03	0.303	-0.0116	0.037269
Tool Assets	0.091282	0.012553	7.27	0	0.066678	0.115885
Agricultural expenses (log)	0.138813	0.015979	8.69	0	0.107495	0.170131
Available land area	0.015409	0.003527	4.37	0	0.008496	0.022322
Precipitation	0.00031	0.001039	0.3	0.765	-0.00173	0.002346
Precipitation (square)	-1.52E-06	1.91E-06	-0.79	0.427	-5.26E-06	2.23E-06
Temperature	0.167411	0.175533	0.95	0.34	-0.17663	0.511449
Temperature (square)	0.003883	0.003739	1.04	0.299	-0.00345	0.01121
Slope	-0.03977	0.017003	-2.34	0.019	-0.07309	-0.00644
Slope (square)	0.000839	0.000681	1.23	0.218	-0.0005	0.002172
Elevation	-6.5E-05	3.03E-05	-2.16	0.031	-0.00012	-6.00E-06
Elevation (square)	2.34E-09	1.47E-09	1.6	0.111	-5.35E-10	5.22E-09
NWDI1	0.114864	0.10334	1.11	0.266	-0.08768	0.317408
NWDI1 (square)	0.037869	0.0184	2.06	0.04	0.001807	0.073932
NWDI2	8.813859	3.770784	2.34	0.019	1.423258	16.20446
NWDI2 (square)	-62.7976	26.27864	-2.39	0.017	-114.303	-11.2925
Constant	8.109225	2.073574	3.91	0	4.045094	12.17336
		μ				
Constant	-994.483	497.3866	-2	0.046	-1969.34	-19.6231
		U_σ				
Constant	6.56864	0.500542	13.12	0	5.587596	7.549684
		V_σ				
Constant	-0.06657	0.037601	-1.77	0.077	-0.14027	0.007124
σ_u	26.69082	6.679936	4	0	16.34297	43.59061
σ_v	0.967261	0.018185	53.19	0	0.932268	1.003568
λ	27.59422	6.680596	4.13	0	14.5005	40.68795

The second method commonly used to measure efficiency is DEA. DEA is a non-parametric approach to measure efficiency (Charnes, Cooper, & Rhodes, 1978). Equation 2 and 3 present the main structure of the model. For each individual *j*,

$$z_j = arg \min_{\beta_j > 0} X_i \beta_j \ such\ that\ \forall i\ X_i \beta_j \geq y_i \quad (2)$$

$$u_j = 1 - \frac{y_j}{z_j} \quad (3)$$

In contrast to SFA, DEA defines a set of production coefficients for each farmer and uses this data to compare itself against the production coefficients of other farmers. The main advantage of this method is its non-parametric definition of the production function. However, in contrast to SFA, it does not contemplate a stochastic component. Thus, noise in the observations is interpreted as being attributed to inefficiencies.

Another conceptual difference between the two methods is the construction of statistical comparisons. In the SFA, data from all farmers in the sample is used to obtain the production possibility frontier, and inefficiency is measured as a deviation from the frontier. In contrast, the DEA method measures the inefficiency of a farmer *j* by comparing it to synthetic farmers, defined by the construction of a linear combination of all the farmers that has the same inputs as *j*, but that is maximizing its output. Thus, the inefficiency of *j* is the difference between this ideal value and its realized value. Hence, to be consistent with the conceptual logic, it was not appropriate to include the six environmental variables among the inputs, as they are not defined by the farmer. Therefore, the output variable (logarithm of the income) was adjusted when using the DEA model to remove the fraction of it that was explained by the environmental factors.

Equation 4, 5, 6 explain how the adjustment is made.

$$y_i = F\left(X_i^{environmental}\right) + e_i \quad (4)$$

$$z_j = arg \min_{\beta_j > 0} X_i^{farmer} \beta_j \ such\ that\ \forall i\ X_i^{farmer} \beta_j \geq e_i \quad (5)$$

$$u_j = 1 - \frac{e_i}{z_j} \quad (6)$$

Hence, the first step, described in equation 4 is the calibration of a model where the logarithm of the income y is a function of the environmental variables and a stochastic error. For consistency with SFA, which was on quadratic form, the adjustment chosen for equation 4 is a linear model where all the terms are also considered in a quadratic form. This regression is displayed in Table 4.

A second technical element is that DEA requires the variables to be positive. To achieve this condition, without affecting the linear structure of the method, each of the farmer variables, as well as the regression error, were adjusted by removing its minimum value and dividing it by its range. By making these adjustments, the error identified by this methodology is conceptually consistent, and at the same time, it adjusts by the environmental factors that affect production. After the adjustment, both methods yield comparable results. Recognizing that each method has its strengths and weakness, their interpretations are complementary to each other.

Table 4. *Regression adjustment for DEA*

Income Logarithm	Coefficient	Std. Error Frontier	z	P>z	[95% Confidence Interval]	
Livestock assets	0.012836	0.012466	1.03	0.303	-0.0116	0.037269
Tool Assets	0.091282	0.012553	7.27	0	0.066678	0.115885
Agricultural expenses (log)	0.138813	0.015979	8.69	0	0.107495	0.170131
Available land area	0.015409	0.003527	4.37	0	0.008496	0.022322
Precipitation	0.00031	0.001039	0.3	0.765	-0.00173	0.002346
Precipitation (square)	-1.52E-06	1.91E-06	-0.79	0.427	-5.26E-6	2.23E-6
Temperature	0.167411	0.175533	0.95	0.34	-0.17663	0.511449
Temperature (square)	0.003883	0.003739	1.04	0.299	-0.00345	0.01121
Slope	-0.03977	0.017003	-2.34	0.019	-0.07309	-0.00644
Slope (square)	0.000839	0.000681	1.23	0.218	-0.0005	0.002172
Elevation	-6.5E-05	3.03E-05	-2.16	0.031	-0.00012	-6.00E-6
Elevation (square)	2.34E-09	1.47E-09	1.6	0.111	-5.3E-10	5.22E-09
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NWDI2	8.813859	3.770784	2.34	0.019	1.423258	16.20446
NWDI2 (square)	-62.7976	26.27864	-2.39	0.017	-114.303	-11.2925
Constant	8.109225	2.073574	3.91	0	4.045094	12.17336

After obtaining efficiency measures for farmers using the SFA and DEA methods, the last part of the analysis regresses the estimated efficiency against ownership, credit, and crop diversity variables to understand how these aspects affect efficiency. For that purpose, two linear regressions are performed (one for the efficiency level obtained from the SFA model and one from the DEA model), where the dependent variable is efficiency, and the independent variables are divided into five groups. The first group focuses on the borrower type and considers ten different sources from where the farmers borrow money. The second group changes the focus to how the farmers use the credit. The third group has three variables that approximate the ownership share of livestock, tools, and land. Group four controls for the five large types of crops. Finally, group five controls for the production scale, and in this case, the variable available land area is used again to understand if the size of the farm affects the efficiency. Finally, these regressions are run without constant term as the set of crops is an exhaustive partition. Thus, without the constant, the coefficients visualize the average efficiency of each group. The descriptive statistics of the independent variables from the first four groups are presented in the appendix tables A1 to A4.

To summarize this section, the methodology presented in this paper is divided into two parts. The first part uses two different methods to calculate the efficiency of the farmers in Myanmar. The second part takes those measurements and regress them against a set of explanatory variables to shed light on the role of ownership, credit, and crop diversification, in production processes.

3. Results and Discussion

This section is divided into three parts. Firstly, it presents the results of efficiency levels. Secondly, it discusses the potential drivers behind them on a national level. Thirdly, specific qualitative conditions per state and region and how they relate to the first two parts are discussed.

Results on efficiency levels

Figure 1 provides a spatial representation of the efficiency results calculated under the two methodologies. Both methodologies give each farmer an efficiency score between 0% and 100%, where higher percentages indicate higher efficiency levels. Nevertheless, these ranks are built within the sample. Ergo a score of 100% does not necessarily mean that the farmer is achieving the highest production given a set of inputs, but that the farmer is the best one (i.e., that is in the production frontier) compare with the other ones in the sample.

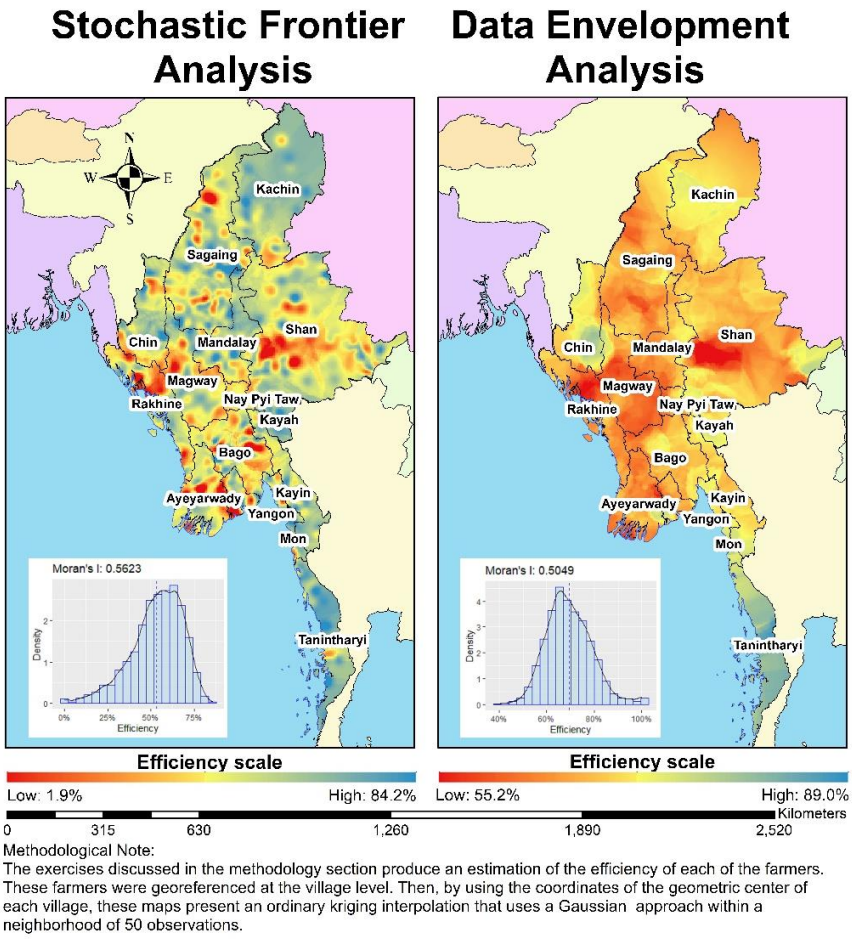

Figure 1. *Efficiency measurements*

As expected, the methods produce different ranges of efficiency, which is illustrated by the difference in colouring in the two different maps in Figure 1. However, three results are common between the two methodologies. Firstly, the efficiency has a high spatial correlation, reflected in the high values of Moran's I (0.5623 for the SFA model and 0.5049 for the DEA model). This result suggests that common production styles, attitudes towards markets, and infrastructure could be factors that guide productivity. Secondly, both maps indicate low levels of efficiency in the north of Rakhine State, which highlight the precarious situation of ethnic conflict in the area. The third shared result is more unexpected: both techniques show that the areas near the basin of the Ayeyarwady river (in Ayeyarwady Region) as well as the centre of Shan State have low levels of efficiency (both maps are coloured red in these areas). In contrast, Tanintharyi region and the frontier between Chin State and Magway region display high efficiency

levels using both methods (illustrated by a light blue tone in both maps). The basin of the Ayeyarwady river, as well as the centre of Shan State, are well-known production areas (DOA, 2018). Therefore, this result suggests that areas that are known to be the main agricultural producers are having large inefficiencies once the inputs and natural conditions are considered.

Expanding on these maps, Figure 2 contrasts real income against efficiency obtained by the models for all states and regions[2]. Figure 2 highlights that there is no relationship between the real income of the farmer and its efficiency. In other words, these results point to the fact that higher-income does not imply that crops are being produced under a technically efficient regime.

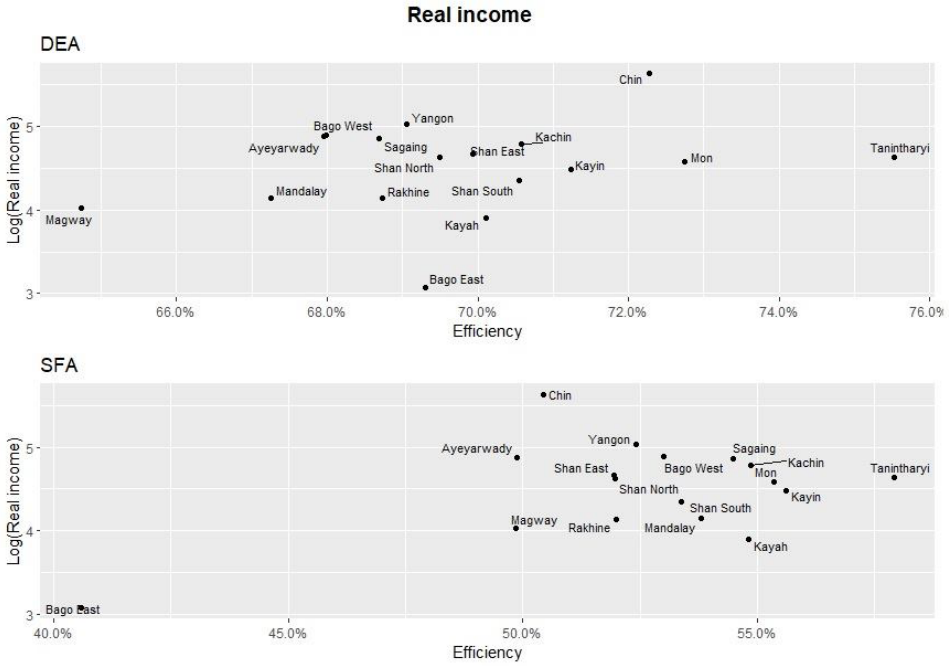

Figure 2. *Dispersion of real income against efficiency*

Drivers behind efficiency on the national level

Moving on to the second part of the analysis, this section regresses the efficiency measurements over the five groups of variables that were described in the methodology section.

Table 5 displays a robust regression that unveils efficiency factors from the perspective of resource ownership, capital sources, and crop diversity. The table's two last columns show the efficiency coefficient obtained from the two different models. These columns show that, except for the production scale, both regressions coincide in the sign of each of the covariates.

The first type of covariates, i.e., debtor type, shows that, in general, having debts is associated with more efficient farms. Efficiency increases more when debtors have close relationships with the borrowers (e.g. family, community saving groups, employers, and traders), stressing the role of monitoring capacity to avoid moral hazards. In contrast, debts with government banks and private institutions do not increase efficiency, and, under DEA, government banks have a negative and significant effect. In Myanmar, agricultural government loans are mostly targeted to the production of rice in specific regions along the Ayeyarwady river that has traditionally produced rice. Moreover, the government continues creating programs to stimulate this sector in these regions to the point that 88% of the loans of the Myanmar Agricultural Development Bank (MADB) are dedicated to paddy crops in these areas

[2] To adjust prices by purchase power, the income produce by the farmer household is divided by the price of a pyi of rice.

(Myint T. , 2018). Hence, given the previous facts, this study indicates that these loans are either inefficiently targeted, or their monitoring is inadequate. The previous statement is supported by the recent reports regarding debt traps that paddy farmers are facing (The Economist, 2017).

Table 5. *Efficiency determinants*

Regressor	Efficiency	SFA Efficiency	DEA Efficiency
Debtor Type	Borrowed from Family	0.0201***	0.0483***
	Borrowed from Trader	0.0336***	0.0411***
	Borrowed from Money Lender	0.00924	0.0306***
	Borrowed from Microcredit Institution	0.0255*	0.0500***
	Borrowed from Village Saving Group	0.0382***	0.0672***
	Borrowed from Pre-Saling	0.0101	0.00283
	Borrowed from Employer	0.0461**	0.0977***
	Borrowed from Private Bank	0.0134	0.0351
	Borrowed from Government Bank	-0.00404	-0.0197**
	Borrowed from Private Company	-0.0206	-0.000346
Debt Purpose	Loans for Agricultural Inputs	0.0149**	0.0168**
	Loans for Agricultural Labor	0.00325	0.0109
	Loans for Productive Assets	0.0161	0.0204
	Loans for Livestock Breeding	0.0308	0.0195
Ownership	Fraction of Owned Livestock	-0.000994	-0.00307**
	Fraction of Owned Tools	-0.00415***	-0.00300**
	Fraction of Owned Land	0.333***	0.424***
Type of Production	Producers of Cereal Crops Roots and Tubers	0.154***	0.205***
	Producers of Industrial Crops	0.128***	0.142***
	Producers of Oilseed Crops	0.0608***	0.0463***
	Producers of Pulses	0.0385***	0.0358***
	Producers of Vegetables and Aromatic Crops	0.0844***	0.121***
Production Scale	Available Crop Area	-0.000114	0.00122***
Observations		3,213	3,187
R-squared		0.891	0.943
Deg of Freedom		3190	3164
Adjusted R Square		0.890	0.943

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The next group of covariates represents the use of the debt. By including these variables, it is possible to investigate whether a capital constraint has limited the farmers' endowment of certain inputs for production (agricultural assets, agricultural labour, productive assets, livestock breeding). Without credit constraints, farmers can get the best inputs independent of their initial capital, but with credit constraints, farmers must compensate their lack of capital with lower quality inputs (Mukasa, Simpasa, & Salami,

2017; Sekyi, Abu, & Nkegbe, 2017; Lin , Wang, Gan, Nguyen, & David, 2019; Ciaian, Falkowski, & Kancs, 2012). The result in this study show that all the coefficients of this section are positive and, agricultural input loans is significant, which indicate that farmers were initially credit constrained. Overall, the first and second groups of covariates highlight the role of monitoring and the role of credit access, respectively to enhance agricultural efficiency. These facts send a joint message to expand funding sources for farmers and improving monitoring and screening procedures to avoid principal-agent problems.

The third group of covariates discusses ownership in assets. The data contains information on whether assets like livestock, tools, and land are either owned by the farmer, shared at the community level, or rented. The results show that land ownership is positively correlated with efficiency, and in contrast, the relationship is negative for livestock and tools. Since the seminal work of Olson (1971), ownership of productive assets, in particular of land, has been considered as a positive element for the production of goods. However, as suggested by Baland and Platteau (1999; 2007), Bardhan (2002), and Bardhan and Dayton-Johnson (2002) these statements strongly depend on the type of social structures that foster coordination and promote social capital in the communities. In the context of Myanmar, the negative relationship between ownership of tools and livestock with efficiency is consistent with the fact that the community life in Myanmar's rural areas is still in the core of the social structure. Therefore, the communities have endogenously developed mechanisms to monitor and coordinate the use of these shared items. The previous evidence justifies the existence of projects, such as "Improvement of agricultural livelihoods and resilience for conflict-affected communities in Myanmar" from FAO (2019), that encourage the use of communal use and ownership of farming assets.

In contrast to the story of shared ownership for livestock and tools, owning land is a positive indicator of efficiency. Historically in Myanmar, the land was commonly owned at the village or other communal levels, but during the military regime, lands were nationalized. In 2012, two laws were created (Farmland Law, and Vacant, Fallow, and Virgin Land Laws) that allowed people to hold land property rights (Jepsen, Palm, & Bruun, 2019). This change created uncertainty in land tenure for small farmers (Yeung & Dotto , 2019; Weir, 2017). As customary laws regarding the use of communal land are being affected, arguments of the tragedy of the commons apply. For this reason, the result of this study does not suggest that ownership is better for the case of land. It limits to claim that due to the change in social norms regarding land, the informal institutions associated with the use of land are reducing efficiency when it is not the property of the farmer.

The fourth set of covariates present which types of crops that farmers produce. Since farmers can have multiple crops, Table 6 was created to represent the average efficiency of different combinations of crops[3].

Table 6 highlights that, on average, cereal crop producers (A in the table) increase their efficiency when diversifying their production. In contrast, producers of pulses and vegetable and aromatic crops are, on average, more efficient than other farmers (the letters D and E appear more often in higher positions than A and C). Finally, the most efficient farmers are associated with industrial crops.

These results highlight that traditional products such as rice are not generating income as efficiently as other products. Before 2011, the Myanmar Government had an active policy of encouraging paddy production in specific regions (those mentioned in the section on public loans), and to do so, farmers did not have the freedom to choose which crops they wanted to produce (Raitzer, Wong, & Samson, 2015). By the standards of 2012, the production techniques were distant from being optimal due to the institutions involved in the production process (Aung, 2012). Today, farmers are free to choose their crops, but several of the institutions remain and sometimes encourage certain production over others which may affect efficiency. Thus, crop diversification should be encouraged

[3]The table only presents combinations of crops that have more than 100 farmers producing that specific combination, to avoid conclusions based on noise from specific observations.

by local authorities. On the other extreme, emerging industrial crops have high efficiency levels. This tendency can be explained due to the market-oriented framework in which these products are embedded (Wiggins, Henely, & Keats, 2015).

Table 6. *Efficiency by types of crops*

Crops	Number of Crops	DEA	SFA	Observations
A, D	2	69.1%	50.5%	526
A	1	68.9%	52.1%	2825
C, D	2	66.0%	52.2%	239
A, C	2	67.8%	52.9%	740
A, E	2	70.5%	53.2%	722
C	1	67.3%	53.8%	226
D	1	67.3%	53.9%	116
A, C, E	3	70.5%	54.2%	131
A, C, D	3	68.6%	55.3%	403
A, D, E	3	67.8%	55.8%	106
E	1	74.3%	56.6%	279
B	1	72.9%	56.7%	195
A, B	2	73.8%	58.1%	110
A, B, C, D, E	5	72.7%	67.9%	219

A=Cereal Crops Roots and Tubers
B=Industrial Crops
C=Oilseed Crops
D= Pulses
E=Vegetables and Aromatic Crops

Finally, the last factor in Table 5 is the farm scale. The results in the table are inconclusive, suggesting that for Myanmar, large farmers are not necessarily getting the benefits of the economies of scale.

Drivers behind efficiency on state and regional level

This section discusses the conditions in the different states and regions to establish the drivers behind efficiency. The states and regions are discussed per agroecological zone. Myanmar's agroecological zones are mapped in Figure 3.

***Figure 3**. Agroecological zones. Source: Myanmar living conditions survey, 2017*

The first agroecological zones to be discussed are the Delta and Dryzones (light blue colours in Figure 3), where the majority of Myanmar agricultural production takes place; 70% of agricultural land of the country is concentrated in Ayeyarwaddy, Sagaing, Bago, Magway, and Mandalay.

Ayeyarwady's land is fertile due to its advantageous location by the Ayeyarwady river. Still, the evidence suggests that, after controlling the geographical advantage, the region is not producing at its full capacity. This issue could be a consequence of the deterioration of the soils due to overexploitation (Myint S. S., 2015), or associated with moral hazard problems linked to the policies implemented by the government to foster paddy that was previously discussed. The geographical location also makes this region prone to natural disasters such as cyclones. These events are occurring more frequently due to climate change (Htwe, Hein , & Than, 2015). Hence, this large agricultural provider is having increasing issues affecting its sustainability. Currently, Ayeyarwady is the main rice producer at 28% of Myanmar's total production, followed by Bago (17%) and Sagaing (12%) (DOA, 2018). Diversification of crops in Ayeyarwady is limited to specific districts like Hinthada and Maubin (CSO, 2018). Hence, the previous results encourage policies that push for more diversification and more efficient use of inputs in this region. In that context, diversification policies backed up with programs to improve the use of inputs are strongly recommended to increase the efficiency of the region. Like Ayeyarwady, Bago is a major rice producer and two thirds of its total agricultural land are dedicated to this commodity. More than 34,000 acres of land has irrigation support, both summer and monsoon rice growing seasons. However, its topography is more varied. Hence, it produces a wider variety of goods, which include corn, groundnut, sesame, monsoon paddy, green gram, soybean, pigeon pea, chill, and vegetables. The efficiency maps created in Figure 1 translate this more considerable diversification into efficiency. Finally, as it is shown in Table 2, the regions of Ayeyarwady, Yangon, and the east of Bago have the largest average farm sizes. However, the current surveys could not provide evidence of economies of scale in agriculture. Hence, more studies are needed in the relationship between productivity and land size on this region as it is a place where potential policies can take place to increase the regional efficiency.

Moving on to dry zone, this study shows that it has higher agricultural efficiency than the delta. The dry zone consists of Mandalay, Sagaing and Magway and is known for oilseed crops (nearly 90 percent of oilseed crops are grown in the central dry zone). Magway is the least efficient in this zone and stands for 34% of the national area used for oilseed production (CSO, 2018). The Myanmar Agriculture Strategy and Investment Plan (2018-2023) noted that sesame is largely produced by smallholder farmers, for which poor agronomic practices and weather-related crop failures result in low yields and large pre- and post-harvest losses. According to the Department of Agriculture (DOA) and USDIA's Value Chains For Rural Development project, the sesame production fulfills international quality standards. Still, improved access to credit and better crop techniques are required to enable exports (Winrock, 2019). This fact is in line with the data in this study presented in appendix table A1, which shows that 35% of the farmers in Magway have debts with money lenders, farmers with loans from a public bank in Magway is only one-third of that of the share in the other regions in the dry zone. Finally, it is worth highlighting that efficiency in Magway is heterogeneous, and the lowest efficiency is achieved in the flood area where most of the comments made about the delta zone apply.

The second region in the dry zone is Mandalay. In contrast to the previous divisions discussed, it is both a major agricultural producer and a region with high-efficiency levels. Mandalay region is a semi-arid and flat region. Primary crops grown are rice, wheat, maize, peanut, sesame, cotton, legumes, tobacco, and chili and vegetables (Sellamuttu, Sotoukee, & Mccartney, 2015; DOA, 2018). Hence, diversification appears to be one explanation behind the efficiency in the region. Another reason could be that the source of credit, as shown in appendix table A1, is commonly from traders and rarely from public loans. This debt strategy affects the risk structure of the loan and can be considered a basic form of contract farming. Several authors, such as Kyi (2016) , have recognized the importance of contract farming as a way to increase efficiency among Myanmar farmers. Still, only in the most recent years, the government has taken steps towards formalizing such practices (Thant, 2020).

The last region in the dry zone is Sagaing, where, except for a few specific areas, efficiency is high. Like Mandalay, the share of farmers with loans from traders in this region is high, which could be one of the explanations behind the efficiency. Sagaing has advantageous rainfed conditions in 87.7% of the region (DALMS, 2018) and has diversified production to both rice, wheat, and pulses (UMFCCI, 2019).

The next agricultural zone is the hill zone. In contrast to the previous zones where the inhabitants are mostly Bamar (the ethnic majority in Myanmar), the states in the hill zone have numerous minority ethnic groups. Therefore, their development has been highly dependent on historical and cultural elements. Kachin State is the most northern state, and despite ongoing conflict, it exhibits relatively high levels of efficiency in both models of this paper. Forested land is predominant, but it is advantageously located by the Chinese border. Recently, agricultural production has benefited by a shift from subsistence-based cultivation systems to cash crop-based systems focused on direct exports to China (Thar, 2018). Imports of agricultural inputs from China is another advantage (Dapice, 2016). Moreover, since 2002, the Government of Myanmar has promoted industrial crops in the hill zone, including rubber, coffee, and palm oil in their National Master plan of Agriculture sector, running until 2030 (Woods, 2012). The proximity to China and the shift to cash crops are the two most likely explanations for Kachin's relative efficiency.

The next state in the hill zone is Shan State. It is the geographically largest division in Myanmar, and Figure 1 shows different levels of efficiency within the state, where the west is largely inefficient. Table A1 shows that other parts of Shan State (Shan East and Shan North) have a minimal fraction of the population with access to public loans, while the west has good access to them. In contrast, the relative abundance of community connected loans in Shan State highlights the relevance of community structures in Shan. Besides the incentive roles that has been discussed about the sources of debts, another reason for the low efficiency in western Shan is land degradation, which has been highlighted as a significant problem in the area due to overexploitation of soils (Kyi, 2019). Due to its complex topography and diverse weather conditions, the diversity of crops is common (Corps, 2015). In particular,

North and East Shan State occupy more than half of total production in vegetables, which have a higher yield than commodities from the delta and dry zones (Morris & Soe, 2017).

Kayah State is the next state in the hill zone. It neighbours Thailand and scores high on agricultural efficiency. Kayah's main crops are rice, maize, and sesame (CSO, 2018; KIC, 2018). Farmers in Kayah State rely on conventional farming methods and have limited access to new technology (KSCCI, 2018). As presented in appendix table A1 and A2, almost half of the farmers have family debts, and more than a third of the debt relates to agricultural inputs. These are probable reasons for the high score in efficiency, combined with the proximity to the strong export market in Thailand.

Kayin State is located south of Kayah and has only slightly lower levels of efficiency. It dedicates a major part of its production to paddy and rubber, but also produces sugarcane, coffee, cardamom, and seasonal fruits and vegetables (DOA, 2018). A large share of farmers in this state has loans with both family members and traders, which could be one explanation behind the relatively high efficiency. Another explanation could be that the Kayin government has attempted to increase the production of industrial crops in this state, more specifically rubber, to export it to China.

The last state in the hill agricultural zone is Chin, the poorest division in the country. Despite challenging topography and lack of infrastructure, the evidence shows that agricultural efficiency is relatively high. The state is mountainous, and two-thirds are covered with forest, which makes it more suitable for forestry than agricultural production (BIC, Overview of Chin State, 2018). Most of the rural household farms and are practicing slash-and-burn cultivation (taung yar) on uplands for their food production and income. The current agricultural techniques are known to deteriorate the land quality, and therefore, the government has made attempts to increase awareness about it. Most farmers in Chin State are subsistence farmers, but agricultural production is currently only enough to feed 70% of the population (MIID, 2014). To improve the situation, the government of Chin State has been encouraging farmers to grow permanent crops such as coffee, mulberries, avocado, grape, yam, and apples (MOI, 2019). While conditions are challenging, the statistical results are showing that once the geography is controlled, the farmers are quite efficient, given their limited resources. On a similar note, once prices were adjusted by the purchase parity, Chin farmers earning the highest real income. Therefore, their high productivity can largely be explained by both a price effect and the correction of the geographical conditions. Based on the facts presented, Chin has important potential opportunities, but the improvement of techniques and infrastructure are required to have an absolute efficiency rather than a relative efficiency.

The last agricultural zone is made up of the coastal areas, Rakhine in the west and Taninthary in the south. However, for the sake of the analysis, Mon State is also included in this group due to its similar efficiency values, its product orientation, and the fact that its population is an ethnic minority. Both Mon and Taninthary show high levels of efficiency. These states mostly produce rice, betel nut, coconut, and rubber. However, crop diversification is good, and several other fruits and nuts are also grown (CSO, 2018). Finally, and especially for Taninthary, palm oil is also becoming a major industrial crop (BIC, 2019). Therefore, in these two states, diversification and the focus on industrial crops are likely drivers behind high efficiency values.

The last state is Rakhine. The areas in the state that display very low efficiency in Figure 1 are specially related to conflict zones in the ongoing ethnic conflict. Another explanation behind the inefficiency is likely that the area has suffered from natural disasters in the past years. The state is mostly dedicated to rice, with 85% of the cultivated agricultural land being used for paddy (LIFT L. , 2016). Pulses, especially black gram, are produced in few specific townships such as Kyauktaw, Mrauk-U, Minbya, and Buthidaung townships, and in some areas, chili and vegetables are important (CSO, 2018). Thus, beyond conflict, the lack of diversity can be an explanatory factor of the inefficiency observed in this area.

4. Conclusions

This paper contributes to the existing literature by being the first to construct a measurement of agricultural efficiency that is comparable across the whole of Myanmar. By using two different methods to model efficiency (the SFA and the DEA), the robustness of results could be assured throughout the analysis. The levels of agricultural efficiency were mapped in Figure 1, and it strikes the fact that traditional agricultural production areas (Shan State and the Ayeyarwady river basin) showed low levels of efficiency. Next, the paper investigated the drivers behind efficiency by regressing the efficiency measurements on five groups of covariates. This section showed that enhanced efficiency was associated with increased monitoring by debtors, improved access to credit for agricultural inputs, the social norms that coordinate the use of communal assets, increased diversification of crops, and an emphasis on production on industrial crops. Finally, the paper discussed drivers for efficiency per state and region and established that the result on the national level seems to hold for many areas. Finally, since drivers behind inefficiencies differ between states and regions, the agricultural policy would benefit from being geographically targeted.

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Appendix

Descriptive statistic tables

Table A1. *Average values of group 1 explanatory variables*

Group 1	Borrowed from Family	Borrowed from Trader	Borrowed from Money Lender	Borrowed from Microcredit Institution	Borrowed from Village Saving Group	Borrowed from Pre-Saling	Borrowed from Employer	Borrowed from Private Bank	Borrowed from Government Bank	Borrowed from Private Company
Ayeyarwady	29.86%	33.48%	39.37%	8.60%	0.45%	4.07%	3.62%	0.90%	75.57%	4.52%
Bago East	36.36%	24.55%	34.55%	0.91%	2.73%	6.36%	4.55%	4.55%	67.27%	0.91%
Bago West	38.01%	28.07%	30.99%	2.34%	0.00%	2.34%	2.34%	0.58%	73.10%	1.17%
Chin	70.31%	12.33%	5.79%	11.47%	10.40%	0.64%	2.89%	0.32%	2.68%	0.21%
Kachin	41.07%	10.14%	4.17%	1.79%	3.18%	0.99%	4.77%	0.20%	4.37%	2.39%
Kayah	49.30%	17.50%	11.73%	0.60%	19.09%	0.00%	0.80%	0.40%	10.74%	0.20%
Kayin	40.15%	37.88%	27.65%	1.89%	1.89%	7.58%	1.89%	0.00%	4.92%	0.38%
Magway	30.82%	19.06%	35.06%	7.06%	2.35%	2.12%	0.71%	2.35%	8.47%	0.47%
Mandalay	26.25%	32.56%	30.90%	9.97%	9.97%	1.99%	1.99%	0.66%	23.92%	2.33%
Mon	25.32%	6.96%	20.89%	1.90%	2.53%	0.00%	1.27%	0.00%	13.29%	0.00%
Rakhine	42.31%	28.21%	25.13%	3.59%	10.26%	1.03%	3.33%	0.26%	28.21%	0.26%
Sagaing	35.60%	32.33%	20.71%	3.92%	4.64%	2.42%	1.37%	0.91%	26.91%	0.65%
Shan East	33.59%	2.07%	1.81%	0.00%	1.81%	0.00%	0.78%	0.00%	0.00%	0.00%
Shan North	37.42%	9.35%	12.58%	1.29%	4.19%	3.23%	2.90%	0.00%	0.32%	1.61%
Shan West	36.71%	22.95%	6.52%	5.80%	2.17%	1.21%	2.90%	0.00%	7.97%	1.45%
Tanintharyi	20.67%	13.41%	21.79%	0.56%	1.12%	3.35%	3.35%	0.00%	3.91%	0.00%
Yangon	46.84%	17.09%	41.77%	1.90%	1.90%	3.80%	1.27%	0.00%	75.32%	2.53%

Note: all the variables are directly taken from the FSS

Table A2. *Average values of group 2 explanatory variables*

Group 2	Loans for Agricultural Inputs	Loans for Agricultural Labor	Loans for Productive Assets	Loans for Livestock Breeding
Ayeyarwady	81.45%	42.99%	2.26%	2.26%
Bago East	70.91%	40.00%	6.36%	4.55%
Bago West	89.47%	36.84%	1.17%	1.75%
Chin	1.93%	1.18%	0.32%	2.79%
Kachin	19.44%	9.33%	0.99%	1.79%
Kayah	36.58%	7.16%	0.00%	4.37%
Kayin	11.74%	10.98%	1.52%	1.89%
Magway	37.65%	15.29%	0.00%	0.24%
Mandalay	42.86%	9.97%	3.32%	0.00%
Mon	27.22%	15.82%	2.53%	1.27%
Rakhine	27.95%	32.05%	2.56%	4.87%
Sagaing	31.29%	16.92%	1.05%	0.85%
Shan East	2.33%	3.10%	0.52%	0.52%
Shan North	16.77%	7.42%	0.00%	1.29%
Shan South	37.68%	4.59%	0.48%	0.97%
Tanintharyi	10.06%	7.82%	0.56%	0.56%
Yangon	80.38%	64.56%	5.06%	4.43%

Note: all the variables are directly taken from the FSS

Table A3. *Average values of group 3 explanatory variables*

Group 3	Producers of Cereal Crops Roots and Tubers	Producers of Industrial Crops	Producers of Oilseed Crops	Producers of Pulses	Producers of Vegetables and Aromatic Crops
Ayeyarwady	91.40%	0.00%	2.26%	36.65%	7.69%
Bago East	90.91%	1.82%	11.82%	68.18%	2.73%
Bago West	85.96%	3.51%	36.26%	59.65%	5.85%
Chin	86.92%	2.68%	13.50%	6.43%	47.05%
Kachin	84.13%	11.71%	13.49%	2.58%	31.15%
Kayah	94.04%	0.60%	23.26%	22.86%	13.32%
Kayin	60.98%	31.44%	13.26%	9.47%	23.11%
Magway	53.18%	9.88%	87.29%	64.94%	1.41%
Mandalay	43.85%	12.29%	68.11%	50.17%	33.55%
Mon	68.99%	38.61%	3.80%	8.23%	9.49%
Rakhine	87.69%	3.33%	22.56%	2.82%	18.46%
Sagaing	83.28%	2.74%	42.98%	30.63%	14.17%
Shan East	98.71%	1.55%	13.44%	3.10%	13.70%
Shan North	95.81%	14.19%	13.55%	4.84%	6.77%
Shan West	88.16%	1.45%	26.57%	21.01%	37.68%
Tanintharyi	52.51%	34.64%	0.56%	3.35%	31.28%
Yangon	88.61%	0.00%	4.43%	56.33%	6.96%

Note: all the variables are directly taken from the FSS

Table A4. *Average values of group 4 explanatory variables*

Group 4	Fraction of Owned Livestock	Fraction of Owned Tools	Fraction of Owned Land
Ayeyarwady	0.098	1.069	0.893
Bago East	0.574	1.999	0.922
Bago West	0.017	2.203	0.946
Chin	-0.104	-1.545	0.950
Kachin	1.339	0.588	0.940
Kayah	0.286	0.542	0.936
Kayin	0.151	-0.361	0.894
Magway	-2.079	-1.954	0.938
Mandalay	-2.079	-1.954	0.931
Mon	-0.742	0.295	0.936
Rakhine	0.224	-0.322	0.859
Sagaing	0.161	0.568	0.941
Shan East	2.136	1.082	0.977
Shan North	0.453	0.693	0.942
Shan West	-0.041	1.022	0.918
Tanintharyi	-0.902	-0.910	0.941
Yangon	0.366	2.304	0.883

Note: to calculate the ownership fraction of a particular asset, the number of units own is divided by the total number of units. However, for tools and livestock, a principal component analysis was performed to the different items in each category and the first category is reported, where higher values are correlated with higher degrees of ownership.

Text ISDRS 2020 track 5f **Is an alternative to private property sustainable in agriculture?**

"How, in a few hundred years, has it been possible to sweep away millennia of predominantly collective, if not common, land management?" (Terre De Liens website)

Since 1945, European agriculture has been losing farmers in all the Member States, while the average farm surface area has increased. The agro-industrial model seems to be triumphant everywhere. Yet many indicators are demonstrating its limits (soil fatigue, desertification of rural areas, effects of pesticides on farmers' health, poisoned ecosystems…). In the face of these observations and the imminence of events threatening this agricultural model, the aim of sustainability presents alternative development paths for agriculture. They suggest creating small to medium-sized farms, applying agricultural practices that preserve ecosystems, labour-intensive and connected to local markets. Some new business models already running (e.g. selling through AMAP[1]), but the main challenge remains the access to land, especially for the newcomers. Indeed, setting up new farmers is a necessity because the transformation will never be fast enough if we count on current farmers only. For instance in 2017, land under organic farming represents between 0.2% (in Malta) to 23% (Austria) of the cropland, i.e. on average 7% of Member States' croplands (EU, 2019). Welcoming new farmers is also a social necessity in rural areas. So, this research deals with the issue of the alternative to private property of land, such as experienced by "Foncière Solidaire" created by the "Terre de Liens" association in France, which collectively buys land (14 700 shareholders, end of 2018) to lease them to new farmers on a long-term basis. The research question is therefore: "Is this alternative to private property of land sustainable?" Sustainability means the survival of farms, despite the ongoing upheavals. In accordance with the works by Mignon (1998) and Macombe (2003) about the survival of farms, we suggest that the values are the key, and that values leading to survival describe a certain concept of justice. In practice, the rationale should be consistent with the six axioms of the Grammar of Justice by Boltanski and Thévenot (1991) when applied to a Local Common Good (Thévenot, 1993). The whole movement cannot last without the association Terre de Liens being permanent itself. We will highlight that the discourse (official communication) of the Terre de Liens association calls on Justice, being consistent with the six axioms. The Grammar of Justice's axioms are as follows:(a1) There is a common humanity ; (a2) There are different states among people, and they are not stable ; (a3) All the states are accessible to all ; (a4) There is an order among the states : The Grand who contribute to the Common Good, and the Petit, who do not ; (a5) To become Grand, there is a necessary effort ; (a6) There is a Common Good which benefits all (Petit and Grand) whatever their contribution. We also highlight that the main challenges are the changing regulations, and especially the European laws and French annual financial laws, which set the rules for fiscal exonerations. Whatever these changes, it is likely that the association would survive, because of the high number of actors (districts searching for farmers, applicants for taking up or transferring farms, donors, shareholders) governed under its "Fair" raison d'être. In conclusion, yes, there is a sustainable alternative to land private property in agriculture.

Key-words: private property-alternative-new comers-access to land- collective property

Introduction

European agriculture has been losing jobs since the end of the Second World War, and farm numbers are continuously decreasing. The average annual rate of decline between 2005 and 2013 stood at 2%

[1] An AMAP is an association of consumers bound to a local producer by an agreement providing for bulk delivery of vegetables.

for the EU-27, but is slowing down in the older Member States (EU-15: -0.9% per year) (Figure 1). For the period 2010-2018, the rate is -1.25% per year for the EU-27.

Figure 1: Decrease in the number of holdings in the EU from 1975 to 2013, by country (Source: Farm structures EU 2019; https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/farming/documents/farm-structures_en.pdf)

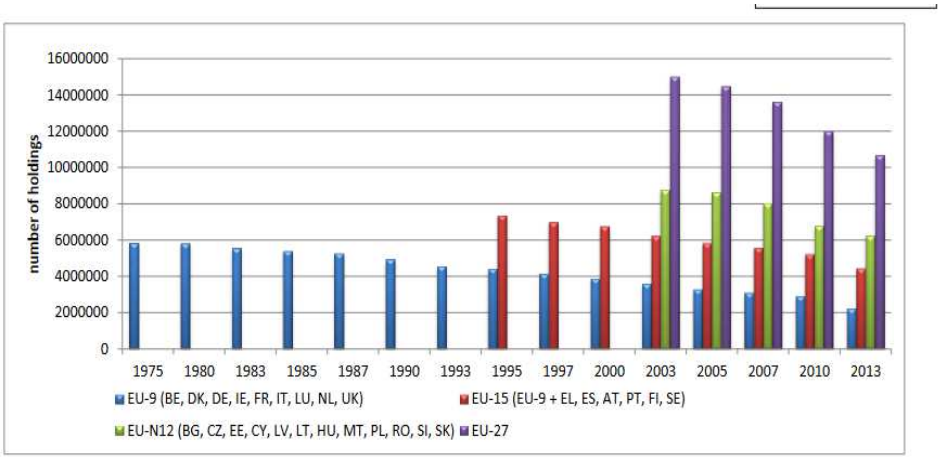
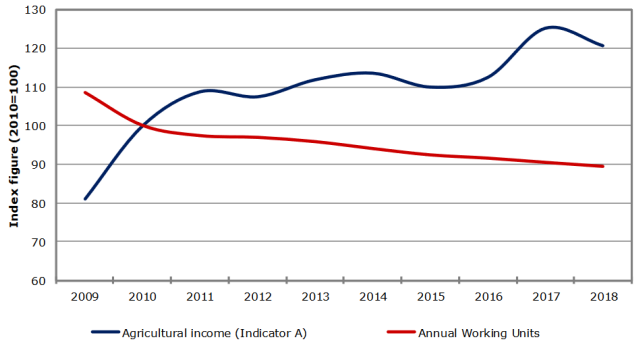


Figure 2: Farmers' income and Labour development index in EU agriculture. (Source: Statistical factsheet, June 2019, European Union, Stat 2019).



The overall decrease in the number of farms is mainly linked to expansion, which for a long time seemed to be the only way to save farmers. Indeed, only large farms were profitable (in purely financial terms) in response to the constant political and regulatory pressure in favour of industrialised agriculture based on mass production, the agro-industrial model. The effects of expansion are well-known in rural areas: drastic reduction in the number of agricultural workers (Figure 2), desertification of the countryside, disappearance of services to the population, advance of wastelands, risk of fires, etc. Today, social requirements for sustainability (rejection of pesticides, desire for locavorism...) and new biophysical threats to agriculture (crop loss due to climate change) are challenging the agro-industrial model. To replace it, two new models are being developed. The first does not renounce mass production, and advocates so-called agro-ecological practices. These assume that farmers design their production systems (e.g. crop diversification and extension of rotations, establishment of hedges) based on the functionalities offered by ecosystems, while reducing pressures on biodiversity (Alim'Agri, 2013). The second model renounces mass production in favour of agricultural or food products that are distinguished by their qualities (AOC, AOP, IGP, organic etc.). This agriculture can be practiced on smallholdings (market gardening, fruits, orchards, small livestock) or medium farms (traditional livestock, cereals, seeds, oils), provided that newcomers are established.

This second model makes it possible to densify the rural fabric, renovate buildings and provide decent jobs for new agricultural workers, while almost 16 million Europeans are unemployed (Eurostat, 2019). Multiple trials show that these alternative models work and continue to work. Yet the main obstacle to the settlement of newcomers is access to land. Proposals for the rental of residential and operational buildings and associated land are rare. Agricultural land prices are very uneven in Europe, and it is impossible for many prospective settlers to buy a farm. In this case, it is worthwhile to propose alternatives that make it possible to establish newcomers under long-term leases, without imposing the burden of land ownership on them. Are these alternative systems sustainable? The purpose of this paper is to contribute to the discussion, based on the case of a French associative system of collective ownership of agricultural land.

Method

To study the case of the “Terre de Liens” association (TDL), its associated pillars “Foncière solidaire” and the “Foundation”, from a sustainability perspective, we rely on works on the sustainability of companies. The meaning of “sustainability” is taken here from the point of view of the likelihood of farm survival, despite the current upheavals. In fact, it questions the survival of TDL itself as an association, since the movement as a whole cannot last without it (explained below). In accordance with the works by Collins and Porras (1994) and Mignon (1998) about survival of firms, we suggest that the values are the key, and that values leading to survival describe a certain concept of Justice (Macombe, 2003). In practice, the rationale leading to survival are consistent with the six axioms of the Grammar of Justice by Boltanski and Thévenot (1991) when applied to a Local Common Good (Thévenot, 1993). For instance, the local common good can be “an environmentally friendly agriculture" or somewhere else "an exporting agriculture", or "a particular endangered cow breed”. We will seek calls for justice in the rationale (official communication) of the TDL association, which are consistent with the six axioms. The Grammar of Justice axioms are as follows: (a1) There is a common humanity ; (a2) There are different states among people, and they are not stable ; (a3) All the states are accessible to anybody ; (a4) There is an order among the states : The Grand who contribute to the Common Good, and the Petit, who do not ; (a5) To become Grand, there is a necessary effort ; (a6) There is a Common Good which benefits all (Petit and Grand) whatever their contribution. After a short presentation of the features of TDL, we will check the consistency between communication (from the website) and the axioms of the Grammar of Justice. Finally, we will set out the present challenges experienced by the association.

Case study

The TDL association was created in 2003, out of the desire of several French actors (from popular education, organic and biodynamic agriculture, ethical finance, solidarity economy and rural development) to influence the evolution of agriculture. It has helped many neo-rurals get established since 2003. Noting the difficulty of would-be new farmers, TDL created “Foncière Solidaire” (a social and solidarity economy company, a limited partnership with variable capital shares) at the end of 2006, and in 2013 a “Foundation” recognized as a public utility (which mainly receives farms as donations and legacies). These two structures purchase the land on which a would-be farmer is bidding, and lease it according to the status of the environmental rural lease (which guarantees ecological practices), in the long term. For the “Foncière”, the funds come from joint and several shareholders (14,707 at 31/12/2018) who are natural or legal persons under private law. The “Foncière” also collects employee and institutional savings (e.g. Caisse des Dépôts et Consignations).

75% of the funds are used to collectively purchase the land, while 25% remain on the reserve to reimburse shareholders who wish to withdraw. When a candidate for installation has located land, his file is examined by TDL. In case of acceptance (80% of cases), TDL launches a public subscription to buy the domain in question. To date, TDL have created 200 farms, out of 5,000 ha that belong collectively to the “Foncière Solidaire” and/or the “Foundation”. The type of farms that can benefit from this scheme was clarified in 2018. They must respect the following four criteria: the values of the TDL charter, the specifications of organic farming, the values of the smallholding charter, and develop mainly food production (Annual Report, Assemblée générale Foncière Solidaire, 2018). Farmers set up with the help of TDL form a network, supported by numerous local actors, which increases farm survival (Bloch et al. 2012). The “Foncière” undertakes never to resell any of the land acquired, and systematically seeks a buyer in the event of the termination or departure of the farmer in place. It should be noted that TDL also provides legal support for management, and communication (classifieds site) for the many local authorities who are looking for candidates to settle on their own land. In 2019, ad traffic (land demand/disposition) represents three to five ads per day.

Results

We analyzed the texts presented on the TDL website (including the movement's charter) according to the grid provided by the Grammar of Justice of Boltanski and Thevenot (Table 1). We deliberately use the same vocabulary as TDL, although many terms would require discussion or definition.

Table 1: Axioms of the Grammar of Justice and illustrations from the website of TDL (December 2019)

No.	Name of the axiom	Extracts
A1	There is a common humanity	"It wishes to enable **everyone** to exercise their responsibility[-] towards the land that they consider[-] as a common good" (charter) "Enable **citizens**, individually and collectively, to exercise their responsibility for the use made of their territory, in particular with regard to agricultural and food matters" (charter)
A2	There are different states among people, and they are not stable	"More than 200 farms disappear every week in France, particularly in favour of **ever larger agro-industrial farms**" "Local agriculture, through its local roots, is at the heart of this dynamic: it is based on **farms on a human scale** and makes it possible to build relationships between citizens and farmers who produce our food".
A3	All the states are accessible to all	"These tools are **within everyone's reach**, so that **everyone** can become effectively involved in the future of our farms and agriculture. » "**Popular education**: creating conditions for volunteers to act[-]" (charter)
A4	There is an order among the states : The Grand who contributes to the Common Good, and the Petit, who does not	TDL was created to "**free the land** from land and real estate **speculation** [-], support **environmentally friendly** agriculture" (website and charter). "This land is definitively emerging from the **speculative market**, is guaranteed to be maintained in the long term in its agricultural vocation and is ready to welcome new farmers with farming practices that **respect** the soil and the environment.” "More seriously, a small number of farms continue to expand by **taking up land resources**, **to the detriment** of young farmers who are discouraged by the difficulties of setting up.” "give meaning to your money by focusing on its exchange value, encourage transparency and **combat speculation**" (charter) "Favour setting up new farmers over expansions" (charter) "Stop the **disappearance and destruction** of agricultural land" (charter)

A5	To become Grand, there is a necessary effort	"to create conditions for volunteers to be able to act [-] in a **lucid, responsible and autonomous manner** and to participate in the social transformation towards a freer and more just society. " (charter) "The purchase of a farm is a **long process** in several stages: monitoring and identification of opportunities, valuation of assets, project appraisal, financial arrangements, legal and administrative arrangements for transactions."
A6	There is a Common Good which benefits to all (Petit and Grand) whatever their contribution	"To consider **the land** as a **living and inalienable common good** to ensure the food sovereignty of the populations" (charter) "The land that they consider[-] as a **common good**" (charter) "Without agricultural land, there can be no peasants or local agriculture that respects the environment and creates links"

If the extract comes from the TDL charter, this is mentioned. All other excerpts are taken directly from the TDL website.

It appears that TDL recognizes a common humanity of citizens (axiom a1) in relation to the agricultural issue, and that land is the common good that benefits all, because it ensures the food sovereignty of populations (axiom a6). There are several "states" linked to different types of farms and people who favour either the agro-industrial model or the local agricultural model (axiom a2). These states are ordered: the Grand are those who fight against speculation, and stop the disappearance and destruction of farms; different kinds of Petit are those who speculate or support agro-industrial agriculture (axiom a4). Citizens can access all states (i.e. support any of the models). In particular, TDL has invented mechanisms that allow everyone to support the local agricultural model (axiom a3). Accessing the state of Grand (supporting local agriculture) requires personal investment (training to become voluntary, lucid, responsible, autonomous, capable), and the provision of farms is a "long process" (axiom a5). The six axioms of the Grammar of Justice are therefore clearly stated by the TDL movement. In accordance with the work mentioned above, we can conclude that - from a values perspective - TDL presents a rationale that is compatible with the sustainability of its activities.

Challenges

What are the challenges for the association? Looking back over TDL's history shows that governance issues are well addressed over time and with experience. The result is a fairly complex system for the layperson, but transparent (there is a diagram on the website) for managing and monitoring of all activities. On the other hand, the number of employees remains modest because many tasks are carried out by volunteers. However, specialisation (e.g. tax) and the growth of activities require new hiring. Through the activity reports of "Foncière Solidaire" and the "Foundation", it is clear that the constant fluctuation of legal provisions on the regulation of shareholding, donations, and especially on taxation (possible tax exemptions) that apply to shareholders are permanent subjects of concern. The rules concerning the nature of the savings that can be raised, the limits on annual subscription, the ceiling and the rate of tax exemptions, are challenged almost every year, threatening "Foncière Solidaire's" land acquisition model (through public savings calls). In response, TDL adapts its underwriting rules annually, and carries out ongoing lobbying work with French parliamentarians, directly and through its members. As long as the influence of TDL and the other French Solidarity Owners associations concerns a marginal fraction of the land released each year, they do not disturb the powerful interests of real estate or land speculation. The land targeted by TDL is too small (average of 23 ha per farm) to be of interest to investment funds, for example. Yet, the movement is growing (with other initiatives also, see de Haas, 2007), and could come up against a regulatory and fiscal wall. However, despite a probable slowdown in acquisitions, TDL is set to continue its assistance to local

authorities and its spin-offs to other French and foreign structures. Belgium, Germany, the United Kingdom, Spain, Italy and Lithuania are developing similar structures. The formula of “Foncière Solidaire” and the “Foundation” seems likely to develop strongly, as long as the legislator allows them to do so.

Conclusion

Compiling data for the entire planet, it appears that the number of agricultural workers per country is inversely proportional to the amount of energy available per capita. Ongoing climate change will force - voluntarily or involuntarily - societies with high energy costs to ration themselves. In a harmonious society (which provides daily food for all), the gradual decline in the energy available per person is likely to accompany a steady increase in the number of farmers. An initiative such as TDL's is preparing for these developments. TDL not only organizes the preservation of agricultural land, but also anticipates the generalization of crop/livestock systems that consume less inputs and are more labour-intensive, which will become more widespread in the future. Also, TDL’s way of working could be a model pathway towards forests protection, which seems to be less developed in France to date (despite some trials like the “groupement forestier citoyen du chat sauvage”, in the Morvan region). There is therefore a sustainable collective alternative to individual ownership of agricultural land, the future extent of which depends on future policy decisions.

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Innovation Levers

Localizing SDGs to leverage policies through stakeholder engagement: a new research project in the Metropolitan City of Bologna, Italy

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Abstract

The Metropolitan City of Bologna, since its establishment, has been at the forefront of Sustainable Development (SD). Following the G7 Environment Ministerial meeting held in Bologna in 2017, the authority promoted the Bologna's Chart for the Environment, which is rooted in the international principles of the UN 2030 Agenda, and has then set the environmental, economic and social sustainability as fundamental principles of the 2018 Metropolitan Strategic Plan 2.0. With the purposes to guide the future political line and the metropolitan development according to the Sustainable Development Goals (SDGs), a new research project aimed at creating a Metropolitan Agenda for SD 2.0 has been recently started. The novelty of the project, carried out by a multi-disciplinary working group, lies in the meaningful stakeholder engagement that is operated in each work phase. The construction of a local Agenda for Sustainable Development aims to provide a shared set of goals, integrated by tools and actions for the implementation, to all the territorial stakeholders belonging to different sectors. Hence, this paper intends to present the context of development, the experimented methodology, and its value of including public, private, and civil society entities both in the drafting progress and in the following stages. The project is not limited to a good practice of localization of the SDGs: it aims at offering a model to be scaled-up in other Metropolitan realities.

Keywords: Local government, Metropolitan Agenda, Metropolitan City, Sustainable Development Goals, Urban Sustainability

1. Introduction

The launch of the Decade of Action by the United Nations (UN, 2019) marks the beginning of the remaining ten years period for the achievement of the 2030 Agenda and its 17 Sustainable Development Goals (SDGs). Since the adoption of the Agenda in 2015 with General Assembly resolution 70/1 (UN, 2015), different stakeholders have been increasingly involved in the action plans aimed at building a more sustainable future, as expressed at paragraph 52. The discussion has hence been extended to the private sector, civil society, and higher education (HE) institutions, as well as local governments and authorities. Even though it is still uncertain how to structure, monitor, and asses the contribution of the latter (Siragusa et al., 2020), it appears evident how their integration to international and national efforts towards SDGs is pivotal.

This paper proposes to present an innovative research project currently carried out in the context of the Metropolitan City of Bologna, Italy, aimed at the definition of a Metropolitan Agenda for the Sustainable Development 2.0. The project constitutes a virtuous practice of localization of the SDGs (Jones and Comfort, 2020; Valencia et al., 2019). This localization is to be holistically understood in order to include all local actors through a territorial approach, as called up inter alia by the UN system (UN Development Programme et al., 2014), and to encourage the adoption of SDGs approach in policies processes and in local entities' management.

Although this contribution is offered from the perspective of the researchers of the University of Bologna, which for years has implemented a governance strategy based on the SDGs (Paletta and Bonoli, 2019), the working group is composed of a variety of actors that well exemplify and enhance the peculiarity of the project: leveraging policies through SDGs by virtue of stakeholder engagement (Rau et al., 2018; Clark et al., 2016).

The Metropolitan City is a peculiar administrative division of Italy with constitutional rank that became operative in 2015 with Italian Law n. 56/2014 (Italian Republic, 2014), whose territory corresponds to the previous homonymous Province. The Metropolitan City of Bologna aggregates the capital with 54 municipalities (51 of which gathered in 7 Unions) and counts1,014,619 inhabitants, 12% of which are foreigners, according to the National Institute of Statistics (ISTAT, 2019a), as on January 1st, 2019.

The area, covering 3,702.3 km^2, is interested by 42% of flat land, 37% of hilly land and the remaining 21% of mountainous terrain (ISTAT, 2014). Situated at the Southern ending of the Po Valley, the area presents a prosperous productive fabric (Infocamere, 2018) ranking first among the 14 Metropolitan Cities in Italy for work activity rate (ISTAT, 2019) and second to Milan for average income (MEF, 2017).

By statute, the Metropolitan City of Bologna is defined as wide-scale local entity and has competence with regard to strategic planning; environment and territorial planning; economic growth and social development; mobility and infrastructures, and services to the municipalities (Conferenza Metropolitana di Bologna, 2014). The authority is therefore in charge of identifying and coordinating development strategies for the whole metropolitan area, in close cooperation with the higher authorities (National and Regional) and the lower ones (Municipalities and Unions).

Since its early life, the Metropolitan City of Bologna has been at the forefront of sustainable development (SD). In June 2017, in the occasion of the G7 Environment Ministerial meeting held in Bologna (Paletta et al., 2019), the Metropolitan City promoted the "Bologna's Chart for Environment" signed by twelve Italian Metropolitan Cities (Città Metropolitana di Bologna, 2017a). The Chart is rooted in the international principles of the UN 2030 Agenda and aims at translating them into virtuous local practices. Specifically, it identifies eight topics related to the SDG n. 11 Sustainable Cities and Communities, and it sets out commitments linked to the European Union (EU) policy guidelines (Città Metropolitana di Bologna, 2017b), it indicates measurable goals and targets and defines the "national perspectives": all necessary conditions for the Metropolitan Cities to achieve those goals. Strengthening its commitment, the Metropolitan City of Bologna has placed environmental, economic, and social sustainability as first of the foundational principles of the 2018 Metropolitan Strategic Plan 2.0 (MSP) the operational guidance tool for the authority. The MSP constitutes the most important document for building a Metropolitan City: it responds to a vision of collaborative action connecting institutions with civil society and other participants of the economic area, and of intervention according to the varying nature of different geographic areas with attention to their vulnerabilities, specific features and role they play (Città Metropolitana di Bologna, 2018).

With the aims to guide the future political line and to enhance the grounds of its policymaking, following a national call issued by the Italian Ministry for Environment, Land and Sea Protection, the Metropolitan City of Bologna has commissioned, the research project on the metropolitan development according to the "Agenda Metropolitana di Bologna per lo Sviluppo Sostenibile 2.0" (Bologna Metropolitan Agenda for Sustainable Development 2.0, referred to hereinafter as Agenda 2.0 or the project).

The paper is structured as follow. The next paragraph will deal with the context of development of the project through the listing of objectives and the composition of the working group, followed by the explication of the methodology and its implications. The expected results will then be outlined, together with the identified weaknesses, and the inputs-outputs relationship of the project. Finally, few conclusions will be drawn based on the first results.

2. Methods

2.1 The context

Since its constituency in 2015, the Metropolitan City of Bologna, in its function of coordinating the overall governance action of the metropolitan territory (Italian Republic, 2014), has aimed to become a focal point for sustainable development for Municipalities and other local divisions, enterprises, civil society organizations, and citizens. This action has been translated into a series of documents and tools, which have been progressively adopted by its government bodies. Following the mentioned Bologna Charter for the Environment, Bologna has published the Metropolitan Strategic Plan 2.0 (MSP, 2018), which incorporates sustainability as funding pillar of its actions, and has been complemented by the first Metropolitan Agenda for Sustainable Development (Città Metropolitana di Bologna, 2019) in March 2019 that mainly deals with environmental sustainability.

The Agenda 2.0 is therefore conceived as a further development of the first 2019 Agenda and will constitute an addition to the Metropolitan Strategic Plan. It will also be directly connected to the corresponding tools at higher level, namely the Emilia-Romagna Region Strategy for Sustainable Development, which is currently being designed, and the National Strategy for Sustainable Development (SNSvS MATTM, 2017). Besides, the project acquires relevance under two profiles: the final product and the process of co-design and dissemination.

First, the Agenda 2.0 as a final product will encompasses the following complementary contents:

i) a comprehensive analysis of existing policies, plans, and actions based on the regulations in force, together with voluntary initiatives related to the 2030 Agenda;
ii) the identification of specific goals tailored on the metropolitan context;
iii) a set of indicators to monitor the progresses towards the achievement of the SDGs at the local level;
iv) focus boxes and hints meant to support the local authorities to design, monitor and report key actions to be implemented towards the SDGs through a multi-level approach.
The document will also be translated into a handy on-line tool to be accessed by all the Metropolitan stakeholders willing to put forward actions on SD, inspired by concrete goals and indicators shaped on each peculiar environment. These tangible outcomes will necessarily require a harmonized line of communication to be easily intelligible to a plurality of users.
In second place, it is appropriate to observe the process, which will lead to the final product, since it forms an integral part of the project's identity. Hence, a participative process of designing is an essential condition to reach the aim of effectively leverage cross-cutting policies. The fully participative nature of the design emerges from both the composition of the working group and the engagement of a plurality of local actors, which characterizes the entire project. In fact, in order to implement the research project of the Agenda 2.0, is it fundamental to embrace an approach based on a multi-disciplinarity, inter-disciplinarity and trans-disciplinarity, that have demonstrated to be essential for sustainability discourse and to achieve sustainable development (Otto and Wohlpart, 2009; Leal Filho, 2015) since it brings together a wide range of perspectives and solutions (Azeiteiro et al., 2015; Milutinovic and Nikolic, 2014; Mintz and Tal, 2014).

2.2 The working group: composition and functioning

The working group arises from a partnership within a multi-disciplinary team, intended to embrace the three dimensions of sustainability (social, economic, and environmental) while adequately relate with stakeholders at all levels.
The working group is thus composed as follows. ASviS, the Italian Alliance for Sustainable Development, includes 227 organizations active in SD actions (ASviS, 2020), publishes an annual report on the state of art of SD in Italy, and elaborates composite indicators for the EU member States, Italy and its 21 Regions and Autonomous Provinces.
Urb@nit, the National Center for Urban Policies Studies, gathers 16 Universities with SIU – Italian Society of Urban Planners, publishes an annual report on cities since 2016 and researches on urban sustainable development (Urb@nit, 2020).
The group is completed by two departments of the Alma Mater Studiorum – University of Bologna (UNIBO), namely the Department of Management (DiSA) and the Department of Civil, Chemical, Environmental and Materials Engineering (DICAM).
The University of Bologna has acquired an extensive experience in environmental sustainability, in social and gender reporting and has developed the cultural, methodological, and technical bases to develop a peculiar approach to sustainability (Paletta et al., 2018 e Calvano, 2017).
Specifically, the two university departments shared the research activity on socio-economic aspects of the 2030 Agenda and on the environmental ones, respectively and the other partners oversee the data collection and quality check, and of alignment of the workflow, respectively.
With regard for the work schedule, the research project kicked off in March 2020 and is designed to last twelve months, until April 2021. The official start comes after an informal consultation process among the involved parties and a methodology test conducted within the working group.

2.3 Phases of the project

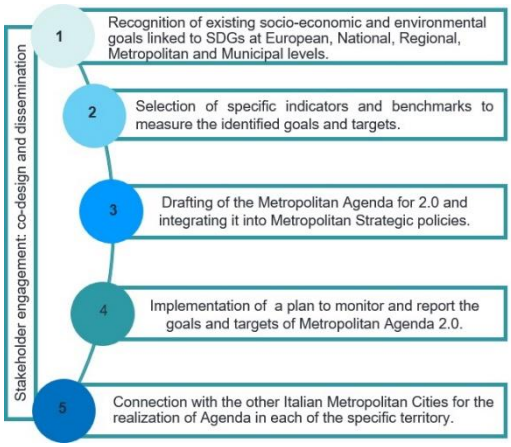

Figure 1. *Phases of the project.*

Figure 1 shows the 5 phases of the project corresponding to the intermediate objectives to be reached along the implementation period. The first phase consists of a full activity of recognition of existing socio-economic and environmental goals linked to the SDGs considering a variety of ordered levels: on one side the European dimension, the National dimension and the Regional (Emilia-Romagna) dimension; on the other side the Metropolitan, the City and the Municipality ones, when applicable. The recognition is carried out through the analysis of a set of documents that has been previously agreed upon by the directorates of the Metropolitan City together with the working group and, for the Regional and the City dimensions by the respective structures and administrative bodies. The set includes current regulations, policy programs, strategic plans, and monitoring tools and reports. The identified goals are inserted into a chart which will be comprehended in the outcome materials for the purpose of working as a starting point for future recognitions. While the recognition of the environmental goals is built upon the previous research that led to the 2019 Metropolitan Agenda for SD, the socio-economic ones are identified *ex novo*.

The method of recognition has been preliminarily tested in the first month of project, aimed at drawing a picture of the current state of art on the goals linked to the SDGs as set at the abovementioned levels. A draft table has been produced to empirically verify the recognition's quality in its applicability to a general range of sources. Indeed, the broadness of documents to extract goals from, including both technical analysis and political plans, requires a versatile form to contain a diverse list of data. The final version of the table, currently in use, an example of which is shown in Table 1, collects data for socio-economic and environmental goals according to each SDGs. Specifically, it let the researcher to classify, with a sheet for each level of analysis (international, European Union, national, and regional, metropolitan, municipal):

a) the precise placement of the goal within a given document (section, chapter, and page);

b) the related target of the 2030 Agenda;

c) the quantitative or qualitative goal as expressed in the document;

d) the linked indicators and their source;

e) the unit of measurement of data, and the last available data when present, with the indication of the historic series;

f) the list of concrete actions to reach c).

Table 1. *Example of table for recognition phase (SDG 7, EU level)*

Document (section, chapter, page)	2030 Agenda target	Quantitative or qualitative Goal	Indicators (source)	Measures (last available year)	Actions to reach the Goal
DIRECTIVE (EU) 2018/2001 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 on the promotion of the use of energy from renewable sources (Clean energy for all Europeans package), art. 3.1 Link	7.2	To reach, within 2030, at least 32% of renewable energy	Share of renewables in gross final energy consumption (Eurostat)	EU 28: 18% (2018)	Member States set national contributions for a collective achievement of the binding EU goal for 2030. The contributions are set in the Integrated National Energy and Climate Plans in compliance with EU Reg. 2018/1999 (art. 3.2).

The second phase addresses the identification of a group of indicators suitable for measuring the achievement of the given goals, among those that are already available. Possibly, this phase would give rise to an adjustment of the goals already determined. Once the indicators are set, they are aligned with the main policies of the Metropolitan City.

Thus, starting from these provisional results, a broad, continuous consultation with stakeholders is initiated. With the purpose of sharpen the set of goals and indicators and to make it consistent with the existing policies and actions, a variety of meetings are convened in a permanent platform of dialogue connecting the working group with the local actors. Hence, the managers in charge of specific areas and sectors of the Metropolitan Authority (such as mobility, education, environment, welfare) are invited to give feedbacks on the provisional work. At the same time, they are encouraged to carry a recognition themselves throughout the inputs provided by the publicly owned companies, the public-private companies, as well as by the trade associations. This mechanism, which includes representatives of Municipalities that have enforced interesting regulations on sustainability, generates a virtuous circle featuring all consecutive actions.

The indicators are gathered from: • European institutions collecting official statistics (Council of the European Union, 2009), • National Statistical System (NSS, 2020), • Intergovernmental Organizations, universities, and research centers or institutions, • Local administrations, • NGOs, independent organizations, and foundations (Siragusa et al., 2020). Arguably, this operation needs to take into consideration the availability of data at the different levels to ensure a possible, visible, and significant comparison of the current trends. To this extent, the absence or the scarcity of data linked to a given indicator might possibly result in a re-definition process of the identified goal.

The following phase aims at facilitating the integration and the management of the Agenda 2.0 goals within the group of tools of local planning. While the Agenda 2.0 is meant to monitor the contribution that the Metropolitan City can provide to the goals set at higher levels, it is also required to well integrate with the existing tools. To achieve this ambitious result actions are required both during the drafting and after it. The co-designing process includes an active and constant engagement of the stakeholders that will be later scrutinized. Once the Agenda 2.0 will be out, its goals will have to be included in the local programming documents (e.g. strategic plans, balance previsions) of Municipalities, along with sectoral plans of management and local development. Finally, different responsibilities, such as political line, planning, management and reporting, will be defined in compliance with the current legislation.

The next step points at turning the Agenda 2.0 into a dynamic and evolving tool of direct applicability, rather than a theoretical analysis to be further converted into actions. Thus, the elaboration of a monitoring system of the given set of goals and indicators will go through the designing of a scheme directed at:

i) measuring the performance of the chosen indicators in comparable time series from the most recent data at a Metropolitan level and, if possible, at the European, national, and regional ones;

ii) analyzing the tendency of the indicators as related to Unions of Municipalities and single Municipalities;

iii) supporting Municipalities, their organizations belonging both to private sector and civil society and their citizens in the process of positioning the Agenda 2.0 goals in their realities.

The scheme will be available to all the interested parties through an on-line platform.

The fifth phase completes the research methodology through the delineation of a chart that sets benchmarks of the Metropolitan Agenda for SD 2.0 to be considered in the conduction of the same research project in other Italian Metropolitan Cities. The chart brings to an effective localization of the SDGs considering a network at a national level. Together with it, a system to foster an exchange of good

practices will be established. Indeed, the project tends to realize a comparable model for other local communities, also through the analysis of relevant case studies and experiences in Italy and beyond.

The action of stakeholder engagement, running throughout the whole project, deserves some clarifications. In first place, the participative process is conducted *in itinere* by way of meetings, seminars, roundtables, workshops, and focus groups. Some open doors seminars are also foreseen with the aim of broaden to the highest extent a meaningful inclusion of stakeholders.

This involvement consents on one hand to widen the impact of the Agenda 2.0 in all sides of the multifaceted local society, on the other hand to strengthen its effectiveness and validity and therefore to ensure its feasibility. In particular, the discussions with the administrative structures of the Metropolitan City will entail:

a) assessments of the proposed set of goals and indicators according to documents and strategic tools that have not been adopted yet but are still being drafted by governing body or technical committees;

b) criticisms on whether the proposed goals are too/not enough ambitious given the related tendency;

c) sharing of data from private sources;

d) insights on valuable practices, initiatives and experiences of well-doing conducted by both public and private entities.

The engagement endeavors to smoothen the final decisional phase of approval and adoption of the Agenda 2.0 by the governing bodies of the Metropolitan City. The outcome of the project will greatly benefit from this essential flow of actions that is intrinsically part of the research methodology.

3. Results and Discussion

The examinations of results and its discussion undoubtedly needs to consider the experimental nature of the research and its current execution. At this stage, expected results are to be extracted from the work plan, along with the methodology trial.

The first cluster of results derives from phases 1-2 and deals with the work of recognition of goals and the subsequent identification of those to be included in the Agenda 2.0. Accordingly, the project will point out and enhance the interaction of different ranks of multilevel governance bodies involved in the overall process. Then, the acknowledgment of existing socio-economic and environmental goals linked to the SDGs and set a local level will help to determine the missing ones and therefore to indicate possible integrations.

The choice will fall on those comprehending available indicators and then will lead to the designing of the core part of the Agenda 2.0.

The consecutive step to take is to highlight the correlation between goals and indicators for which data are available at the metropolitan and municipal levels. Once identified, these indicators are to be associated with ongoing policies put in place by the Metropolitan Cities and the Municipalities in order to assess their performance, also in relation with the budgetary and administrative documents. This is an essential component to build an accountable mechanism of assessment to build future actions upon.

Moving onto phase 3, the integration of the provisional content of the Agenda 2.0 into the metropolitan strategic and sector planning, is functional to ensure a harmonious and effective performance of the Agenda 2.0 itself in its life after completion.

Since the first consultations conducted to reach that result, the exchanges have demonstrated their usefulness. Regarding the quality of the consulted stakeholders, the dialogue has gone beyond the regular meetings with the commissioning body. Hence, specialized agencies (such as ARPAE – Regional Agency for Prevention, Environment and Energy of Emilia-Romagna, Italy) are being involved in the process when asked to clarify data sources or to elaborate more on given issues. These mere examples help to understand the need to reconstruct *ex post* the steps that led to the current policies before their integration. Moreover, the integration of the Agenda 2.0 with the local policies through stakeholder engagement allows a significant reduction of the margin of error in the choice of data, in their analysis or in the establishment of connections between situations and alleged causes or implications.

Phase 4 will drive to the concrete result of an on-line tool functioning as a platform for continuous monitoring of the goals/indicators, and including practices carried out by Municipalities, citizens, and other relevant stakeholders. The platform will hopefully engage not only those entities and subjects that have been involved in the drafting process of the Agenda 2.0, but also users that are either familiar with the strategies for SD or are willing to implement them. As expected result there is not just the raising of a stronger awareness on the contribution each territorial stakeholder might bring to sustainability conversation and actions, but also a betterment in their relationship with the local authorities and among each other due to the embracement of the same goals and through the adoption of the shared measures. The group of potential stakeholders includes, while is not limited to, companies, trade associations, civil society organizations, and third sector entities.

The argument on SD from a local perspective shall then be considered in conjunction with the corresponding processes seen at a larger scale. Setting mutual benchmarking processes at a national level is expected to offer enduring learning opportunities to strengthen the quality of the overall results. Starting from the experience gained with the Bologna project, other Metropolitan Cities in Italy and beyond will be able to improve their action of SDGs localization. A compelling use of the Metropolitan Agenda for SD will require a balanced comparison with those drafted in other realities: while similarities in specific sectors might bring to conclusions that have already been verified elsewhere, and therefore avoid unnecessary amount of energies, collective results can benefit all parties.

On this basis, the project will be initiated in other three Italian Metropolitan Cities, namely Milan, Rome and Bari, with the approach in a shifted time frame of few months: the presence in the respective working groups of ASviS and Urb@nit will permit to reinforce the positive outcomes of Bologna's project and to adjust its weaknesses.

In the end, consider that the project is not meant to be self-concluding. Instead, the Agenda 2.0 will constitute a solid ground for further development. The objectives and the results of the project will be communicated also with leaflets and through dedicated newsletters. Thus, the final phase of communication and dissemination of the project results to different entities will guarantee an effective public-private stakeholders' engagement in the definition of future goals and policies for sustainable development.

If the Agenda 2.0 will provide specific targets designed on the peculiarities of the territory of the Metropolitan City of Bologna, together with recent and measurable indicators, it will also contribute to the composition of an operating sustainability cycle.

Figure 2 displays the placement of the Metropolitan Agenda for Sustainable Development 2.0 in the major cycle of localization in the context under analysis. The Bologna Charter for the Environment, as well as the Metropolitan Strategic Plan 2.0, gathers inputs for the project in different stages of the cycle. The category of input providers is to be completed by higher instruments, primarily the 2030 Agenda, and lower ones as the 2019 Metropolitan Agenda for Sustainable Development. As explained, the Agenda 2.0 will collect actions for SD, together with indicators to be progressively implemented and monitored.

Figure 2. *Sustainability cycle of the Metropolitan Agenda 2.0.*

The monitoring process, to be continuously conducted, implicates an evaluation mechanism the results of which let decision makers to set new goals or to review those that have been previously set. New strategies are hence arranged, and concrete actions planned and enforced. The engendered outputs, including the final product of the Agenda 2.0, will therefore be inserted into the cycle. The inclusion of all territorial stakeholders is critical to assure the completeness of the inputs-outputs system of the cycle.

The virtuosity of this sustainability cycle cannot avoid some comments on the weaknesses that emerged from the first phases of the project. The first concerns the phase of recognition of goals and their connection with indicators, the second the availability of data, and the third the relationship among stakeholders.

Regarding the recognition of goals in first instance, then internal to the working group, some difficulties have emerged in both the selection of documents to analyse and in their nature. The great amount of documents dispersed at all levels, from international to local, called for a compulsory selection, which had to balance the different natures of the sources, whether political, technical or private and, on a different stage, whether provisional, normative and binding or not binding. The selection, aiming at making the source list as

uniform as possible, might on one hand lack of completeness, on the other hand be sometimes overabundant from the perspective of a single SDG's analysis. Certainly, the contribution to the list from stakeholders has positively upheld the selection process.
Moreover, difficulties have come to light in deducing goals from political programs or manifestos, yet relevant for the purposes of the projects. The ambiguous nature of those documents has sometimes complicated the translation of broad plans into measurable goals. Besides, the missing reception of certain documents at lower levels, e.g. the European Green New Deal (European Commission, 2019), has raised some questions on the usability of elements that cannot be ignored in this context of fast changing paradigms.
In second place, the identification of goals aligned with measurable indicators has encountered some issues related to the availability of data. The multi-level comparison is hence not always possible due to the absence of data for lower levels, or to the lack of disaggregated data (e.g. on productive sectors, on means of transportations etc.). Indeed, the research is showing how local authorities and entities sometimes struggle in performing an effective monitoring of policies or in updating a series of data in recent times. As in Oosterhof 'Local statistical capacities to collect data, monitor, evaluate, and engage in national SDG-related data efforts are critical elements of the successful implementation of the SDGs' (Oosterhof, 2018).
Lastly, while the relationship among stakeholders, up until now experienced, has proved its value, it has also outlined some criticalities. In particular, the scientific approach of the working group has sometimes confronted with the representatives of the involved authorities in the attempt to smooth the highlight of some negative data, e.g. concerning the level of harmful emissions in the metropolitan area. Listing all actors that have legal responsibility on a given matter or that have directly or indirectly contributed to a specific result could be a viable solution of the issue. Before the official adoption of the Agenda 2.0 by the competent authorities, the right balance in the display of outcomes that set a wider distance to the achievement of the SDGs will have to be found.

4. Conclusions

Even at its early stages, the research presented in this paper allows to outline a preliminary array of conclusions. The first relates to the practical outcome of the research project, the following concern the methodology and its applicability in different contexts.
In first place, the drafting of a new Agenda for Sustainable Development at a Metropolitan level will incorporate all the dimensions of sustainability, heightening both the interconnections that link the SDGs, as foreseen by the 2030 Agenda, and those tying the distinct sectors and actors that are present on the territory. The comprehensive approach leads to the construction of a solid and effective instrument, while not necessarily exhaustive, to be used by a broad range of actors: starting from political decision makers to administrative bodies, all the way to private companies and civil society organizations. The versatility of the such an Agenda as conceived in this project, will consent a valid scalability at a national level and beyond. Hence, starting from the explained methodology which includes a multi-disciplinary working group and a line of action based on a meaningful stakeholders' engagement, this appears as a feasible pilot project to be scaled-up and replicated in other Metropolitan Cities. The contextualization of the contents in other territories would rely not just on an experimented method, but also on a useful recognition of goals which can provide a starting point for new researches.
In second place, the value given by the stakeholder engagement in preparing an Agenda that combines assessment, reporting and planning on sustainability, has been confirmed. Conceiving a sustainability project in a network perspective guarantees on one hand a higher quality of its outcome, on the other hand a wider effectiveness of its implementation. Purposefully engaging stakeholders in localizing the SDGs has demonstrated its function of increasing the precision of the results and of making the overall process more accountable. Following this consideration, the role of higher education for sustainable development (HESD) emerges to be vital also in the process of localizing SDGs. While universities can provide transdisciplinary teams that are able to face complexity, they can effectively function as models of local innovation hubs, capable of relying on a consolidated network of stakeholders of different nature not just in the territory they are based on, but also at a global level. Thus, the involvement in this research project can represent an example of capacity building on sustainable development across public sector in its different shapes, private sector and local citizens, while constitutes a significant opportunity to strengthen the university accountability among its stakeholders.

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Resilient Nangang: Co-Producing Educational Programs and Curriculum for Elementary School in Face of Climate Change

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Abstract

Although the official Adaptation Strategy to Climate Change in Taiwan was announced by the government in 2012, a new government guideline for school education was not in place until 2018. And in practice, it is still yet far from mainstreaming, since there are very limited examples on how this issue can be developed and fit to current curriculum. Given this institutional hysteresis, co-producing knowledge across related stakeholders is very needed for social innovation.

Based on a multi-stakeholder approach, this paper reviews the knowledge co-producing process among three different levels of educational organizations including the national university, community college, and elementary school. The demand of local knowledge and social change, in face of the climate change, created an abundant field for the three partners to work together. It started as an experimental educational program based on the pedagogy of experiential education, active learning and hands-on courses. Later it keeps developing toward a full curriculum for the elementary school students.

Our experience demonstrated how a multi-stakeholder approach to curriculum creation can bring new perspective and dynamics into the classroom. The research validates that a nonlinear and collaborative model will effectively enhance the process of knowledge integration. And four factors, including shaping vision, constant revise, open boundaries, and institutional supports are keys for knowledge co-production in education for climate change.

Keywords: Climate Change Education, curriculum, knowledge co-production, pedagogy, resilience

1. Introduction

Many studies of sustainable environmental development have shown that educational interventions are the most effective way for environment sustainability. Among them, local, visible and action-oriented education can effectively change people's environmental attitudes (Anderson, 2012). In view of the urgency of Climate Change, the United Nations Educational, Scientific and Cultural organization (UNESCO) incorporated Climate Change Education (CCE) as part of its sustainable development program in 2010. Addressing the nature of climate change education, UNESCO claims that it is not enough to teach the scientific contents, causes, effects and solutions. There is a need to introduce new values, creative thinking, and problem-solving skills to students at all levels of schools through participatory, experiential, and open approaches to education and learning.

In Taiwan, the Curriculum Guideline of 12-Year Basic Education (hereby Basic Curriculum Guideline) was implemented by Ministry of Education since 2019. In the face of a new era, it attempts to cultivate citizens through innovative and constructive pedagogies for elementary, junior high, and upper secondary schools. Climate change is also identified and incorporated into the 19 important topics. Furthermore, a "Domain-integrated Teaching" approach is recommended to combine the knowledge across the field of nature, society, culture, life, comprehensive science and other fields in current curriculum. But schools at all levels are unfamiliar about this new approach yet. This paper examines how our team from the Graduate Institute of Building and Planning of National Taiwan University (NTUBP), work together with Nangang Community College (NCC) and Jiuzhuang Elementary School (JES) on designing, producing and disseminating educational programs together for climate change. We will demonstrate how we developed the contents and pedagogy through the process of multiple stakeholder

collaboration and knowledge integration. Features of our program design will be identified. The factors of how the result has been achieved, further disseminated and institutionalized will also be analyzed.

2. Theoretical review

Under the framework of Education for Sustainable Development (ESD), UNESCO released a strategy and action plan on climate change Education in 2010. According to it, the contents of climate change education should include the causes and phenomena of environmental changes, the threat of flood, living environment and economic and social impacts, disaster reduction and adaptation, possible actions, global systems, regional characteristics, global citizens, etc. The United Nations has also stressed that climate change education should emphasize transdisciplinary practices.

In practice, however, climate change education is not easy. In terms of knowledge contents, climate change education requires knowledge about the climate system, scientific contents and its social impacts. But because human behavior is the often the issue to be addressed, sensitivities about environmental justice, decision-making processes, and cultural differences need to be in place. Besides, major difficulties often come from curriculum management, which may include the complexity of the topics, the lack of training of teachers, limited teaching resources, the time limit of arranging classes, the competition with other teaching contents, and the lack of support of the system (Filho and Hemstock, 2019).

To overcome the problem, knowledge co-production by cross-disciplinary actors rise to serve as the way in climate change studies as well as initiatives. For example, Lang et al. (2012) pointed out that the key approach of environmental sustainability research is to introduce non-academic participants into the research process, which will help to strengthen knowledge integration and coordinate different values and preferences. It will also contribute to connect relevant stakeholders to issues and solutions. This approach emphasizes interdisciplinary, community-based, interactive or participatory methods to address real-world issues and respond to the goal of sustainable research as a discipline that promotes social transformation. Transdisciplinarity, thus is the characteristic of knowledge production process. In this, Lang et al. defined transdisciplinarity as a reflective, comprehensive, methods-driven scientific principle that aims to solve problems or promote social and scientific change by differentiating and integrating knowledge with knowledge bodies from different sciences and societies.

At the same time, in addressing relations between global governance and knowledge practice, Mauser et al. (2013) referred to the experience of Future Earth and also pointed out that cross-domain knowledge integration is the key to the knowledge co-production on global climate change. They argued that "integration" often requires overcoming stereotypes of existing organizational, technological, and cultural structures. This demands not only new methods and concepts, but also appropriate communication tools, institutional arrangements, funding, resource inputs, as well as continuous reflection and revision by stakeholders in each stage of the process. Mauser et al. adopted Kuhn's scientific community epistemology, and highlighted the influence of the knowledge producer’s worldview on knowledge production. They pointed out that the concept of knowledge-integration for the scientific community is very often different from that of non-science/multi-actor communities. The latter emphasizes the continuity of knowledge form through learning and practice in a particular context. Social knowledge and scientific knowledge are interdependent and inseparable. From this point of view, the focus of knowledge integration is to maintain and enhance the diversity of knowledge forms and discourse language.

Mauser et al. further depicted the stages of knowledge co-production between academic and non-academic actors, which may include the government, citizen groups and others, as an incremental process from interdisciplinary to transdisciplinary model. In their knowledge integration ladder diagram, the three stages, including knowledge co-design, co-production and co-dissemination are identified. In the stage of co-design, stakeholders come together on framing issues and making the work and management plan. Then, in the next stage, the co-production of knowledge is gradually consolidated through the inputs of individual expertise and the joint efforts of overcoming of uncertainty. The third step is to disseminate the results in different groups to evaluate and give feedback, which depends on translation, dialogue and response. The result of the application may come back to induce another round of co-design (FIG. 1). Mauser et al. conclude that successful integration relies on criticism

and reflection at each stage, which requires innovative research methods, communication tools, organizational arrangements, and financial management.

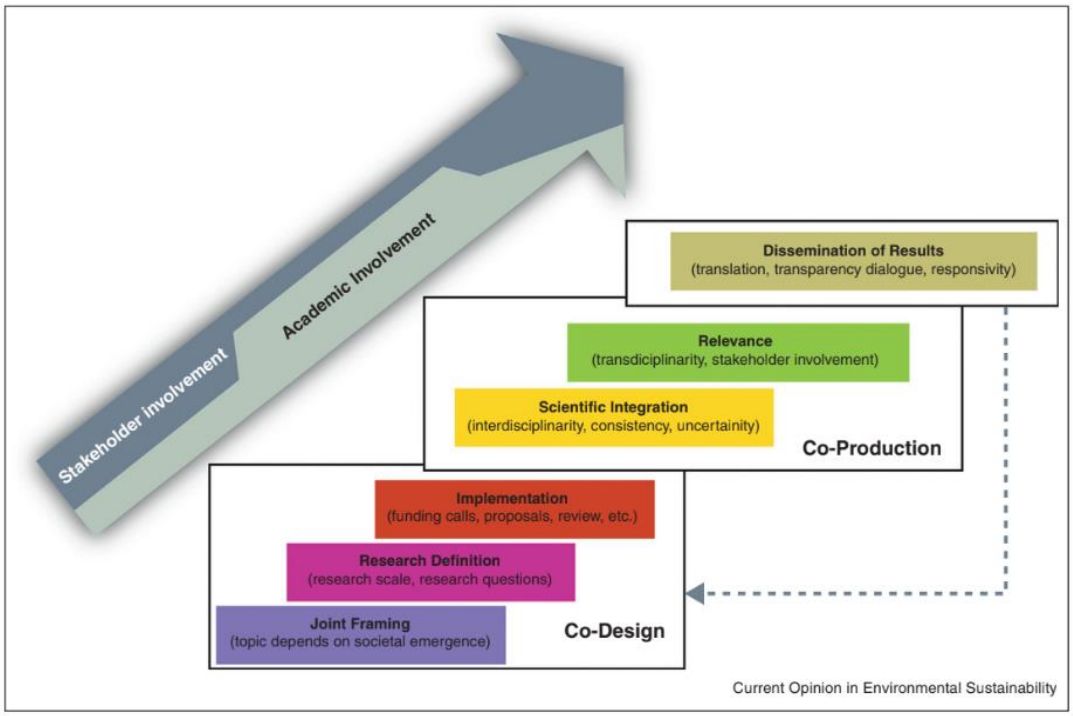

Figure 1. *Framework for interdisciplinary and transdisciplinary co-creation of the knowledge castle. Source: Mauser, 2013, p.427.*

We use the framework above to interpret our knowledge co-production process for climate change education programmes with our partners. In this study, integrated knowledge is necessary, since any party cannot carry out the task individually. On the one hand, it demands the knowledge of systematic environmental change, the impact of urban development on the community; It requires knowledge about local and regional environmental characteristics; Finally, it also requires specialized knowledge in the primary education, such as the curriculum management and its connection to the development of children's recognition. In addition, a new approach of pedagogy is in need. Many studies on education of environmental change point out that students' active learning is more important than teachers' lecturing at classroom. And an experiential approach on environment will make a greater influence on students than learning specific knowledge content. Therefore, in the course design, how to link students' personal experience with environmental knowledge and how to encourage sharing and expressing their experiences toward the community environment is at our concern.

In Taiwan, the Basic Curriculum Guidance which was implemented from 2019, aims to revamp the traditional way of education. Different from the past model of learning by teaching, it targets at developing students' ability to actively construct systematic knowledge. Thus, students' active participation, experience and hands-on learning are much emphasized.

The Basic Curriculum Guideline also has a new approach to climate change. The topic is no longer be confine as a subject in natural science, but as cross subjects include nature, society, culture, life and comprehensive science in curriculum. The Basic Curriculum Guidance for climate change indicate elements to learn, including: "global warming and its induced changes in climate patterns, as well as impacts and impacts on human beings; the causes and impacts of climate change and the awareness in daily life; practices of mitigation and adaptation of climate change in daily life". In the stage of elementary education, the awareness of climate change and its impact to daily life is given priority. In details, it includes "to understand the weather changes through factors such as temperature and rainfall, and enhance the awareness of the trend of extreme climate", "to understand how climate change impact on life, social and environmental", and "to be aware that human behavior is the cause of climate change" (National Institute of Education, 2017). Upon our course design, the aforementioned directions serve well as a referential framework.

3. Action for Resilient Community

We, one instructor and three students from NTUBP, together with lecturers from NCC and teachers of JES, developed a climate change education program. The idea was originated from the NTUBP studio, a main course of its curriculum featured by site analysis and participatory planning. Started from the fall of 2018, the studio for the first-year master students were a require course, and was conducted by three professors for 28 students. At that time, the professors chose Nangang District of Taipei city to be the site, because it was undergoing fast transformation. Numbers of mega-projects, including New Business Exhibition Center, Popular Music Center and National Bio-technic Park were under construction. Nangang as the East Gate of Taipei was identified. Its transportation networks to the airport and seaport were also expanding. These intensive investments kept pushing for the continuing changes of urban landscape and population. Our first half of the semester focused on urban and regional scale survey, spatial policy and topic analysis, etc. In the second half of the semester, students were required to develop substantial planning plans with local communities through participatory planning. The UN's Sustainable Development Goals (SDGs), especially Target 11, Sustainable Cities and Communities was also introduced as the checklist as well as reference for developing vision plan for Nangang. Then students had to propose planning suggestions corresponding to Nangang's ecology, history, culture and traditional industry, making sure that the elements of sustainable development will not be missed in the process of economic growth and infrastructure expansion. During the semester, the faculty invited Mr. Pan from NCC came to speak on Nangang's ecological environment and the NCC's environmental citizenship initiatives. Local politics in Nangang has long been dominated by traditional factions, and NCC, founded in 2000, is one of the very few organizations promoting public engagement in Nangang. Therefore, NCC has become an important local partner for our studio.

In the first year of the studio, students are divided into six groups to explore places and define issues to work together. The "water group" was one of them. Starting from exploring the water environment in Nangang, they researched on Nangang's natural environment, climate, and the history of basins and rivers. The group also interviewed local environmental educators and volunteers to learn about natural disasters, pollution incidents, water management control policies and local environmental actions. The group members discovered that "people/water disconnection" and "over-dependence on hydraulic engineering" are the two main problems of water management in Nangang. The group members concluded, community resilience in response to multiple type of disasters and residents' adaptability to climate change will serve as the themes of their work in the next phrase.

In the second semester of the first year, since the studio requested students to form action plan, the water group further chose Jiuzhuang Community which located in the southeast corner of Nangang, as the site (FIG. 2). Jiuzhuang Community is right on the border area between Nangang Mountain and the dense developed urban area. While enjoying abundant resources of rivers and forests, it is also faced with the risk like flood, mudflow and landslide. Over-artificialization of river banks is also a problem. And the factories along rivers produced water pollution from time to time. Ms. Chang, the Chief of Jiuzhuang Community has long been safeguarding the local environment and ecological tea farm upstream. She has also cooperated with NCC to offer disaster prevention courses for the residents and river cleaning actions in the upper reaches of river. We then started to work closely with Ms. Chang.

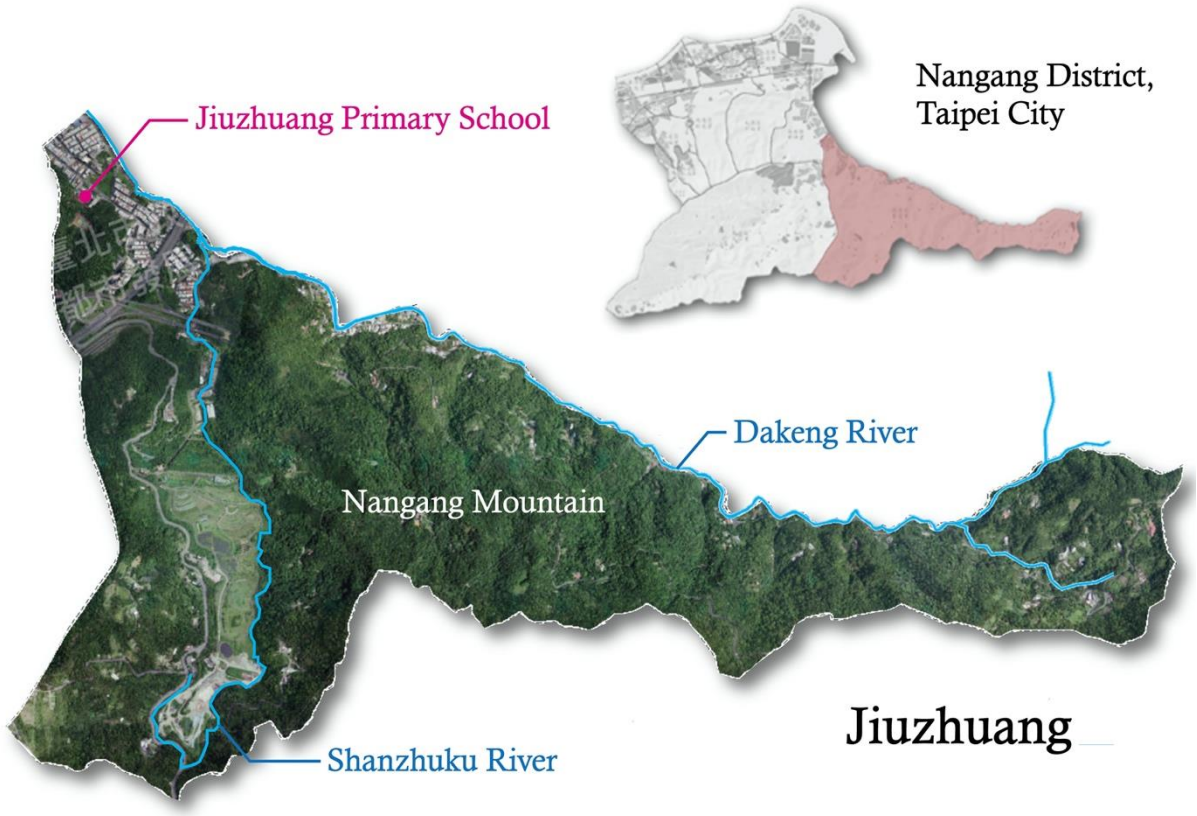

Figure 2. *Location of Jiuzhuang community.*
Source: History GIS system (Department of Urban Development, Taipei City government)
http://www.historygis.udd.gov.taipei/urban/map/

After fieldwork and interviews with residents in early 2019, our students decided "enhancing environmental awareness and shaping resilient community" as the subject of participatory planning in Jiuzhuang Community.

Our task is to complete the above work of green space renovation and the characteristic courses of JES.

On the project of green space, students first conducted a series of activities, include workshops, story-telling, and social media campaign, to promote the concept of resilient community. After a few months, some local residents began to show up and discuss how to transform the community's riverside into better green spaces. Our team aimed to introduce the low impact development (LID) facilities such as rainwater recycling system, permeable pavement, and transform an idle space in the community into a community farm, so that residents can better understand the concept of resilience and have space to reach the nature and interact with people.

At the same time, on the recommendation of a pastor of local church concerned with environmental education, the group also contacted JES to discuss the possibility of incorporating Dakeng River and climate change issues in the school's curriculum. Also, the teachers of JES expressed their willingness to cooperate with us and NCC to pilot the special courses with the theme of Dakeng River in the new semester. Therefore, a two tracks of strategic plans for enhancing both environment and social resilience, one on transforming community space and the other on school education program of environment, was formed. And we hope that in the long run, the two projects will produce synergy effects.

In the process of delivering these two tasks, our partnerships with NCC, the Community Office, and JES have also consolidated in back and forth discussions. After the required one-year studio finished, in order to continue building capacity with the local community and implement the phased work results, three members of the water group and the instructor decided to continue the work. We formed the "Resilience Community Group" to carry out the Advanced Studio since the fall of 2019.

The latter aims to enhance children's awareness on the impacts and threat of climate change through environment educational program. We also hope in the long term, parents will be influenced by the kids.

By April 2020, the NTUBP group and NCC have successfully assisted JES to pilot an experimental program on environmental education about Dakeng River and the community spaces along the river. At this moment, we are working with teachers to expand the experimental program into a formal curriculum and to be taught continuously. Our goal is to respond more closely to UNESCO's initiative to promote climate change education. And we hope our case can serve as good example and then be disseminated widely for the "sustainable development" and "climate change" topics incorporated in Basic Curriculum Guideline by the Ministry of Education of Taiwan (MOE, 2018). On the other hand, the community farm project officially kicked off in March. So far, the project is going well and will be documented in another research paper. In this paper, we will focus on examining our project of climate change education.

4. Develop climate change courses with local partners

Established in 1955, JES is the only national elementary school in Jiuzhuang community. Although the school has only 280 students and 56 staffs, in terms of the size of campus it is the largest one in Taipei city. Facing the Dakeng River, located at the foot of the Nangang mountains, JES has a rear hill area as its hinterlands for activities, which is very unique in Taipei. From our interview with the director of student affairs in the early stage, we learned that in order to counter the dropping rate of enroll, the school began to develop the "school-distinctive courses" three years ago through incorporating outdoor activities such as garden cultivation, scouting, bike riding, eco tour, and river-tracing for the third to sixth graders.

The climate change course was executed in the fall semester of 2019 after a few months of co-design through the tripartite discussion of partners including our team, the faculty from NCC and teachers from JES. The contents are described below.

(1). Course contents

This idea of educational program on Dakeng River in response to climate change adaptation was originated from the NTUBP's early trips to communities along the Dakeng River. Later, the three parties started the course design intensively from May to September 2019. It started from that teachers of JES explained their needs. They suggested that the special courses of Dakeng River should be implemented on third to sixth graders, to help students to understand their community. And they also hope an activity focus on the scientific experiment could be included so that the climate change course could response to the social and natural domain respectively.

On the other hand, faculty of NCC discussed with us intensively to enrich our understanding of the local environmental knowledge and spatial features. From September to December 2019, NCC faculty also joined us in teaching the experimental program for JES. There were 8 classes (178 students in total) to participate in the program. Because it was a trial project, the teachers of the school mainly assisted in class management while they also participated as observers. In order to have enough time to guide the students to observe the community space and discuss the topics afterwards, we divided the contents into two rounds of teaching. After that, according to the students' response in class and the feedback, the program was further fine-tuned. The first phase of the contents of the program are shown in table 1.

Table1. *Climate Change Education Program in JES: Phase 1*

Course Grade	Contents	Elements	Time	
The third and fourth graders Module 1	Observing the community riverfront space（Outdoor）	River and community guide tour	90 mins	110 mins* Two Classes
		Sensory experience and observation		
		Observation record		

	Group competition with the community observation map （Indoor）	Community map and magnets Collaging	20 mins	
The third and fourth graders Module 2	Discussing the observation of community riverfront space （Indoor）	Drawing Workshop	35 mins	110 mins* Two Classes
		Drama Performance	45 mins	
	Understanding the relationship between community river and climate change （Indoor）	Videos	30 mins	
		Maps		
		Photos		
The fifth and six graders Module 1	Introduction of Jiuzhuang and Dakeng River （Indoor）	PPT Presentation	15 mins	110 mins* Three Classes
	Making simple water collectors （Indoor）	Making water collectors	40 mins	
	Water quality testing in the lower Dakeng River （Outdoor）	Water quality testing and recording	55 mins	
		River and community guide tour		
		River observation		
The fifth and six graders Module 2	Description of water quality data （Indoor）	PPT Presentation	40 mins	110 mins* Three Classes
	Microscopic observation of water quality （Indoor）	Water sample collection and observation with microscope	70 mins	

（*Time of activities feedback and homeworks assignment are not included.）

Source: Authors

The features of the program are as below:

- **Observing community space along the riverfront**

In In the early stage of our fieldwork, we focused our environmental observation on the upper reaches of Dakeng River, including the area of tea mountain and the "Nangang Tea Manufacture Site". However, due to the time and transportation constrain, the school suggested that we conducted the guided tour for the students in the lower reach of Dakeng River near the school instead. We did accordingly, to guide students how observe the river, the surrounding open spaces and community (FIG. 3). We aimed to make students have a basic understanding of river ecology system, water management, system of watershed, and the connection between river and community life. Students were also guided to observe the flora and fauna, infrastructure, green space, human activities and possible sources of pollution to the river. Students are asked to record their observations by drawing or photographing on the spots. After returning to the classroom, students were asked to mark the people and objects they had just observed on the community map through teamwork and group contests (FIG. 4). At the end of the course, we reminded the students that observation is the first step in understanding and caring about the community. Only by starting to look carefully at the natural and built environments can we detect signs of environmental change and take action to protect the environment.

Figure 3. *The third and fourth graders observed the Dakeng riverbank.*
Source: Authors

Figure 4. *The third and fourth graders marked their observations on the community map.*
Source: Authors

- **Experience-oriented Education on Water Quality Survey**

For the fifth and six graders, after a few times of discussion with our partners, we decided to conduct the water quality analysis with the collaboration of lecturer from NCC community. We understand that the impacts of climate change have many faces, and these changes may be hard to detect in the short term. Therefore, we aimed to encourage students to continuously record the water quality changes. In the long run, it may link to the existing water quality databases of neighboring rivers such as Keelung river and Sifen River developed by NCC, to visualize the impact of climate change from a more comprehensive perspective.

Despite that the Ministry of Education in Taiwan provides guidelines for elementary school courses on climate changes, most of them are the fixed contented oriented knowledge, and there are little contents on related practices or actions related. In this, our course features that students can have hands-on experience on water quality monitoring. The course design is divided into two rounds. The first one focuses on operation. Students used the self-made water intake device to conduct the sampling of Dakeng River (FIG. 5), and then analyzed the water quality data. Thus, students can learn the professional knowledge through practices.

In the second round of the operation, we explained the relations of water quality and the indicators, so that students could understand factors affecting the environment and would know how to improve it in the future. Faculty from community college also used a microscope to demonstrate the water samples collected from the upper and lower reaches of Dakeng River and Shanzhuku River nearby, so that students could differentiate quality of water by scrutinizing the creatures via the microscope. This visualizing process increases science professionality as well as fun, which impressed students very much.

Figure 5. *The fifth and sixth graders collected water sample from Dakeng River.*
Source: Authors

- **Theatre pedagogy**

For the third and fourth graders, first round of the course focused on outdoor observation around Dakeng River and its surrounding spaces. The main goal was to encourage students to use their senses to experience the environment. What we emphasized was not the knowledge contents, but the students' ability to discover and perceive. In the second round of the course, we asked students to share their observations and narrate their feelings. For graduate students of planning like us, we are familiar with using "workshops" to facilitate communication in participatory planning and design process. Text and verbal communication are essential tools for these occasions. But when it comes to elementary school students, we need to rethink how to communicate with them more properly. After consulting friends in informal educational institutions, we decided to introduce the idea of “learning by playing.” To spice up the course, we divided the students into two groups, each composed of about 8 to 11, then we encouraged them to share their feelings through drawing, game, drama and team competition.

First, each team of students collaged a map of the people, creatures and objects which impressed them in the community space. Then they discussed with their team members and identified the environmental characteristics of certain spaces in the community. Through the drama competition and cooperation between the two groups, various hints were given to help the other team to get the right answers. This game served as a tool for summarizing the unit. Not only demonstrated the students' cognition of particular spaces, it created a possible new connection between body and space. (FIG. 6)

Figure 6. *The drama performances of the third and fourth graders.*
Source: Authors

- **Worksheets design**

We designed different worksheets for the third/fourth graders and the fifth/sixth graders, and asked them to continue their observation on the river and open spaces. Different from regular worksheet that merely focuses on the delivery of knowledge contents, our worksheet aims at encouraging students to observe and think about the relationship between climate change and their environment even after classes. In addition, we were able to collect students' feedbacks that helped us expand our understanding on the characteristics of Jiuzhuang Community via the worksheets.

During the teaching practice, we also re-designed the worksheet according to students' response. The initial version of the worksheet was designed to make students freely record by drawing and open-ended answers. Some students responded it well. For example, in the following drawings the river, trees, birds, fishes and even garbage were presented in a close connection to the urban environment. Especially, the Aerial view map shows the bridge and sidewalk to indicate the route of our guided trip.

Figure 7. *The Drawing of the community observation on the third and fourth graders' worksheets.*
Source: Authors

However, we also found that some students needed guides on demonstrating their findings. Therefore, we adjusted to use more texts and questions to guide the students' reflection. Therefore, we used the community map as a guide to remind students of their observation in environment, and we also asked them how can they apply what they learned to their daily lives. (FIG. 7). Students gave comments such as "This course is fun", " I didn't know that in I traveled across the river to school every day until I participated in the guided tour", "I know I can protect the environment", " I will reported to the police if I see someone throw garbage to the river" …and so on.

In the span of teaching at JEP, our team started to get popularity at the school. Team members would be greeted loudly and cheerfully by children everywhere when they walked in the school. And when we had workshops in the community, we started to meet parents telling us that they would like to send their kids to JES. And because in the trail project, we only design for the third to the six graders, there were parents of the first and second graders told us that they wish their kids would have a chance to participated in our course.

During the three months after the courses, the NTUBP resilience community group held two discussions on teaching experience with the principal, academic director and teachers of the Elementary School and NCC. Its objectives include: (1) to review the implementation of teaching and to improve it; (2) to examine the possible difficulties when the program is implemented by JPS teachers in next stage; (3) to deepen the current educational program and to develop it into a curriculum. As shown in table 2, we discussed how the third to sixth grade curriculum could be developed in a spiral model, and how could the advancement and continuity of contents be addressed. The meeting also discussed how to expand and integrate the contents and teaching plans into other subjects, as well as to coordinate the teaching staff, so we can make the courses structure more complete and concrete.

Table 2. *The development framework of future curriculum*

Grades	Domain	Theme	Time (min)
1	Comprehensive	Picture Books on environment issues	120
		Agriculture and Food: growing beans and vegetables with water	360
2	Comprehensive	Picture Books on environment issues	120
		Agriculture and Food: growing beans and vegetables with small portion of soil	360
3	Society	Introducing Community and Dakeng River	80
	Language	How do I observe and document community	40
	Arts	Paint my community	40
	Nature	Community environment: water and food under extreme weather	160

	Comprehensive	Special course on Dakeng River: observe and discuss spaces along the river through workshop	180
		Agriculture and Food: rooftop garden in school	360
4	Society	Culture, history, environment and future development of Nangang and its surrounding region	200
	Nature	disaster and green energy at communities	40
	Comprehensive	Special course on Dakeng River: guided tour to the upper stream area	330
		Agriculture and Food: from garden to table	360
5	Nature	Water survey and explaining the indicators	80
	Comprehensive	Lecture delivered by NCC: water system and resources in Nangang	100
		Special course on Dakeng River: Water survey and microscope observation	240
		Agriculture and Food: planting on the rear mountain area of JES	360
6	Society	Table game on Nangang characteristics	40
	Nature	Table game workshop on “Earth overshot day” and water resource management	40
	Comprehensive	Special course on Dakeng River: cleaning water in the upper stream area	150
		Agriculture and Food: rooftop garden in school and food making	360
Time in total			4120 mins About 68.7 hrs

Source: Authors

After the review of the first phase of teaching, we three parties agree to try to expand the program into a full curriculum on climate changes. Now new framework is under discussion. There are a few points. Firstly, it will cover from the courses for first to six graders, and the total hours will be roughly grow from 7.5 hours to about 70 hours. Secondly, in terms of domains, it will expand from the original Comprehensive-based domain to integrate further domains like Society, Language, Arts, and Nature. This also means that there will be more teachers involved in the climate change course at JES. Lastly, NCC’s emphasis on mountain and farm will further be incorporated in the curriculum for Climate Change. Topics related to agriculture and food will be taught to all the 6 graders by the NCC lecturer. The collaboration of NCC and JES will be strengthened further.

(2). The co-design of environmental action, the co-production of environmental knowledge

Climate change education emphasizes on the integration and joint production of cross-field knowledge. Our team adopts a revolving design of framework. We continuously discuss and revise our program through the collaboration of our partners. There were constant exchanges of ideas based on the professional knowledge on each part under the shared educational goals. There was also frequent discussion on innovative pedagogies which will make learning more effective.

Teachers of JES often gave us timely suggestions to improve contents, structure and course management. Sometimes we also received personal feedbacks. For example, some teachers told us that despite worked at JES for years, they had never looked so closely at the river right in front of their school. In terms of the curriculum structure, JES had a course for marine education previously. Some teachers pointed out that it can be linked to the river program in the future, to provide the students with a more complete picture of the water system. On the other hand, the teachers also consulted us about the knowledge of environmental planning and climate change since they are preparing to combine the school's curriculum with the first phase program of climate change.

The teachers also mentioned that their students favored our teaching because the learning atmosphere were fresh. However, it was a constant challenge for us to translate scientific knowledge into something comprehensible to the students. For example, instructing knowledge of river ecology and water quality through microscopic observation was a bit too intricate for the JES students. Therefore, we explained water quality indicators by using daily life examples to show what the pH value and

temperature stand for. After that, the NCC lecturer demonstrated the result of water sample through microscope. The micro creatures under the lens left the students deep impression about the visible and invisible about the river water.

As our partner, NCC has been collaborating with us since the early stage of course design. Their faculty are equipped with rich environment and local knowledge, and at the same time, they understand well how to conduct cultural translation based on their long-term experience on promoting citizen science.

5. The interaction of stakeholders and knowledge co-production

Our knowledge co-production is conducted in a process of continuous communication and collaboration between stakeholders. It is embedded in the interactions of organizational goals, knowledge traditions and other factors. And the confluences took place in a momentum that the institutions are willing to make breakthrough in face of challenges. Therefore, we may term the relationship as a way of "mutual actoring" between stakeholders.

In our case, NTUBP has beholds a goal of empowering communities, and it takes "people-based local planning" as the core value of its planning education and practice. Our students are trained to safeguard local cultural assets, environmental resources and social network. On the other hand, community colleges in Taiwan was born from the education reform movement in the 1990s, and it aims to promote community power and lifelong learning (Huang, 2002), and to "liberate knowledge, nourish civil society" (Ku, 2001). As an important link of national education, JES is tasked with cultivating students by civic responsibility. In addition, its school-distinctive courses conducted for a few years has been successful because it gave the school a new identity and became more confident even when it need to encounter other elite schools. This has help to pave the way for the development of climate change courses as one of the series steps for reshaping itself.

Since climate change education has been a rising issue for education at different levels, the tripartite cooperation provides the possibility of profession complement and knowledge co-creation. In the following, we will analyze how we gradually develop stable partnership with NCC and JES.

(1). Shape the common vision

In a community action plan, identifying stakeholders and forming partnership is an important step. NCC has long been promoting environmental education, so it was glad to collaborate in this project. It used to collaborate with local high schools on climate change programs, but it was its first time to conduct the climate change programs at the elementary school level. It was an innovative experience for both of them. And this expanded the spectrum of civic science which NCC applied previously.

The three of us are not fully identical in terms of languages and epistemologies. NTUBP, NCC and JES aim at "resilient community", "environmental education" and "school-distinctive course" respectively. But we are all interested about building up rich knowledge of rivers and communities. And we all believe that education should reach beyond the geographic boundary of the schools. Get to know the local and region is a good start point for environment sustainability and social change. The differences of three institutions are more complementary than exclusive.

(2). Integration of expertise and experience

The NTUBP team is good at data collection, environment scanning, participatory workshops and other skills for local investigation. But since we were new in Nangang, we were very insufficient with local knowledge. We also had no sense about the social networks to start mobilizing issues. On the other hand, with the core of professional knowledge in environmental education, NCC has developed its bases of “local knowledge” through long-term social involvement. NCC aims to further link the local with the region through the concept of *Sotoyama*, namely “community mountains”, and has devoted itself to the education and promotion of local environmental education and ecological rehabilitation. Based on its more than 20 years of experiences, it also established wide networks with local communities. Lastly, the teachers of JES have rich experience in teaching, and have a good command of teaching methods, curriculum and course management. And when it came to the issue of shaping new courses on climate changes, it requires the knowledge about how to bringing new elements into old curricula.

It also called for their expertise on evaluating how students could absorb the knowledge in a better way. The three parties continue to provide their expertise and experience during their collaboration. Although the professional perspectives and disciplines of the three parties may not be completely the same, the continuous communication and discussion helped us to translate each other's profession into common language, and promote further collaboration.

(3). Focus on problem-solving discussions

In conducting the experimental program, the three parties had various discussions on curriculum administration, course design and pedagogy. There were many discussions on how to avoid chaos, carry out the activity, and identify proper tools. Finally, we ventured to decide to combine mechanisms like, competitive/collaborative group work, and theater pedagogy for course. This innovative idea works well and reverses the traditional way of how knowledge is taught in the classroom.

The co-production of knowledge is not limited to scientific knowledge about climate change education, but also on pedagogy and class management. In the process, how to face problems and solve them together is the key to consolidate the partnership. It also tests the commitment of all parties on how much each will invest their time and resources. Fortunately, all the three partners showed the sincerity and supportive ways. As the new phase would start, each promised to put in more institutional resources, such as training volunteers (NCC), teachers (JES) and graduate students (NTUBP). And this created a positive milieu for continuing collaboration. New projects beyond the curriculum is also in planning.

(4). Knowledge boundaries are crossed in rolling solution production

The interaction between stakeholders is not a linear collaborative process, but a process that allows partners to have the opportunity to repeatedly express their opinions and reactions at any time during the course design, execution and revision. It is evolving as revolving process. All the three parties have to push ourselves to cross the boundaries and reach to each other.

From JES's point of view, the shortage of local knowledge and related environmental majors of teachers is a barrier in the development of characteristic courses. It depends on introducing external professional resources to assist the curriculum development, increase the cooperation with external units, and strengthen the teaching resources of the school.

The faculty from NCC also mention that they as the environmental educator may have their own fixed mode of thinking, and through idea-exchanging with us, teacher and students from planning background, they will learn different perspective of education. This can enrich experience on climate change education for students from planning, this project emphasizes the link between planning theory and practice in the real world. This experience went beyond their imagination about communicative planning, since it indeed involved very wide dimensions of learning.

(5). Institutional support and further institutionalization

The integration of knowledge through transdisciplinary collaboration often requires the stakeholders to bring in different resources. This can produce synergy. In terms of the resources invested, the NTUPB group mainly supports with the development of educational program. Students and faculty input help to fill the lack of manpower and expertise in deliver new program. Three students participated in the course design and classroom teaching. They even called for the support from their classmate to help taking photos and documenting activities. The community college has expertise in environmental knowledge and water quality survey. It provides with professional support for JES. JES provides practical teaching and class management skills.

The three institutions not only completed the initial climate change program, but also continue to further deepen the curriculum. In discussing about continuing the next phase of future development, school teachers raised the issue of lacking manpower and professional training. NCC, thus promised to train its volunteer to help. NTUBP also decided to continue the next year studio conducted in Nangang. And there are also some teachers suggested that a capacity building workshop could be conducted among the three parties to learn the details.

Meanwhile, NCC has incorporated the existing teaching plan into its environmental community courses, and hopes to provide training and support in the talent pool for special programs of JES. The NTUBP resilient community group has been trying to correlate the courses with the concepts of SDGs, climate change, and the curriculum requirements set by MOE, making the course plan more completed and feasible. The idea of climate change had also become part of the other curriculum subjects in the JES, such as nature, society, language and art. As a result, the knowledge, experience, and resources of different local agencies, as well as institutionalized climate change issues can be integrated and implemented in a longer term.

6. Conclusion

John Friedmann, the venerated founder of planning theory, have identified policy analysis, social reform, social learning and social mobilization as the four epistemology traditions of urban planning (Friedmann, 1987). In our case, we experienced how they often entangle with each other in practices. This may indicate that the frontier for climate change education requires wide knowledge spectrums and it may call for continuous efforts from various and different levels of educational entities. The cooperation between NTUBP, NCC and JES in the course of local climate change education shows a new attempt from the three educational institutions. It requires knowledge exchanges and integration. And the task also tested how we can develop vision, communication culture and working methods together.

Our experience echoes the “knowledge creation ladder model” developed by Mauser et al. (2013). Initially, three institutions worked together to frame issues and design contents. In the second stage, each of us starts from our own domain expertise, gradually move to knowledge exchange and integration, which elaborating a process of knowledge co-production. The implementation of the results in the third phase has elaborated the results of the joint work, but it is critical to continuous examine the temporary result. Finally, look for opportunities to expand or deepen the project in the next phase will help to consolidate the result. Our case illustrates the aforementioned processes. Our results show that the climate change education program, developed jointly by multiple actors, can be effectively enhancing students' learning, in an innovative way. And we identify that how stakeholders find common goals, overcome operational obstacles, and integrate resources are important factors for continuous knowledge co-production.

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Nexus Relations and Dynamics

Trends and dynamics in material flow analysis in an urban context. A case study of a city with an emerging economy

Material Flow Analysis

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Abstract

Currently, most of the world's population lives in cities, and this trend of the rapid urbanization of the population affects the increase in the demand for products, goods and services. It is important to know the trends in the flow of energy and materials that enter and leave the city, and this knowledge allows us to recognize key elements in these dynamics to move towards urban sustainability and to be able to face supply challenges in the future. This document presents the recent trends that have occurred in the material flow in the city of Bogotá in 2001, 2005, 2010, 2015 and 2017, in order to compare and identify the changes in the main input flows, wealth production, emissions and waste in the city. This analysis is important insofar as it contributes to establishing strategies and actions aimed at improving efficiency and reducing environmental impacts. The results show that in Bogotá, there was a decrease in some of the material flow in recent years, such as the consumption of water and the generation of discharge, while there was an increase in the consumption of energy and cement and the production of CO2emissions and construction materials. Solid waste production remained relatively stable. The findings of this study are important to advance the characterization of the trends in material and energy flow in the city and contribute to the consolidation of a baseline that allows for the definition and evaluation of the different impacts of public policy that promotes the sustainability of the city in the coming decades.

Keywords: Material flows**,** urban context, changes in the time, Bogotá

1. Introduction

According to the UNDP (2012), globally, cities occupy 3% of the earth's surface, produce 80% of gross domestic product, consume 75% of natural resources, produce 50% of solid waste and between 60% and 80% of greenhouse emissions. However, they have a potential to improve their efficiency where it is estimated that global water consumption can be reduced by 30% and energy by 30-50% and infrastructure investments are required for the next 20 years of approximately 41 trillion dollars.

Sustainable analysis and management in urban areas requires understanding the demands of natural resources and the environmental impacts that are generated. The material flow analysis allows to demonstrate how a relationship of inputs and outputs that can promote eco-efficiency is generated, which is essential for policy makers and decision makers to formulate an urban policy that guarantees sustainability and productivity improvements and competitiveness (Moore et al, 2013).

Bogotá is selected to carry out the flow of materials, taking into account that it is the capital of Colombia that is a country with an emerging economy that contributes to a quarter of the country's internal product with a high level of industrialization, presence of different productive activities and the city with the highest population concentration that currently faces many environmental challenges and this type of studies can be an input to develop more effective programs for sustainable development in urban areas.

The objective of this analysis is to determine the trends of the flow of materials in the city of Bogotá in different periods of time, which allows to establish changes between them, which could become a key input to establish effective programs so that this city can improve its environmental performance in favor of sustainability. This document is structured in five sections, the first is the present introduction, the second describes the main characteristics of Bogotá, section three presents the data and variables used in this study, the fourth the results and their analysis and finally some conclusions.

2. Methods

This study part of concepts as flows and urban metabolism (Bai, 2016) that includes the relationship between inputs (such as food, water, construction and other materials, raw materials, energy, capital, information, and people) and outputs (such as industrial products, goods, services, knowledge, waste, emissions). Inputs are important because support and allow societal activities, urban functions within a city, formation of urban stocks as infrastructure, housing, building, public space and green areas and parks and production of products and services and the whole urban management, that according to outputs determine the magnitude, distribution and internal interactions and feedbacks regulated by governance, policy, culture and individual and collective behavior of the city as urban system.

To analyze the trends in the flow of materials and energy in Bogotá, the years of 2001, 2005, 2010, 2015 and 2017 are taken. The variables and indicators used in this study are the following: i. Inputs: water consumption, energy consumption and grey cement; ii. Outputs: wastewater, emissions (COx, SOx, NOx and particulate matter PM10), solid waste and construction waste. The main data sources are the following: the secretary of planning District of Bogotá, the Superintendency of Public Services, and statistical office.

3. Results and Discussion

In this section, the trends and analysis of the flow of materials in different periods of time in the city of Bogotá are presented, taking into account the main inputs and outputs at a general level and by components where dynamics of growth and decrease are observed according to different pressures or actions on the environment or the greater awareness of the inhabitants of the city.

During the study period, the flows of materials and energy in the city of Bogotá have been increasing especially due to population growth that went from 6302880 in 2001 to 8064000 in 2017 increasing every year Around 100,000 inhabitants. Period of study reflects the increase in some flows such as energy, cement, CO_2 emissions and construction waste that shows the growth of the city. On the other hand, from the design and application of some public policy instruments at urban level with dissemination and awareness campaigns, the reduction in other flows such as water consumption and wastewater generation were achieved, while the production of solid waste It remains relatively stable.

In the urban sphere, water consumption is essential for different personal and business processes and its use generates wastewater since they maintain a direct relationship for the study period. It is observed that in 2001 the total water consumption of the city was 61014567 m^3 while in 2017 the consumption was 57811956 m3 indicating a decrease 3202611m^3 during these years. Similar situation is observed with the wastewater, since in 2001 65642718 m^3 were produced while in 2017 its production was 53988449 m^3.

During the period of study, there is a tendency to a more efficient use of this resource which generates a lower generation of discharges with the consequent benefits for the environment. These results are products of various public awareness campaigns to generate less waste and opt for saving technologies which have resulted in a rational and efficient use of water.

Energy consumption is vital for cities and is synonymous with development and progress. In the case of Bogotá, the two most important sources of energy for residential use are electricity and natural gas. The consumption in 2001 of these two sources was 7240701.31 TJ and in 2017 of 9646171.83 TJ, which implies an increase during the period of 33%. With respect to a total of electricity and natural gas where it is observed that from 2001 to 2010 there was an increase in consumption, while in recent years it has been reducing the same per inhabitant.

In general terms, it could be said that energy consumption in the residential sector of Bogotá has remained relatively stable with minor increases in electricity consumption, reductions in natural gas consumption and a slight increase in the last three years. These results may also be given by technological changes and increased awareness of the rational use of energy.

As a result of energy consumption, emissions that generate air pollution arise. It is observed that CO_2 emissions have increased slightly on average in recent years, sulfur dioxide and average nitrogen show a similar trend while maintaining or decreasing and PM10 particulate has tended to decrease due mainly to improvements in the quality of the city fuels. However, in Bogotá the need to improve the quality of fuels, especially in transport, is already observed due to the alerts for air quality that have been presented in 2019, indicating the importance of analyzing the trends in emissions taking the cycle of value of the energy sources used by sector and determine alternatives to improve air quality in the city of Bogotá.

In urbanization processes a large number of construction materials are required that in parallel generate construction waste that in many cases is difficult to recover and / or deal with its consequent pollution problems. In 2001, the consumption of gray cement in the city was 962,000 tons and in 2017 1461,000 tons were consumed, which meant an increase of 52%. Regarding the generation of debris, in the year 2001 6132000 tons and 15487802 tons were generated in the year 2017, which meant an increase of three times compared to the base year.

Cement consumption per inhabitant has remained relatively constant, while the generation of debris per person in the city has increased mainly due to the urban expansion of this city in recent years and to meet the demand for housing and industrial areas and commercial, which is evidenced by high densification in all areas of the capital.

Another fundamental element to ensure sustainability in urban areas is the management of solid waste. In Bogotá, in the year 2001 1794430 tons of solid waste were generated, while in 2017 the generation was 2295821 tons, which implies that in the study period the increase in waste was 28%. For the study period, it indicated that between 2001-2010 there was an increase in per capita waste generation and that in the last year a downward trend has been achieved that can be given for greater awareness and awareness of the importance of reducing waste generation and contributing to recycling.

These results show the importance of knowing the dynamics of the different inflows of inputs and outputs in urban areas in order to determine how actions can be achieved where the population participates in the importance of their environmental responsibility and how they can be aware of pollution and environmental problems where local actions take precedence to impact global indicators and improve the environment and contribute to the sustainability of the city.

4. Conclusions

This document shows the calculation and analysis of the different inflows and flows of the city of Bogotá for the period 2001-2017 as a fundamental element to understand where the main environmental problems are generated and how actions could be taken.

The results show that at a total level most of the flows increased under pressure from population growth and city expansion. However, when reviewing the flows at the inhabitant level, greater efficiency is evidenced, which demonstrates that day by day citizens are more aware of consumption and the environmental problems that they can generate.

During the study period, the flows studied that increased in the city were the consumption of energy and cement and the generation of CO_2 and debris emissions, which is consistent with the dynamics of the city. In contrast, the reduction of water consumption and the generation of landfills and the production of solid waste were relatively stable.

This type of analysis is essential to prioritize public policy instruments that allow, from the macro level, to impact citizens' actions in favor of sustainability and an adequate urban environmental management based on a baseline that allows measuring the impact of the different programs that promote the care of the environment.

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Urban and Rural Transitions: Resilience and Adaptivity

Improving climate change resilience through risk communication supporting effective private risk reduction

Strategy making in the face of complex communicative options and motivation factors

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Abstract

Climate change driven risks in urban areas increase pre-existing challenges of risk management. Often and for good reasons public risk reduction cannot be offered to all areas due to lacking efficiency or acceptability, because they are hardly compatible with the dense and multifunctional urban fabric (i.e. inundation) or because of the spatially unrestricted or unpredictable pattern of the hazard (i.e. heat, heavy rain). Private action and its effectiveness to reduce risk or damage has been described on several occasions. It is widely agreed, that private risk reduction despite cardinal challenges can play an effective part in reducing risk and improving resilience. However, communication between public authorities and "private risk reducers" lacks a sound basis of reflected communication goals and well-founded communication strategies.

Resilient and social just solution not only protect but also involve the potentially affected stakeholders. We propose, that targeted and well-designed communication strategies offer the potential to leverage the risk reduction potential of private actors affected by climate change induced hazards. On the one hand, strategy design implies that both public authorities and private actors recognize and accept adapted role models to allow for an efficient knowledge transfer and the implementation of effective risk reduction at private level. On the other hand, communication design requires a knowledge basis about communication options and their potential effects taken alone and in combination. However, systematic knowledge about communication options and their motivating or enabling effects remains fragmented and sound knowledge on the potentials of different options rather rare.

We address a part of this gap by systemizing knowledge about potentially effective communication options and their possible effects understood as communication success in motivating private stakeholders to act. The scientifically sound detection of effects of communication is a task addressed by ongoing research the results of which may help to fill the other parts of the knowledge gap described. We present an innovative approach to classify communication measures and provide a first overview of their potential effects. The proposed classification looks at individual and collective effects and on the directionality (mono- to multi-directional) of communication. And we present our approach to strategy design and an exemplary communication strategy designed to address individual and collective motivation factors. Finally, we discuss important design elements for successful communication at the level of strategies and single measures.

Keywords: risk communication, private risk reduction, climate change induced risks, risk management, resilience

1. Introduction

Climate change driven risks in urban areas increase pre-existing challenges of risk management. Often and for good reasons public risk reduction cannot be offered to all areas due to lacking efficiency or acceptability, because they are hardly compatible with the dense and multifunctional urban fabric (i.e. inundation) or because of the spatially unrestricted or unpredictable pattern of the hazard (i.e. heat, heavy rain). Private action and effectiveness to reduce risk or damage has been described on several occasions (e.g. Schünemann et al., 2020).

Private risk reduction is a significant contribution to the risk management that is usually carried out by the public sector and thus also an important component of resilience at the local level. The importance of communication for awareness raising,

knowledge about options for action and the development of capacities for individual and collective action has long been emphasized, e.g. by IPCC documents (Noble et al., 2014). In 2015, also the 2030 Agenda for Sustainable Development (United Nations, 2015) formulated resilience and adaptive capacity as a central element of Goal 13 and addresses explicitly the need for the education of individuals and institutions to adapt and reduce impacts. However, communication between public authorities and the actors of private risk management still lacks a sound basis of reflected communication goals and well-founded communication strategies.

In practice, the delegation of risk management to the private level usually takes place without any additional involvement or resources (Kuhlicke et al., 2020) and is thus partly interpreted as a rather neoliberal approach (e.g. Coaffee & Lee, 2016). Systematic communication between institutional actors in risk prevention (e.g. municipal specialist administrations or state offices) and affected "non-state actors" (“laypersons” according to Ballantyne, 2016) is not established or is part of a learning process in the ongoing development of risk management (cf. also Demeritt & Nobert, 2014, p. 313). Thaler et al. (2019, p. 1074) speak in this context of an ongoing social transformation with regard to dealing with natural hazards, and underline the need for a "new social contract" in this field, including a readjustment of organization and responsibilities.

Risk communication with private actors has already become important. Risk communication in relation to health risks is well established and already better investigated (Adekola, 2020b; Fitzpatrick-Lewis et al., 2010). In contrast, approaches to risk communication relating to flood risk management, other environmental risks (Kuhlicke et al., 2020; Wachinger et al., 2013), or climate change and climate adaptation (Körfgen et al., 2019; Moser, 2016) are newer, less established and less studied. Knowledge, experience, competencies and capacities among the actors acting as communicators are often not sufficiently developed to date (Körfgen et al., 2019; Moser, 2016). Participatory formats in risk communication are being discussed as particularly effective, but are still rather the exception (Rollason et al., 2018, p. 1670; Wirth et al., 2014, p. 36). Moser (2016, p. 360) even speaks of the need to develop "boundary institutions dedicated to the improved exchange between CC-Communication researchers and communication practitioners ... and ... involving ... the intended audiences".

In our paper, we present an innovative approach to classify communication measures and provide a first overview of their potential effects. The proposed classification looks at individual and collective effects and at the directionality (mono- to multi-directional) of communication. And we present our approach to strategy design and an exemplary communication strategy designed to address individual and collective motivation factors. Finally, we discuss important design elements for successful communication at the level of strategies and single measures.

2. Private risk reduction and strategic risk communication on three levels

The term "private risk reducer" is not defined in the literature. It is used here to refer to actors who are responsible for deciding on and implementing measures to privately reduce their own risk. These may include non-state actors such as private individuals, organizations or even companies which, on their own responsibility and in their own interest, implement measures to reduce risks to health, objects, buildings, production facilities, etc. Individuals making their own provisions for risk reduction are typical addressees of risk communication.

The term risk describes the probability of negative consequences triggered by events (e.g. natural hazards influenced by climate change) such as heat, heavy rain or floods. Risk results from the interaction of hazard, exposure and vulnerability. Communication is generally understood as a process of mono- to multi-directional exchange of information and knowledge between actors (Adekola, 2020b; Covello et al., 1986). Risk communication is one of the (external) factors that influence how people understand risks, how they perceive them and how and which decisions they make in dealing with these risks (cf. e.g. Grothmann & Patt, 2005; Vulturius et al., 2019). The aim of risk communication is to support private risk reducers in taking measures to reduce the negative consequences of natural hazards. Risk communication is thus also related to the wider fields of "climate change communication" (Ballantyne, 2016) or "environmental communication" (Cox, 2007; Hansen, 2019).

Risk communication takes place at various levels and involves different communicators and addressees (target groups). Organized actors from politics, administration, associations etc. sometimes have formally defined tasks in the management of climate change risks and are both target groups of communication (e.g. from science) and central actors of risk

communication (Carius & Renn, 2003). This group is the subject of climate change communication science (Moser, 2016). Citizens, business enterprises or associations are often addressees of risk communication (cf. Ballantyne, 2016). In the context of our work, we consider risk communication primarily as communication between actors of state institutions (including local administrations) on the one hand and citizens as private risk reducers on the other. In a "modern" understanding of communication, however, private risk reducers not only passively receive communication, but also shape contents and processes of strategic communication designed to strengthen their willingness and ability to perform in private risk reduction (P. Wiedemann & Schütz, 2010).

Our contribution is based on the working hypothesis that there is an increasing number of studies on risk communication, but that these do not sufficiently address the strategic orientation of such communication. Targeted and well-designed communication strategies offer the potential to leverage a risk reduction potential of private actors affected by climate change induced hazards. Communication strategies can be seen as contributions to the development of climate-sensitive and resilient societies (Körfgen et al., 2019). The targeted design of communication strategies is an important part in a contemporary role definition and role perception of public actors of risk management. Strategies can also make an important contribution to the development of the perception and fulfilment of the role of private actors by addressing influencing factors such as risk perception, sense of responsibility, knowledge, self-efficacy or outcome efficacy (see section 3 and Figure 2).

Ballantyne (2016, p. 340) describes strategic communication as "coordinated effort with a strategic aim, clear objectives, coordinated messages and media tactics, well defined audiences, carefully considered time and resource management". A strategic approach to risk communication thus implies the aim of achieving goals through planned and coordinated communication processes in the sense of better information and exchange and the joint search for solutions, right through to influencing the behavior of addressees (P. Wiedemann & Schütz, 2010). Strategies for risk communication can affect different phases of risk management (Höppner et al., 2012) and may pursue short, medium and long-term communication concerns (Loroño-Leturiondo et al., 2019). For the understanding of the strategic orientation of risk communication in this paper, however, (1) the measure-oriented understanding of strategy and (2) the analytical distinction of three levels of effectiveness of strategies are important.

(1) As a communication strategy we consider bundles of communication measures that are put together with regard to defined communication goals, target groups and natural hazards ("strategy design"). A strategy thus consists of at least two measures ("mix of measures") and is also justified by synergy effects between them. Synergy effects can result from factual, temporal and social dimensions (Howlett & Mukherjee, 2018). This includes two different perspectives when looking at a communication strategy (a) from the perspective of the combination and sequence of applied measures and (b) from the perspective of the individual measures, involving aspects such as timing and "framing" of implementation for selected communication goals, target groups and contexts.

(2) The understanding of effectiveness of risk communication strategies is important on three levels (see Howlett, 2019):

Level 1 "Objective of strategy development as a process": Risk communication can be the more effective the more strategic it is realized under consideration of conditions for the implementation of measures. Strategy development (or design) as a process is thus already a contribution to increasing the effectiveness of risk communication. Communication objectives are only part of the relevant aspects.

Level 2 "Effectiveness of an individual strategy": This level deals with the substantive objectives of a communication strategy as a whole. Several measures are combined to contribute to the realization of a strategic communication objective through mutual complementarity and synergy effects (e.g. synergy effects through "addressing" individual and collective motivational factors, see section 3). Local contexts, previous experience, communication habits, communication obstacles, ongoing communication processes and the implementation of certain communication formats also influence strategy design.

Level 3 "Aim of a single communication measure": A linear causal link between measures and possible desired effects (in the sense of motivation to implement private measures) cannot be assumed (Moser, 2016, p. 351; Steelman & McCaffrey,

2013, p. 695; Wachinger et al., 2013, p. 1063). The impact of measures depends largely on their design and the context of their implementation.

3. Traditional and innovative communication measures for communication strategies

As a means of risk communication, communication measures pursue different (single or multiple) communication goals, address or involve specific (also differing) target groups, make specific use of single to multiple communication methods or communication formats, address selected communication contents and convey intended key messages. Coordinated with each other and aligned with higher-level goals, communication measures can form communication strategies. We have identified different and differently complex communication measures (see Table 1). These range from well-known formats such as brochures and maps to rather new formats such as serious gaming or citizen science. The extremes range from mono-directional forms of information provision to multi-directional communication formats and collaborative physical actions. Occasionally, rather traditional formats such as story-telling or very new formats such as communication through visual or performing arts where identified.

Types of communication measures can be classified according to different aspects such as target groups, methods, contents, the intended effect, etc. A comprehensive systematics of communication measures has not been identified in the literature. Kuhlicke et al. (2016) have presented the potential specific effectiveness of different communication methods with reference to four selected communication objectives of flood risk management. Mast (2008, p. 424) contrasts communication methods from the field of change management in the economy with their potential scope and depth of effect. Körfgen et al. (2019) categorize schematically according to the frequently discussed mono-directional and inter-active communication formats. In line with our action-oriented strategy design, we propose a classification according to two basic dimensions of communication instruments. These two dimensions allow only a rough but innovative and helpful systematization of the variety of measure types with regard to the goals of strategy development:

Dimension 1 "Basic communication approach" - mono- vs. multi-directional. As has been described, there is a discrepancy between the recognition of the particular effectiveness of dialogical, multidirectional communication approaches in addressing numerous motivational factors on the one hand, and the still predominant practice of mono-directional, “under-designed” approaches risk communication on the other.

Dimension 2 "Type of impact of a measure" - individual vs. collective. Both individual and collective effects have their importance and justification as a communication objective. They can complement each other optimally to improve effectiveness. However, collective effects in particular have so far been severely underrepresented both in the orientation of measures and in research (cf. also Kuhlicke et al., 2020) and deserve increased attention.

Table 1. Types of measures in risk communication

Communication measures	**Brief description**
Hazard maps, risk maps	Hazard and risk maps (printed or web-based) visualize areas of potential hazard or risk related to different land uses and allow a differentiation of hazard levels or damage probabilities.
Planning documents	Plans are documents containing statements on aims and measures authorized by the public authorities with a regulatory character, e.g. in relation to land use or risk management.
Brochures/flyers	Brochures (printed or downloadable) usually provide generalized information, e.g. on local risks or options for private risk management.
Websites	Websites usually offer generalized information, e.g. on local risks or options for private risk management - as an alternative form of preparation to brochures or with the possibility of user-oriented guidance through the contents.
Real-time information (e.g. water levels)	Real-time information provides current values about the status of parameters that can indicate danger or risk - as a basis for behavioral private decisions: e.g. water levels, temperatures, precipitation

Warning services (e.g. app-based)	Warning services (increasingly web-based) provide event-related warning information on the sequence of expected or ongoing events (natural hazards).
Advertising campaigns	Advertising campaigns can communicate public and private messages about risk management solutions. Advertising campaigns convey focused key messages that can provide information or provide the impetus for further work on issues relating to personal provision.
Reporting in traditional media	Widely spread and usually little site- or solution-specific reporting on risks or options and examples of (private) risk management.
Exhibitions	Exhibitions are temporary (e.g. days to weeks) offers of information and interaction on specific topics.
Online forums	Forums are web-based, highly interactive exchange formats between experts and citizens (among themselves or mixed), which are usually managed by an administrator and focus on specific topics.
Blogs	Blogs are web-based, thematically oriented information channels that offer thematically focused information. By offering commentary functions, an exchange with bloggers or between readers may be supported. Blogs tend to be less interactive than online-forums.
Social networks	Communication based on social networks (e.g. Twitter, Instagram, Facebook) enable short-term, thematically oriented notifications to subscribers of the channels or network partners, which can be distributed quickly by forwarding.
Traditional information events	Traditional information events mainly transport mono-directionally thematically focused content from the authorities to the citizens. Participatory or dialogical formats and possibilities are rather limited.
Activating communication events (ACE)	Activating communication events are time-limited (rarely longer than a few hours) events. They serve to activate desired behavior with regard to private risk management. ACEs specifically address the target audience and combine different formats of information, discussion and interaction to address different motivating factors that support and enable behavior modification. Wherever possible, ACEs work with concrete information and respond to the information needs of the addressed citizens in order to enable them to adapt their behavior to their personal situation.
Participatory workshops	Participatory workshops are short-term (usually shorter than one day) content-related and/or spatially focused events for the development of solution options with regard to issues related to risk and risk management.
Citizen dialogues	Citizen dialogues are communicative events, usually organized by the local or regional level (specialist administrations), in which citizens are both addressees and actors. Citizens' dialogues are intended to engage in intensive discussions with citizens, e.g. about current or future planning and implementation. Citizens' dialogues differ from information events in that they are actively designed to promote exchange and are supported by suitable settings and event formats.
Planning games / scenario workshops	Planning games serve a creative exploration of possible shapeable futures, e.g. with regard to the development of risks and/or the realization of risk management options.
Consultation	Consulting supports the search for solutions by citizens* for private risk management in a targeted, technically sound and context-related manner.
Explanatory video clips	Video clips are used to illustrate explanations, making them easier to understand and more responsive to specific situations.
Computer-based simulation	By means of 2D or 3D reproductions of processes in space (e.g. flooding, heat distribution, etc.), simulations are suitable for the representation and transfer of complex, e.g. spatial relationships between natural events and their effects. For example, variants of measures and their impact on the affected area or potential damage can be simulated. In simulations, there is usually no personal interaction between the providers and recipients of the information. However, the technology and programming of a simulation offers a high degree of bi-directional communication. Simulations are also suitable for offering participatory elements/participation elements such as different adaptation options. Simulations can thus be part of Serious Games (adapted from STZ, 2019).
Serious Gaming	Serious games are a form of technology-based communication. They are used to communicate complex e.g. spatial relationships between natural events and their effects in a playful way (e.g. risk perception) and to strengthen them through visual recognition and repetition (adapted from 2av & STZ, 2019).
Virtual reality applications	Virtual Reality applications enable a particularly life-like representation of interrelationships and thus potentially enable a higher degree of understanding and identification between users and content.
Education and training	Education contents may integrate issues of risk management into the curricula of educational institutions such as universities, colleges or schools.

Citizen Science	Citizen Science serves a rather project-like integration of citizens into knowledge-creating processes.
Competitions	Competitions motivate citizens to participate in the development of ideas and solutions or the documentation of solutions.
(Protection) exercises	Community exercises related to the management of natural hazards organized by competent authorities, private sector operators or other organizations such as fire or water brigades.
Reconstruction workshops	Joint, partly guided reconstruction activities after damaging events.
Neighborhood help	Mutual support of (potentially) affected persons in exposed areas in the preparation and management of natural events.
Financial support instruments	Financial support instruments to promote "desired" (in the sense of risk-adapted) behavior, e.g. from local, regional or state level.
Legal regulations	Legal regulations on the framework and obligations in connection with, for example, personal provision.
Performances (arts, theatre, installations)	Artistic, performative examinations of the content of risk and risk management.
Story-telling	Traditional form of communication for the transmission of knowledge, experiences, rules, social norms etc.

Figure 1 illustrates the assumption that the majority of communicative measures (such as brochures, risk maps or warning media) tend to be mono-directional and address rather individual factors. Types of measures with a stronger potential for multi-directional communication and collective effects include, for example, citizen dialogues and participatory workshops of actors from different areas of society such as politics, administration, economy, civil society, etc. Such measures are also considered to be more effective in terms of motivating social and emotional factors (Höppner et al., 2012). Figure 1 shows a preliminary and approximate classification as an insight into a process of "work in progress". For many measures, the classification is not clear-cut due to the wide scope for designing options: both the communication approach (mono- vs. multidirectional) and the more individual or collective impact of the measures are strongly linked to the design and implementation of a communication measure. The placement near the axes indicates a greater flexibility in this sense. The types of measures that have been selected as elements of an exemplary strategy (see section 4 below) to strengthen private provision are highlighted in red.

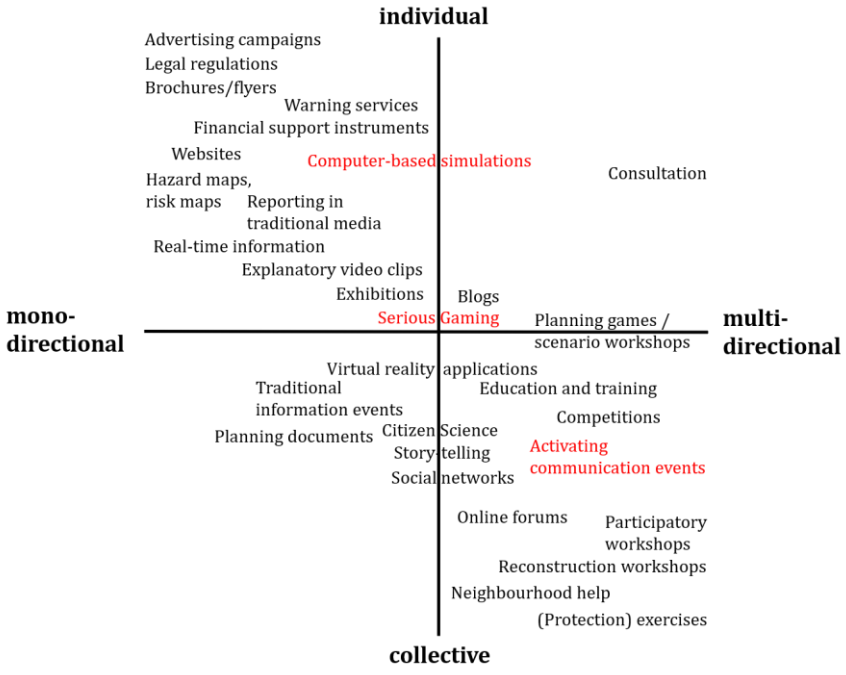

***Figure 1**. Classification of communication measures according to the characteristics individual vs. collective and mono-directional vs. multi-directional.*

Effects that can be achieved by communication are measure specific. "Effects" are represented by motivational factors that have been identified and described in environmental psychological research as relevant for influencing human behavior. These motivation factors are central elements for understanding a communication measure and thus for steering the design of strategies and individual measures towards specific effects with regard to intended protection and adaptation behavior. Motivational factors can be divided into individual and collective factors. Figure 2 gives an overview of motivation factors considered. Factors particularly regarded in our work are highlighted bold.

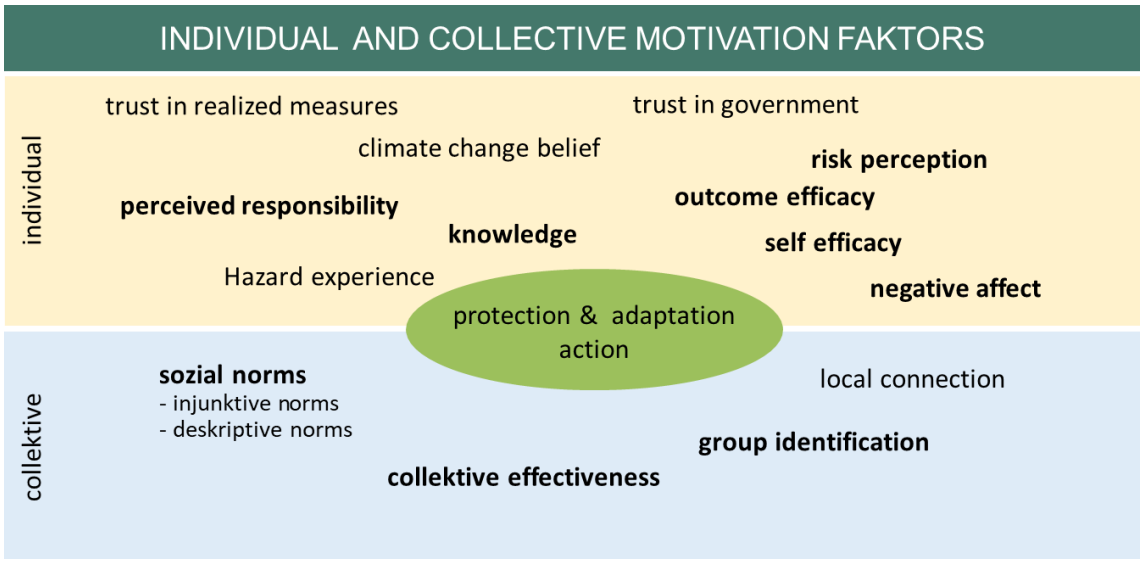

***Figure 2**. Individual and collective motivation factors (following Köhler & Masson, 2020; van Valkengoed & Steg, 2019).*

Which of the effects are ultimately achieved by an implemented communication measure depends on design and numerous other factors (see section 5). The impact spectra are a basis for two considerations that are central to the development of a strategy. First: Which measures are basically suitable for achieving certain impact objectives? Second: Which measures can be sensibly combined to achieve the strategic objectives as a whole? Table 2 attempts to describe a potential spectrum of effects for the communication measures chosen for the communication strategy. The information is taken from the authors' assessments based on literature and their own experience. A broader empirical basis and validation of the impact spectrum for all identified communication measures (cf. Table 1) is part of the ongoing research work. The listing of the spectrum of effects does not imply an evaluation of the possible effectiveness. Nor is it likely that any individual measure is generally suitable for addressing all relevant motivational factors (Loroño-Leturiondo et al., 2019).

***Table 2.** Design-dependent impact potentials of communication measures (preliminary results).*

Motivation factors / **Communication measures**	Trust in implemented measures	Trust in the government	(Event) Experience	**Knowledge**	**Risk perception**	**Belief in the reality of climate change**	**Perceived responsibility**	**Self-efficacy**	**Outcome efficacy**	(Action) Experience	**Negative affect**	Local connection	**Social norms** (injunctive und descriptive)	**Group identification**	**Collective effectiveness**
Activating communication events (ACE)															
Computer-based simulation															
Serious Gaming															

4. Design of an exemplary communication strategy

The clarifications of strategy design (section 2), the portfolio of measures and the potential spectrum of effectiveness of individual measures (section 3) form the basis for the development of an exemplary communication strategy within the framework of an ongoing research project. The strategy will be implemented at various locations in cooperation with local stakeholders wherever possible integrated into existing communication processes. The effectiveness of this strategy will be examined. We want to trace the stages of strategy development in relation to the three levels of strategy development discussed in section 2.

Level 1: Objective of strategy development

The background to the undertaken strategy design is a research project (Private Risk Reduction, German Federal Environment Agency, FKZ 3718 48 101 0), which is intended to enable reliable statements about the effects of risk communication by implementing and measuring the impact of strategically developed communication measures. We were looking for a generic communication strategy to strengthen private risk reduction in the context of climate adaptation for different target groups and several natural hazards influenced by climate change. Work on risk communication shows that a communication strategy can generally be applied to different natural hazards (Höppner et al., 2012). Indications of limited transferability are discussed for environmental impacts with highly different dynamics such as for flooding and air pollution (Loroño-Leturiondo et al., 2019).

The strategy is also intended to specifically address gaps in previous risk communication in order to strengthen the intentions (motivation) and ability to act of private risk reducers. By combining methods and content in multi-directional and mono-directional formats, we want to ensure that different groups can be reached by the communication strategy and that multiple of the selected motivational factors can be addressed. In the case of the developed strategy, the project consortium selected a number of individual and collective motivational factors considered to be of particular importance in motivating individuals (cf. Figure 2): Knowledge, risk perception, perceived responsibility, self-efficacy, outcome efficacy, negative affect, social norms, group identification and collective effectiveness.

The orientation towards communication measures with a high impact potential suggests a concentration primarily on measures that combine multi-directional forms of communication and innovative communication concepts. Three criteria are particularly important for the selection of measures:

- Expectation of effectiveness. *Is the type of measure basically suitable for addressing the desired motivational factors?* (level 2, below)
- Strategy orientation: *Can the type of measure support the effectiveness of other measures in the strategy?* (level 2, below)
- Feasibility: *Can the measure be implemented in high quality within the existing time, financial limits and partner constellation?* This question only sounds project-specific at first. Also in the real world, risk communication is subject to temporal and financial restrictions and must be implemented within defined partnerships (level 3, below).

Other project-specific "test criteria" also played a role: the project-internal interests in knowledge generation, innovative measures and the suitability of a communication measures for methodologically rigorous impact measurement. Neither of these criteria was found to be significant for strategy processes or was selective for the constellation of measures. They are omitted in the following discussion.

Level 2: Effectiveness of an individual strategy

The relationship between knowledge or perception and action is complex, not linearly predictable. It has been repeatedly stated that the traditional linear and mono-directional approach to communication by providing information does not

necessarily lead to action (Moser, 2016, p. 351; Steelman & McCaffrey, 2013, p. 695; Wachinger et al., 2013, p. 1063). Numerous factors influence the extent to which a risk is perceived as such and the extent to which it translates into an intention to take action. In order to achieve communication goals, the motivational factors to be addressed must be clarified before designing strategies or measures.

The result of the strategy development in our study is a combination of measures that is suitable for supporting the goals formulated for the strategy development (see Figure 2 and Table 2) in a promising way. As a result, the developed strategy comprises three types of communicative individual measures framed by a fourth communication path being the embedding of the measures by accompanying locally specific communication concepts:

- Activating communication event
- Computer-based simulation
- Serious Gaming
- accompanying on site communication concept (framing)

The combination of measures offers a variety of methods and formats and is found to be appropriate to address the motivation factors identified as particularly relevant. The types of measures jointly form a generic strategy that addresses different natural hazards and target groups. In accordance with the classification (Figure 1) and description (Table 1) of the communicative measures outlined above, our strategy combines (a) multi- with mono-directional communication formats, (b) individual and collective factors, (c) "factual" with more "playful" formats and (d) familiar methods (e.g. established event formats) and comparatively new approaches such as simulation or serious gaming.

Level 3 „Aim of a single communication measure“

The selected types of measures have already been defined in previous sections and characterized in relation to a) communication approaches "mono-directional vs. multi-directional" and b) expectations of effectiveness "individual vs. collective". In combination, the measures meet the requirements of the selection criteria introduced above:

Expectation of effectiveness: All three types of measures address important individual and partly collective motivation factors (Table 2). The decisive factor in determining which motivation factors can be addressed and to what extent is the individual and coordinated design of the individual measures.

Strategy orientation: We expect that synergies can be achieved in the implementation of the measures both for the content and the effectiveness of communication. While computer-based simulations and serious gaming can deploy explicit strengths with regard to risk perception, self-efficacy and outcome efficacy, activating communication events are able to address these and complementary motivational factors accompanying or preparatory manner.

Feasibility: For the selected types of measures, considerable organizational and partly technological (in particular for computer-based simulation and gaming applications) effort is to be expected, especially when they are implemented for the first time. The implementing consortium combines the necessary know-how and experience to realize the coordinated design of measures in high quality, to develop local cooperation and to implement the measures in a synergetic way in terms of organization, content and methodology.

For the target levels of strategy development and the selection criteria, it is the design of the measures that determines whether the objective of strategy development has actually been implemented (level 1), whether the objectives of the individual strategy can be consistently addressed (level 2) and whether individual measures can be successfully implemented and develop the desired effects and synergies both individually and in combination (level 3). Section 5 summarizes some central aspects that may are useful for guiding the development of strategy and measure design.

5. Design of communication measures – interface to the implementation of the communication strategy

Communication design is more than the translation of content into a language that can be understood by the addressee, an understanding often used by conventional approaches to transfer or dissemination. The challenges of risk communication directed at citizens are not trivial. The first major communication hurdle already exists between science and the main communicators, including actors in politics, administration, interest groups or the media (Moser, 2016, p. 356f). Impact-oriented design of communication measures serves the high claim to achieve the defined communication intentions through communication. Good strategy and implementation design shape communication processes in such a way that the communication reaches the addressees, involves them wherever appropriate and can be understood, accepted and transformed into action patterns.

Numerous studies deal with the question of how best to communicate in order to achieve the desired enabling or empowering of private actors (Moser, 2016, p. 351). Wirth et al. (2014, p. 33) name 18 success factors for good communication mainly with reference to content, target groups, motivational elements. Adekola (2020a) summarizes a range of requirements for good communication. Many other authors emphasize single or several of these requirements. In the following, significant challenges for the strategic design of strategies and measures are condensed. Only few of these can be addressed at the strategic level (Table 3). The definition of communication goals were already discussed in section 3.

Table 3. *Design challenges of strategy development on three target levels.*

Strategic target level Challenge	Level 1 „Goal of strategy development “	Level 2 „Goal of the individual strategy“	Level 3 „Goal of an individual communication measure“
Communication goals	X	X	X
Continuity of the communication process		X	X
Local context		(X)	X
Obstacles to communication			X
Communication content			X
Communication formats			X
Confidential persons			X
Product and media design			X

Continuity of the communication process

Project-like (predefined start and end) interventions carry the risk that they may reduce the reach, acceptance and also the learning and motivation effects among the addressees. In addition to changes in contexts, knowledge or personal decision-making phases (Bryan et al., 2019), the memory of knowledge and experience - e.g. from previous events - is also subject to the gradual loss over time (e.g. Sutton et al., 2020). Risk communication is therefore an ongoing task, both in general and specifically through the various phases of risk management before, during and after events (based on Steelman & McCaffrey, 2013, p. 690).

Local context

Individual action is always embedded in social structures and power relations that originate from the past, but are also shaped by daily interactions. Understanding the local context, such as the need for knowledge or discussion, special sensitivities towards issues or actors, and communication experiences, is important in order to frame communication appropriately at the local level, to formulate messages sensitively (acceptability) and thus to enable an effective local discussion (based on Steelman & McCaffrey, 2013, p. 689).

Communication design is therefore oriented towards numerous questions which, in addition to communication intentions, also deal intensively with the possible realities and perspectives of the addressees in order to integrate them as effectively as possible into the communication process. Such questions can be: What previous knowledge and experience do the addressees have as actors in dealing with e.g. heat, floods or heavy rain? With which other, possibly "more important" topics do these questions compete? How do the addressees see their own role in dealing with these hazards (also in contrast to the role of the state)? What communication habits do the addressees have?

Obstacles to communication

Measure design must take into account communication obstacles, which can vary greatly from case to case and can weaken or completely counteract the effectiveness of communication. These include, for example, the emotions triggered by a topic (Chapman et al., 2017; Rakow et al., 2015; Roeser, 2012; Wirth et al., 2014) or fears (P. M. Wiedemann et al., 1991), social norms and values prevailing locally or in society (Kuhlicke et al., 2020), a possibly developed passivity ("learned helplessness" (Paton & Johnston, 2001) or the simple lack of willingness of the addressees to absorb knowledge ("knowledge-ability", cf. Adekola, 2020b, p. 4). Such communication barriers are often deeply rooted in society and cannot necessarily be addressed or removed by means of risk communication (Ballantyne, 2016). Nevertheless, taking them into account can help to facilitate effective communication.

Adequacy, relevance and comprehensibility of the communication content

It is not the information itself that determines its effect, but rather the way in which people interpret and process it in the context of their experiences, convictions and expectations (following Paton, 2008, p. 4). Different addressees - e.g. men, women, representatives of different milieus - have different communication needs and experiences (cf. e.g. Bryan et al., 2019; West & Orr, 2007). Therefore, both the relevance and appropriateness of the selected contents (Steelman & McCaffrey, 2013) and their preparation are central, so that they can be understood and " integrated " into the body of knowledge and experience (e.g. Slovic, 1986). Also important are factors such as the closest possible connection of information to one's own living environment (e.g. the own property Rollason et al., 2018, p. 1672), the integration of local knowledge and the interweaving of local knowledge with external expert knowledge, reliability (Steelman & McCaffrey, 2013, p. 690) as well as the timeliness and transparency with regard to uncertainties and knowledge gaps (Adekola, 2020a; cf. also Rollason et al., 2018).

Communication formats

The choice of communication formats should be closely aligned with the communication objectives, addressees and their contexts. Even if individual communication formats are never equally suitable for all population groups (Loroño-Leturiondo et al., 2019), the view has become accepted that the mere provision or dissemination of information according to the transmission-reception paradigm (Rollason et al., 2018, p. 1666) to serve a supposed "knowledge deficit" (transmission paradigm) is not promising to motivate people to act (Ballantyne, 2016). Interactive formats are generally regarded as the more suitable approaches to risk communication (Adekola, 2020a, p. 121). In CC communication, a shift towards dialogical formats has only intensified in the decade after 2010 (Pearce et al., 2015). Research has also shown that private actors are prepared to become involved in natural hazard management processes if their concerns are heard and taken into account (Thaler et al., 2019, p. 1079).

Confidential persons, suitable communicators

Decisions relating to natural hazards are made in the context of uncertainty (Paton, 2008, p. 4). People tend to trust rather related parties than government agencies, and they are often organized in groups to which access must first be established (Tyler & Sadiq, 2018). The involvement of accepted actors, who enjoy a high degree of trust among the addressees, is of utmost importance for the acceptance of the communication content and the success of the communication process as a whole (Grothmann et al., 2013; vgl. Paton, 2008; Steelman & McCaffrey, 2013, p. 685). Trust helps to reduce the perceived uncertainty and complexity of risk (Siegrist & Cvetkovich, 2000). This effect is even larger the less knowledge is available and is therefore of great importance when decisions have to be made despite uncertainties (Paton, 2008, p. 4f). The involvement of trusted third parties can be an important "door opener" when it comes to reaching local people. At the

same time, opinion leaders can also have a markedly contrary influence on an intended process (Thaler et al., 2019, p. 1079).

Product and media design

In addition to other factors, computer-aided simulations and serious games are subject to specific technical and optical quality requirements from the field of classical product and media design.

6. Conclusions

The targeted design of risk communication strategies and measures is important to increase the resilience of people and locations to climate-influenced natural hazards. We present a "look into the workshop" of an ongoing strategy and measure development. The effectiveness of the communication strategy not only depends on the chosen types of communication measures, but especially on the specific design and implementation of the chosen measures in local context conditions. Strategy design and measure design go hand in hand. Strategy design defines the goals and target groups of communication and coordinates the selection and combination of communication measures. The design on the level of communication measures implements the strategic goals through the targeted development of communication measures. At the same time, the specific spectrum of possible effects of communication measures also determines the combination of measures within a communication strategy.

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Improving heat resilience of prefab concrete residential buildings

Vulnerability, adaptation measures and structural implementation

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Abstract

Rising summer heat is an unambiguous and robust climate change signal. In addition to an increase in mean temperature, it is likely that the number of extreme events, e.g. summer heat periods with high temperature, is going to increase too. Thus, actions to reduce summer overheating are highly required, particularly in cities and densely populated urban districts. Due to these facts, the research partners within the joint project "HeatResilientCity" decided to develop detailed studies for vulnerability assessment of specific residential building types, which exhibit typical structural parameters and building construction methods. These building types include prefabricated concrete residential buildings raised between 1970 and 1990. Using this approach, it is possible to transfer the results to many comparable residential buildings. By implementing the methods (1) dynamic thermal building simulation and (2) indoor thermal monitoring under summer climate conditions, the vulnerability of residential buildings regarding summer overheating, has been analysed both in the initial state and in an adapted level of enhanced heat resilience. Based on the assessment of the initial state, suitable adaptation measures to reduce the summer heat vulnerability are planned following four basic adaptation strategies: (1) reduction of solar heat gain, (2) improvement of thermal storage capacity, (3) improvement of air change and (4) cooling measures. To compare and assess the effectivity of single adaptation measures as well as combinations of various measures, the Multizone Building Model is modified. By using this approach in dynamic thermal building simulations, specific adaptation measures can be recommended for implementation onside. After implementation, the effectiveness of the recommended adaptation measures will be analysed by indoor thermal monitoring. The described examination process will be presented by examples of different resident building types made of prefabricated concrete slabs, which were built around 1985 in Dresden (Germany). Due to the results, various adaptation measures, such as external shading devices and mechanical support for night ventilation, have been recommended and implemented in these buildings. Summer overheating in densely populated urban districts is a relevant impact on residential buildings and their inhabitants. Thus, an important goal of this research topic is to conduct systematic studies on effective and reasonable adaptation measures, which provide a comfortable indoor climate during summer heat periods for residents both now and in the future.

Keywords: Heat resilience, residential buildings, vulnerability, adaptation measures, structural implementation

1. Protection of residential buildings against summer overheating

Driven by the climate change, several regions in Europe experienced an increasing number of extreme weather events in recent years, which often caused serious impacts for the residential building stock. The public usually pays special attention to types of events, which induce significant tangible damage to buildings or building parts, triggerd by heavy / torrential rain or large hail. Furthermore, it is increasingly recognised and discussed, that summer heat periods should be regarded as important impacts on buildings too, with a variety of negative consequences. If the indoor climate is under change due to summer heat periods, the thermal comfort for the inhabitants is going to decrease. The consequences may occur in the form (i) of a reduced performance and capacity, (ii) of a temperature related morbidity and (iii) finally of a higher mortality (Hellwig 2018).

Especially the insights of the latest summer heat events in 2018 and 2019 in Central and Eastern Europe leaved a mark that climate change does not only cause an increasing mean temperature. It is also perceptible for everyone by increasing summer heat periods with perseverative heat periods and intensive dry spells, sometimes in combination with intensive heavy rainfall impacts (Imbery et al. 2018). Suitable parameters to depict the growing demand for building protection against summer overheating are (i) the average temperatures, both for years and summer periods, and (ii) the number of heat days per year, each with a maximum temperature of at least 30 °C. Figure 1 shows the development of both parameters from 1961 to 2019, using the example of the city of Dresden.

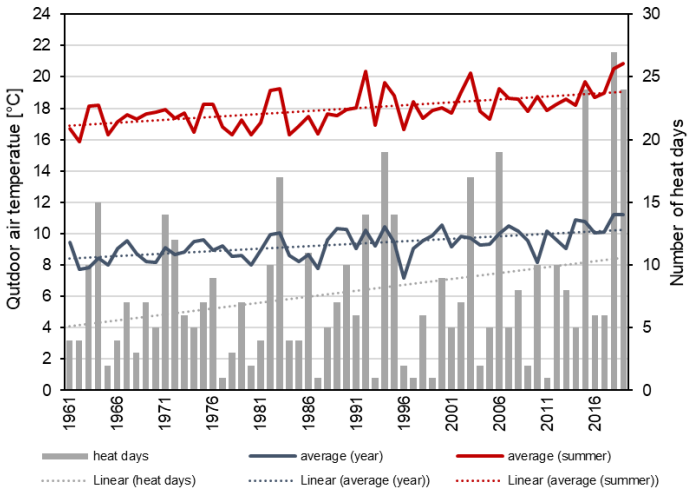

Figure 1. *Variability of the parameters "heat days", "average air temperature (year)" and "average air temperature (summer)" in Dresden from 1961 to 2019. © Kunze (2020), Data origin: DWD, Dresden-Klotzsche*

Based on the described developments, an important goal for research and implementation is an enhanced adaptability of buildings regarding summer heat impacts, both for new buildings and the stock of buildings. As a part of this process it is necessary (i) to analyse the vulnerability of existing buildings in their current state as well as (ii) to estimate both the capability and the effectiveness of adaptation measures. Based on the knowledge regarding the variety of construction-specific adaptation measures for different environmental impacts (Weller et al. 2016), this approach gives us the opportunity to prepare our buildings anticipatory for future heat impacts to reach a suitable living comfort. For the exemplary implementation of this analytic process the authors are concentrating on the Elbe valley around the city of Dresden (Germany), a region with intensive thermal load during summer heat periods (DIN 4108-2, 2013, Figure 2). In this area the assessment methods have been developed and tested on prefab concrete residential buildings, a widespread building type in densely populated urban districts.

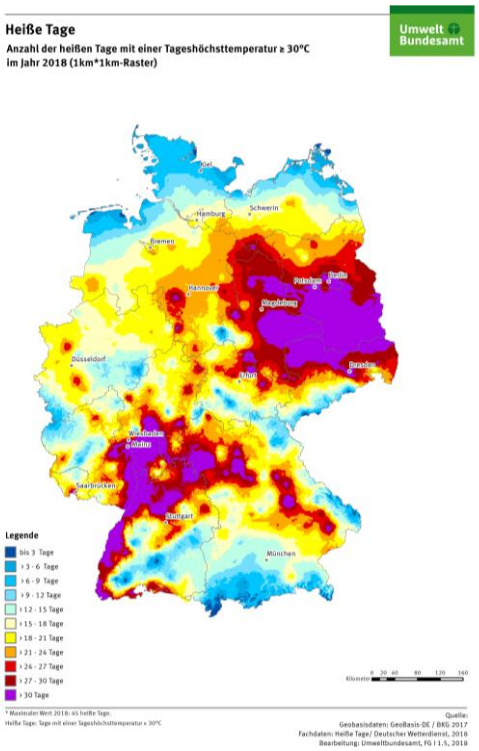

Figure 2. *Sum of the parameter "heat days" in Germany in 2018. Reference: UBA 2019*

2. Investigation approach to reduce thermal stress in residential buildings

The applied investigation approach uses principles of building typology, which are also in use for vulnerability analysis of buildings regarding other environmental threats (e.g. flooding). The detailed examinations are carried out on reference buildings, which are characteristic for the respective building type and thus correspond in essential structural and typological features. Based on the typological characteristics, conclusions can be drawn for further buildings of the same building type from the results obtained (Nikolowski et al. 2012).

The activities on the reference buildings start with a detailed source research. During this process, plan papers and construction documents for the building from different time periods are researched and reviewed. This is followed by an on-site as-built survey, which includes all important information about building construction and building services. The construction methods and layer sequences of the individual structural components as well as the geometry of the building are explored and compared with the results of the source research. In the following step, the gained knowledge is transferred into a multizone building model including the model of the building services, which is essential for later dynamic thermal building simulations. This step completes the basic research on the reference building.

The next step of investigation comprises the assessment of the thermal conditions in the initial state. For this purpose, dynamic thermal building simulation is applied, which is currently the most accurate method to objectively evaluate the summer thermal insulation of buildings and rooms. Within this investigation the simulation program TRNSYS 18 is used. In addition to the created multizone building model, a weather data set is required, which contains the meteorological parameters necessary for the simulation for every hour of a year (see Figure 3). These requirements are fulfilled by the test reference year data sets (TRY) provided by the Deutscher Wetterdienst (DWD). These data sets are based on weather observation series (1995 to 2012) for the current state and on climate change projections (2031 to 2060) for the future state. They are available for the area of the Federal Republic of Germany in 1 km² grids. (DWD, 2017)

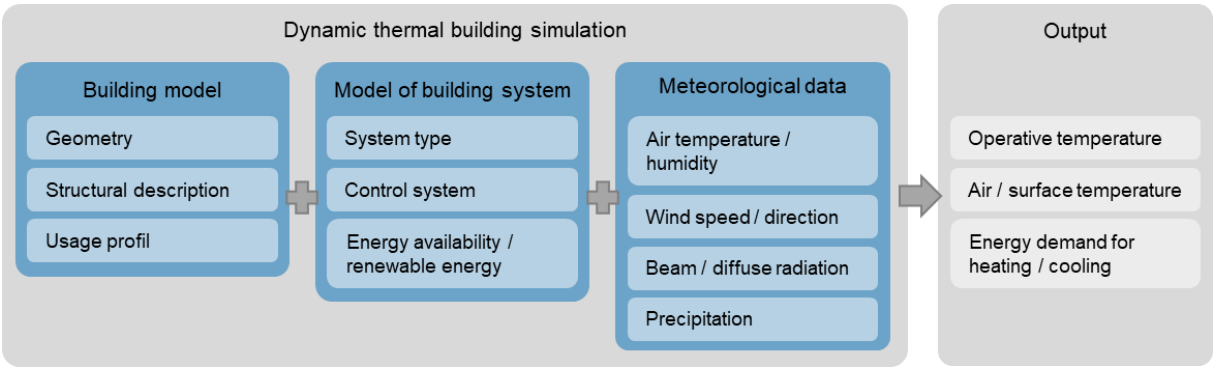

***Figure 3**. Structure of a dynamic thermal building simulation. © Kunze (2020)*

Parallel to the simulations, indoor air temperature, relative humidity and CO_2-concentration are measured systematically in selected rooms of the reference building under summer climate conditions over a period of several months. For the evaluation of these thermal conditions in the reference building, the maximum temperature value and the number of "overtemperature degree hours", according to the German standard DIN 4108-2:2013-02, are determined with the help of the values obtained from the simulation and the indoor thermal monitoring. Furthermore, the measurement data collected will be used to validate the simulation model in order to realistically represent the thermal behaviour of the building as well as the user behaviour. The parameter "overtemperature degree hours" is suitable for assessing the temperature conditions within a room over longer time periods and for comparing these parameters with those of other rooms. It considers not only the duration in which a defined temperature is exceeded, but also the amount of the excess. Depending on the geographical location of the building, the standard defines a reference temperature. To determine the overtemperature degree hours, for each hour, in which the operative indoor temperature exceeds the reference temperature, the difference between the two values is calculated, followed by the determination of the annual total. The proof of summer thermal insulation according to

this standard is fulfilled, if during the period of use (residential building: 24 hours per day) the number of overtemperature degree hours in each room of the building over one year is less than 1200 Kh/a.

Based on the assessment of the initial state, an adaptation concept considers appropriate measures for the reduction of the thermal load in the reference building. Therefor it is recommended that the following four basic adaptation strategies are used as a guide:

i. Reduction of solar heat gain,
ii. Improvement of thermal storage capacity,
iii. Improvement of air change and
iv. Cooling measures.

Because measures that reduce or minimise solar heat gains (e.g. external shading devices) achieve positive effects in reducing thermal stress, their feasibility is examined first. Furthermore, measures are developed which retain the heat so that the maximum indoor temperatures are lowered and the stored heat is released during cooler outside temperatures, e.g. through ventilation. In order to use the mostly colder temperatures at night to exchange the heated indoor air, measures to improve the air change are also capable. Finally, it is possible to reduce the interior temperatures by cooling systems, at best in combination with regenerative energy sources installed at the building itself. Since individual measures can affect the vulnerability of buildings to other influences or climatic conditions, a holistic approach is always necessary, including the weighing of the advantages and disadvantages.

In order to be able to compare and evaluate the effects of individual measures and their combinations, the building and building system model is modified accordingly and examined in thermal building simulations. Subsequently, the thermal conditions in the adapted state are evaluated with the above-mentioned parameters. In addition, after implementation of the measures, a success control is carried out by an indoor thermal monitoring under summer weather conditions. Finally, the transferability of the adaptation concepts to existing buildings with comparable typology is assessed. Figure 4 summarizes the individual steps of the investigation approach.

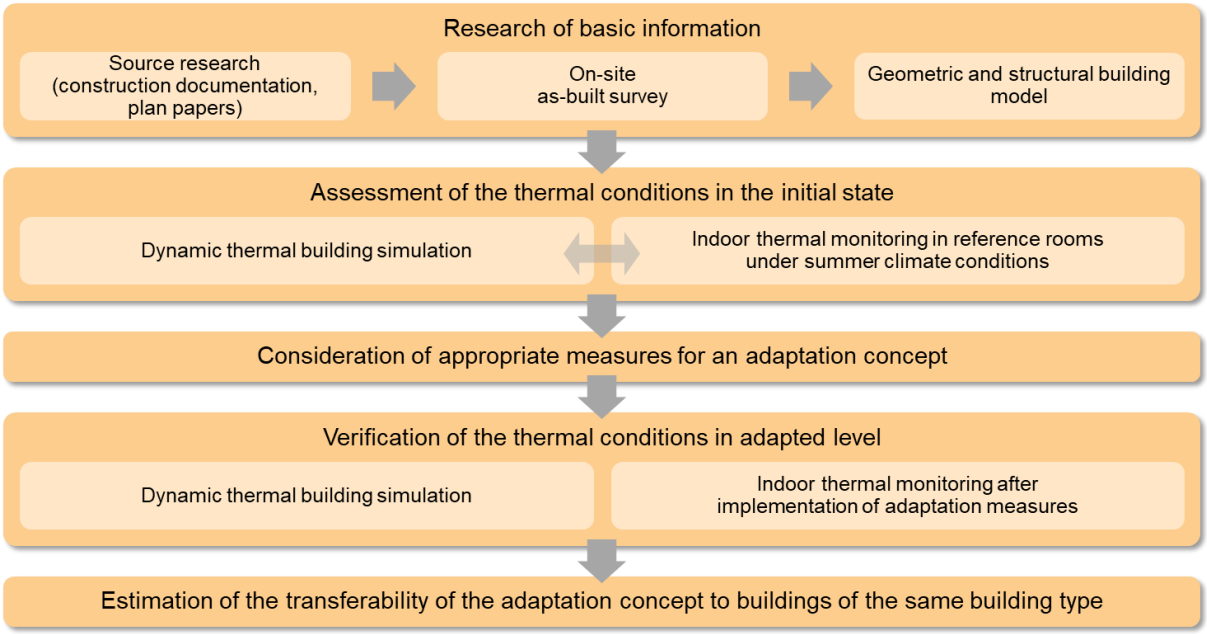

***Figure 4**. Organisation chart of the investigation approach. © Kunze (2020)*

3. Implementation at prefab concrete residential buildings in Dresden – Gorbitz (Germany)

Within the conception process for the joint project "HeatResilientCity" the authors decided to develop, to implement and to validate their research approaches and methods using the example of a specific building type, whose application gives several advantages. The selected building type of prefab concrete residential buildings, hereinafter named as 'PCR buildings', is suitable for vulnerability assessment regarding summer heat periods,

i. because this type represents a large stock of typified residential buildings, erected between 1972 and 1990, which covered almost 650.000 flats within the former GDR area (Allisat et. al 1997);
ii. because this type still stands exemplary for densely populated urban districts inhabited by families from medium and lower income classes as well as senior citizens;
iii. because the typified structures and building constructions of the PCR buildings, planned and erected on identical rules of technology, give a chance to develop capable adaptation measures for a widely spread usage.

The designation 'PCR buildings' is about a building type, which has been developed from 1970 for mass housing construction to satisfy the demand for rationalized multi-storey dwellings. Based on former typified residential buildings the PCR buildings, originally labelled as 'WBS 70 series', were developed as a panel construction method, which combines several precast elements made of reinforced concrete, such as (1) basement retaining walls, (2) exterior and interior wall constructions, (3) ceiling slabs, (4) stair flights, (5) multiple-leaf cold roof constructions and (5) loggia elements. All the parts of the panel construction were prefabricated in regional precasting plants, which basically followed the former rules of technology, but sometimes developed their own constructions in detail. Even if these PCR buildings have been developed for different urban planning situations, the spatial pattern and the footprints follow predefined solutions, what is a further feature for their far-reaching standardisation.

For the detailed process of vulnerability analysis and adaptation planning, as described below, the authors are going to use a reference building from the building stock of the research partner Eisenbahner-Wohnungsbaugenossenschaft Dresden eG (EWG), an important residential cooperative. This is a six-storey PCR building, erected in 1985 as a part of a large development area in the west of the capital of Saxony, Dresden. Among the specific building construction features there are both the three-layer exterior wall constructions [(a) base course, made of reinforced concrete, 14 cm, (b) thermal insulation, made of polystyrene, 6 cm, (c) weatherproof barrier, made of reinforced concrete with surface structure, 6 cm] and the flat roof with multiple-leaf-construction, named 'Trogdach', and internal drainage system. Due to the building condition the reference building has been selected by the EWG as a part of a refurbishment planning project, including energy-efficiency measures. (Insulation of external walls and top floor slab, installation of windows with 3-pane glazing) Beyond that it was planned to improve the heat resilience of the reference building so that the indoor climate within summer heat periods in the future will experience sustainable improvements.

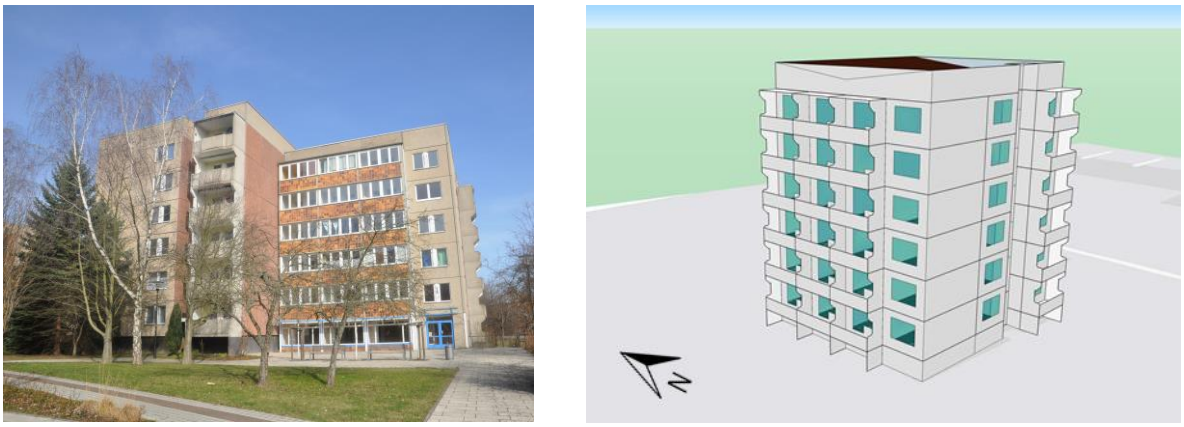

Figure 5. *Reference building, left: south façade, right: 3D-geometric building model. Pictures: © Kunze (2018)*

Results of indoor thermal monitoring under summer climate conditions

During both the summer of 2018 and 2019, systematic measurements were executed from June to September in still unrefurbished, previously described reference buildings to record the indoor climate. Table 1 shows a comparison of the recorded weather data of these two summers with the data from the test reference years of the DWD for the identical location. The presented characteristic values of the two years essentially correspond to the characteristic values of the test reference year data set for the future state and show that these two summers were characterized by extraordinarily warm weather conditions.

Table 1. *Comparison of characteristic values of test reference year data sets and of recorded weather data. Data origin: DWD*

	$T_{Ø,year}$ [°C]	$T_{Ø,summer}$ [°C]	T_{max} [°C]	Total beam radiation (summer) [kWh/m² a]	Heat days ($T_{max,day}$ > 30 °C) [-]	Tropical nights (T_{night} > 20 °C) [-]
TRY present	9.5	15.4	31.5	369.0	7	0
TRY future	11.6	17.8	35.7	505.0	18	4
Weather data of 2018	11.2	17.8	35.0	502.9	27	5
Weather data of 2019	11.2	16.9	36.7	473.5	17	4

In the summer of 2018, the indoor air temperature, relative humidity and CO_2-concentration were recorded at least seven times per hour in a total of eleven rooms with windows facing the south and west façades. At least one room per floor was selected. In order to depict the top floor (6th floor), which is particularly relevant regarding summer thermal insulation, in detail, four different rooms were captured here. In the summer of 2019, the measurement concept was repeated in another structurally identical reference building in seven different rooms, which are spread over four of six floors. Most of the rooms have windows with 2-pane glazing facing the west façades, two further rooms facing the east façades. Because the selected rooms were all unoccupied in 2019, the positive and negative effects of user influence on the indoor temperature, especially through ventilation and internal heat gains, were reduced. Thus, the results of the individual rooms are easily comparable.

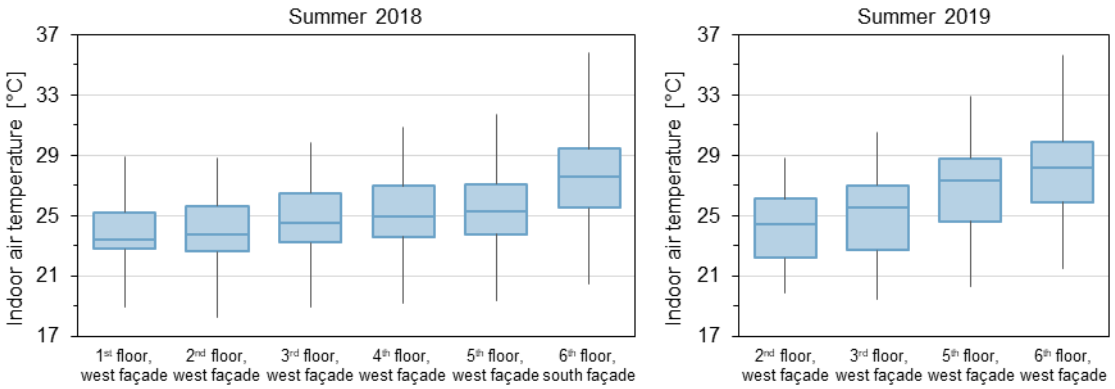

Figure 6. *Exemplary results of the indoor thermal monitoring under summer climate conditions in different, but structurally identical reference buildings in the years 2018 and 2019, presented for different floors, only 6th floor, south façade was occupied. © Kunze (2020)*

Figure 6 shows the results of these measurement series as box whisker plots for one room per floor. The extreme values as well as the median of the respective measurement series are specified. The interquartile range is limited by the 75 % and 25 % percentile. From mid-July 2018 onwards, the interior temperatures raised until the beginning of August 2018 without any significant cooling in the meantime. At that time, the absolute maximum values between 28.5 °C (1st floor) and 35.8 °C (6th floor) were reached in the various rooms. In the summer of 2019, the month of June was already an unusually warm

period, which caused the indoor temperatures to rise sharply and the absolute maximum values between 28.8 °C (2nd floor) and 35.6 °C (6th floor) were already reached. At the beginning of July there was a noticeable cooling down and the indoor temperatures dropped below 26 °C on all floors. Subsequently, two further phases could be determined, within which the interior temperatures from the month of June were approximately reached again.

In addition, Figure 6 illustrates that there are significant differences between the individual storeys of the building regarding thermal load, as both the median and the maximum values rise with increasing floor height. On average, the median increased per floor by 0.83 °C in 2018 and by 0.95 °C in 2019. Furthermore, the evaluation of the measurement results regarding overtemperature degree hours, which need to be calculated with a reference temperature of 27 °C according to DIN 4108-2:2013-02 due to the location of the reference buildings in Dresden, results in a wide range between 147 Kh/a (1st floor) and 4766 Kh/a (6th floor).

In order to illustrate the necessity for action to improve the thermal conditions in the rooms on the upper floors, a selected measuring sequence is presented in more detail below. This sequence was recorded in 2018 in a bedroom on the 6th floor of the reference building. The room is bordered by south- and west-facing exterior walls and its double-wing window with a window area of 3.15 m² is oriented to the west.

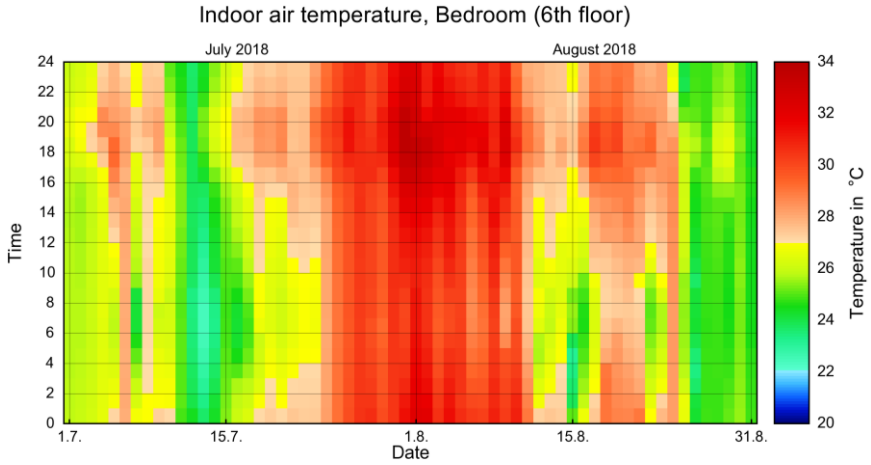

Figure 7. *Measurement results of the indoor air temperature in a bedroom on the 6th floor during summer 2018.*
© Kunze (2020)

The carpet plot presented in Figure 7 shows the time course of the measurement series for each day recorded. It clearly illustrates that the daily maximum of the interior temperature was reached after 6 p.m., because on western façades the solar radiation only reaches the window surfaces directly during the afternoon and consequently the heat input is particularly high at this time. The maximum of the indoor temperature was achieved on 31st July 2018 with over 33 °C, over the year a specific value of 2132 Kh/a overtemperature degree hours was reached. The indoor temperature is above the reference temperature in 37.5 % of the considered period and there is a continuous period of approx. 19.5 days during which the indoor temperature never falls below 27 °C. Altogether, this illustrates that the thermal comfort in this room is very limited during high outside temperatures and that there is a strong need for action to reduce the thermal load in the reference buildings.

Object-specific adaptation measures to reduce the summer heat vulnerability

In order to reduce the solar heat gains of the reference building during persistently warm outside temperatures, the replacement of windows, which was planned anyway as part of the renovation, is evaluated positively. By reducing the heat transfer coefficient (u-value) as well as the total solar energy transmittance (g-value) of the glazing, a positive impact on the indoor climate under summer weather conditions is achieved. For further improvement, roller shutters are installed as external shading devices on the windows of the southern, western and eastern façades (see Figure 8). Excluded from this are windows which are shaded by external components, e.g. overhanging balcony systems. By choosing a manual control of the

shading devices, the user behaviour significantly influences the effectiveness of this adaptation measure. However, the investment costs as well as the maintenance effort are lower than choosing an automated control system and the lifetime of the measure is influenced positively.

Figure 8. *External shading devices on the windows, left: southern* façades *with planned adaptation measures. Reference: IGC Ingenieurgemeinschaft Cossebaude GmbH (2018), right: window after implementation of the roller shutters. Picture: © Kunze (2020)*

In comparison to typical flat roof constructions of today, it is advantageous that the reference buildings have available an unused air space, which is ventilated via outdoor air diffuser in the external walls, above the top floor ceiling (multiple-leaf construction). In order to particularly reduce the thermal load in the upper floors, this airspace is considered comprehensively in the conception of specific adaptation measures for these buildings. For optimization between the thermal resistance and the heat storage capacity of the top floor ceiling, additional layers of floor screed (e.g. 3 cm thick) and mineral wool insulation (e.g. 16 cm thick) are recommended (see Figure 9). Further additional loads cannot be applied due to the low reserves of bearing load of the ceiling tiles.

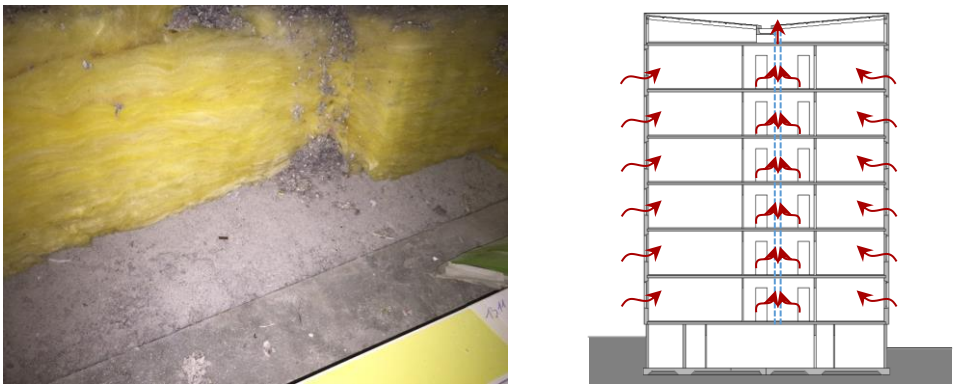

Figure 9. *left: additional layers of floor screed and mineral wool insulation. Picture: © Zweinert (2020), right: section with central ventilation system to support air change during night. Picture: © Schiela (2019)*

Because the reference buildings have predominantly bathrooms on the inside, an exhaust-air plant is mandatory, which discharges an exhaust air volume of 30 m³/h in each bathroom to ensure ventilation for moisture protection according to the German standard DIN 1946-6:2019-12. Following the adaptation strategy to optimize the air change, this exhaust air volume is doubled to support the air change in summer nights (see Figure 9). In order to prevent warmer outside air from entering the building via the necessary outside air diffusers at the windows, this adaptation measure is only activated if the inside air temperature exceeds 26 °C and is above the outside air temperature. This measure is particularly effective during low outside air temperatures at night and is independent of the user. However, its effectiveness is severely limited during heat waves with several consecutive tropical nights (minimum temperature > 20 °C).

The three previously presented adaptation measures for reducing the thermal load in the reference buildings have already been implemented during the summer of 2019 on example buildings owned by the project partner Eisenbahner-Wohnungsbaugenossenschaft Dresden.

Positive effects of the proposed adaptation concept

In order to evaluate the effects of the adaptation measures described above, these measures were implemented in the multizone building model, both individually and as a combination of all the three adaptation measures. The effects on the indoor climate were examined with the use of thermal building simulation again. The test reference data set of the future state was used for the simulation, to enable statements to be made about the influence of the adaptation measures on future indoor temperatures in the buildings. To ensure the comparability of the results, the same user behaviour was used in all simulations (average internal heat gains of 100 Wh/(m² d), basic air exchange rate of 0.5 1/h, additional window ventilation: windows fully open from 7 am to 8 am and 9 pm to 11 pm, windows tilted during the night (11 pm to 7 am)) For the exterior roller shutters, a use depending on the outdoor temperature is assumed. With an average outside temperature of over 23 °C on the previous day, the external shading devices are used between 7 am and 6 pm. To guarantee an adequate daylight supply for the residents, a level of closure of 75 % was anticipated. All other boundary conditions of usage were assumed to be identical in all variants investigated in order to ensure comparability of the results.

Table 2 shows the overtemperature degree hours determined from the results of the simulation for the bedroom and the adjacent children's room on the 5th floor and for the identical rooms on the 6th floor. In the following, the results for the bedroom on the 6th floor are evaluated in detail.

Table 2. *Evaluation of the overtemperature degree hours [Kh/a] for the selected adaptation concepts for living spaces on the 5th and 6th floor.*

Adaptation measures		5th floor		6th floor	
		Bedroom	children's room	Bedroom	children's room
Initial state	Status quo	2701	2701	**3868**	3071
	after normal refurbishment program	2358 (-9%)	2358 (-13%)	**3437** (-11%)	2618 (-15%)
Adapted level	with roller shutters	1081 (-49%)	1081 (-60%)	**2081** (-46%)	1292 (-58%)
	with additional layers over the top floor ceiling	2238 (-14%)	2238 (-17%)	**3175** (-18%)	2405 (-22%)
	with increased night ventilation	1947 (-30%)	1947 (-28%)	**2712** (-30%)	2195 (-29%)
	with a combination of the three measures	747 (-66%)	747 (-72%)	**1333** (-66%)	865 (-72%)

Owing to the implementation of external shading devices, the maximum operative temperature is reduced to 31.4 °C (see Figure 10), by 2.5 K compared to the status quo and by 1.6 K compared to the normal refurbishment program (without any special adaptation measures). In comparison to other described adaptation measures, the measure on the top floor ceiling has a minor influence on the reduction of the thermal load. For instance, the maximum value of the operative temperature is still 32.8 °C. For the status quo, the permissible limit of overtemperature degree hours is exceeded by 220 % at 3868 Kh/a. A slight reduction would still be achieved by implementing the originally planned refurbishment. But only through additional measures such as external shading devices, increased night ventilation or a combination of these measures, the overtemperature degree hours are significantly decreased and the thermal load in the living rooms can be reduced by a maximum of 72 %. The lowest values are achieved with the combination of the three considered measures at 1333 Kh/a. Within the reference building, the selected bedroom in the 6th floor is the only one in which the permissible limit of overtemperature degree hours is still exceeded. Figure 10 shows that the individual measures can significantly reduce the

occurring range of indoor temperatures. In the examined combination of the three measures, the 75 % percentile of the indoor temperature for the room considered is just 27.4 °C and the median sinks to 26.1 °C. These results indicate explicitly that the selected measures lead to a considerable reduction of the thermal load and enable a comfortable and pleasant indoor climate even in the summer half-year for the remaining useful life of the reference buildings in the future.

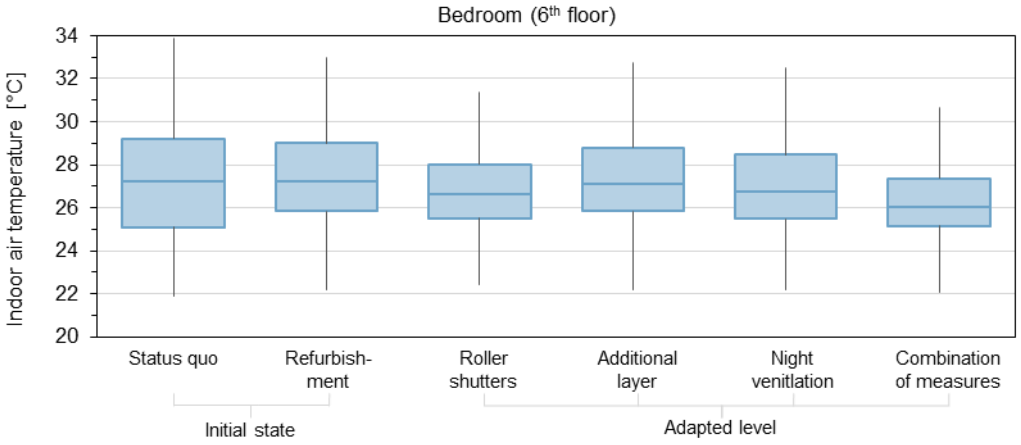

Figure 10. *Assessment of the indoor air temperature of the bedroom (6th floor) for the selected adaptation measures during the months June to September. © Kunze (2020).*

4. Conclusions

Summer overheating in densely populated urban districts is a relevant impact on residential buildings and their inhabitants both in present and future. Thermal building simulations, based on a precise building assessment, are an effective instrument to estimate and evaluate the effects of such heat loads in the form of expected indoor temperatures, accurate to floor and room level. During the assessment process well-founded knowledge of the structure and the structural design of the building is essential. For the development of object-specific adaptation concepts, the four adaptation strategies (1) "Reduction of solar heat gain", (2) "Improvement of thermal storage capacity", (3) "Improvement of air change" and (4) "Cooling measures" should be combined as effectively as possible. The load-reducing effect of the selected structural and technical adaptation measures can be realistically estimated both by appropriate implementation in thermal building simulations and on-site validation for comparison. Thus, an important goal of this research topic is to conduct systematic studies on effective and reasonable adaptation measures, which provide a comfortable indoor climate during summer heat periods for residents both now and in the future.

Acknowledgements

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Study of Societal Resilience against Natural Disasters: Perspectives of Risk Perception and Prospect Theory

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Abstract
The increasing frequency of severe natural disasters due to climate change has greatly threatened people's lives and properties in recent years; disaster management has become a key issue for sustainable urban and regional development. To minimize the damage caused by natural disasters, societal resilience to withstand disaster impact is critical for disaster management. It requires the understanding of people's perception and/or response to disasters in both pre-disaster and post-disaster contexts to form better management strategies to strengthen the resilience of a society. This research seeks to study risk perception and relevant attitudes, which are the fundamental factors of human behavior under the threat of disaster impact, and the perspective of the prospect theory is highlighted. A Stated-Preference (SP) survey and a Double-Bounded Dichotomous Choice (DBDC) model are applied to investigate people's willingness to pay for risk reduction. The expected results of this research can be used to develop a solid resilience-enhancement program. Based on the improved understanding of risk perception, the associated authorities may be able to determine more effective strategies to strengthen the built environment (including information dissemination mechanisms) and disaster response efficiency, thereby minimizing the damages and injuries caused by disasters.

Keywords: societal resilience, risk perception, prospect theory, willingness to pay, disaster management

1. Introduction

In recent years, the frequency of disasters has been significantly increasing due to climate change and probably over-development, which is one of the major challenges for the human society. To reduce societal losses and develop a more sustainable society, the importance of disaster management cannot be neglected. Disaster management is highly emphasized in order to reduce the loss of lives and properties and strengthen the capability of a society to withstand external threats. It has also been introduced to enhance societal resilience and improve people's awareness toward disaster preparedness and response.

Societal resilience is defined as the ability of social entities to cope with hazardous events which induce serious threats; it includes the adaptive capacity of the social community, which requires people's knowledge of disaster and their ability to deal with potential risk in the future (Keck and Sakdapolrak, 2013). This is relative to the concept of disaster management. People's knowledge of disaster includes the risk of it which may be neglected or overweighted because of the low disaster probability. Prospect theory (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992) can be effective to analyze the decision making behavior under uncertain events and explain the possible behavior which contradicts the expected utility theory (Starmer, 2000). Also, it is crucial to take loss aversion into consideration when conducting disaster planning (Asgary and Levy, 2009). Hence, this research adopts the prospect theory to study human behavior under the threat of disaster impact and seeks to explore under what circumstances people may be more concerned for the threat of disasters. The relationship between disaster risk (probability), risk reduction, and risk perception is the main focus of this research. The disaster management program and more thorough insurance policies may be promoted by incorporating people's risk attitudes and associated behavior into account.

The formulation of disaster management strategies to enhance the resilience of a society inevitably requires the understanding of its people, relating to how they perceive and/or respond to disasters in both pre-disaster and post-disaster contexts. According to the prospect theory, proposed by Kahneman and Tversky (1979), people may reveal different risk attitudes in regard to a reference point, which delimits gain and loss domains for a specific problem context of decision-making. Such risk attitudes can lead to the ignorance of the basics of the probability theory and the expected return, especially when extremely small probabilities of event occurrences are involved; for example, the minimal chance to win the lottery prize can be

exaggerated (Laury and Holt, 2008). In terms of preparedness for disasters, people are also dealing with a relatively small probability of disaster occurrences or being impacted by them. The low probability of disaster may not be received precisely, and the importance of preparedness such as purchasing catastrophe insurance may be neglected (Kunreuther and Pauly, 2004). Hence, based on the prospect theory, this research is exploring how the small probability (risk) may be perceived by people or communities of different socioeconomic backgrounds, how the perception may affect the formation of their risk attitudes toward disasters, and what the reference point is for this peculiar problem.

According to the World Bank report "Natural Disaster Hotpots - A Global Risk Analysis" (Dilley et al., 2005), Taiwan has 73.1 percent of total area and also population exposed to three or more hazards. Several kinds of natural hazards, such as earthquake, typhoon, and flooding, cause serious damage to the island annually, and it is essential to reduce Taiwan's vulnerability and enhance its resilience (Chang, 1996). Among all the natural hazards Taiwan is now facing, this study focuses on the impact of earthquake for the reason that Taiwan is in the Circum-Pacific seismic zone, a region where a great number of earthquakes occur. Frequent earthquake happens particularly along the coastal areas of Eastern Taiwan and also the plain and low hill areas in Western Taiwan (Chang, 1996). Earthquakes have caused severe damage and mortality in Taiwan. The 1999 Chi-Chi Earthquake caused 2415 people death and NT$300 billion of damage. A few years later, the 2016 Meinong Earthquake caused 116 deaths and a severe collapse of residential building. People's lives and properties are threatened and many buildings are damaged or even collapsed because of the hazardous earthquake. Hence, improving societal resilience to decrease the possible damage caused by earthquake and to protect life and property of every citizen is important. Relevant policies regarding earthquake insurance and structural reinforcement has been implement in Taiwan for several years; however, it seems that these policies are not really effective. There are only about 30% of the residents in Taiwan purchase earthquake insurance, and few people apply for structural reinforcement actively. Understanding people's opinions on these policies is essential, and this relates with their perception and possible responses to earthquakes. Therefore, this study aims to adopt prospect theory and the concept of willingness to pay to determine the factors of people's risk perception toward earthquakes in order to improve societal resilience.

Willingness To Pay (WTP) is a concept which can be used when valuing people's risk behavior (Botzen and van den Bergh, 2012; Itaoka et al., 2006), and Stated-Preference (SP) survey is one of the major methods to investigate WTP (Breidert et al., 2006). In this research, the concept of WTP is employed to quantify risk attitudes toward earthquakes as how much people are willing to pay for the reduction of disaster risk and expected loss resulting from earthquakes. A SP survey is designed to explore people's attitudes toward the relationship between risk probability, risk reduction, and risk perception. Scenarios to investigate people's WTP for risk reduction toward probabilities of different earthquake magnitude scale are designed in the SP survey. Furthermore, the risk perception of both the general public and vulnerable populations is planned to be investigated. A Double-Bounded Dichotomous Choice (DBDC) model, which is more efficient than a single-bounded model (Hanemann et al., 1991) is employed to value respondents' risk behavior. The DBDC model can be developed based on the SP data, and it can construct the relationship between risk attitudes, personal attributes, and hazard characteristics, and on the other hand, to identify the reference point regarding the perception of gain and loss upon disaster impact.

Disaster management is one of the key issues to improve societal resilience and to develop a more sustainable society. Earthquakes in Taiwan has caused serious damage to our society continuously, and better solution to solve this problem is needed. This research conducts a SP survey and models people's perception toward earthquakes by using the concept of WTP and a DBDC model. If people's attention to disaster preparedness can be understood better, management strategies may be improved, and thereby advances the resilience of our society.

2. Problem Statement

This study seeks to develop double-bounded dichotomous choice models considering different scales and probabilities of earthquakes so as to capture the behavioral realism related to disaster preparedness and response. The main objective is to discover people's attitudes toward earthquake loss, and the amount of money that people are willing to pay for risk reduction.

The study also focuses on the people's behavior of exaggerating or ignoring potential earthquake loss due to the relatively low probability of the occurrence of severe earthquakes.

According to the prospect theory, people are not always rational and completely follow the theory of expected utility when making decisions. In this study, we design three scenarios with the same expected outcomes (loss) to study people's irrational behavior with respect to risk reduction. People's WTP for risk reduction is the principle indicator to be observed in this research. For instance, when people are determining whether to buy an insurance against low-probability high-loss events, the low expected return from investigating the advantage of the insurance stops them from searching for the information (Kunreuther and Pauly, 2004). The effect of information and how it is disseminated (perhaps via different media and societal networks) is also the concern of this research and incorporated in the design of the SP survey, especially in terms of how information may lead to different levels of intended or unanticipated framing effects. This perceived bias will be further discussed, including the reason why people exaggerate or ignore the potential risk.

3. Methods

Questionnaire Design

To explore the attitudes toward earthquake risk, this study focuses on investigating acceptable earthquake insurance by conducting a Stated-Preference (SP) survey. The survey consists of five parts: disaster preparedness, disaster perception, WTP for earthquake insurance, information reception, and socioeconomic information. People's understanding of the earthquake and related policies, such as structural reinforcement and earthquake insurance, will be measured in the "disaster preparedness" part. Respondents' preparedness for potential disaster risk may be closely related with their risk attitudes and their WTP for risk reduction. The "disaster perception" part is to explore people's perception of earthquake, including the potential threat to their lives and properties. This part also investigates their awareness of earthquake disaster compared with other accidents (that maybe more frequently occur in daily life, such as traffic accidents).

The part of "WTP for earthquake insurance" is formed by three scenarios which include different earthquake magnitude scales and probabilities, seeking to construct the relationship between risk probability, risk reduction, and people's willingness to pay. In this section, respondents are asked to answer the amount of money that they are willing to pay for avoiding a certain level of loss. Providing complete description of scenarios and a proper event (as a reference) to compare with is critical for respondents to evaluate low-probability events that are of interest to this research (Kunreuther et al., 2001). Hence, a thorough description of each earthquake scenario and a comparison point which tells respondents average numbers of deaths from car accidents per year are included.

The expected value of loss is presented by:

$$-r_k L_k \tag{1}$$

where r_k is the probability of the earthquake in Scenario k, and L_k is the associated loss in Scenario k. It will be designed to be the same in all three scenarios, which implies that the utility of the expected outcomes across the three scenarios are al equivalent. By contrast, the difference between the WTP for earthquake insurance in different scenarios leads to different Certainty Equivalent (CE). If a respondent is risk averse, the utility of expected loss for him/her will be less than CE; if the respondent is risk seeking, the utility of expected loss will be greater than CE instead.

Further, Double-Bounded Dichotomous Choice (DBDC) method is employed to form the WTP model. The method separates every scenario into two sections. As shown in Figure 1, the respondents are presented with two payments successively, and each payment is related with different levels of risk reduction. If they accept the first payment P^F, they will be presented with the second payment P^H which is higher than the first one. On the other hand, if they do not accept the first payment, they will be presented with the second payment P^L which is lower than the first one. S^F, S^H, and S^L are the consequent risk reduction levels upon payment P^F, P^H, and P^L. The expected value of each payment is presented by:

$$-[r_k(P + L_k - S) + (1 - r_k)P] \quad (2)$$

where P is the payment the respondent accepts, and S is the risk reduction he/she can attain. The expected values of the three possible payments P^F, P^H, and P^L are designed to be the same. In other words, higher payment provides higher risk reduction for the respondents.

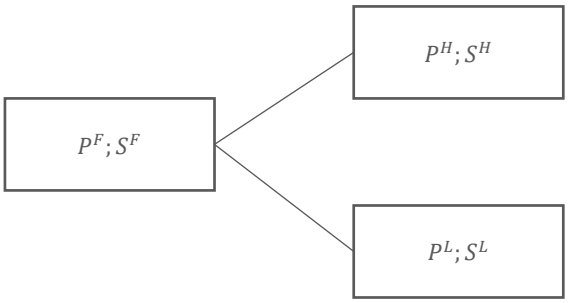

Figure 1. *DBDC method.*

In addition, the expected value of paying for risk reduction is greater than that of paying nothing for risk reduction, in order to derive the circumstances for the possible exaggeration or ignorance behavior. The relationship between the expected values can be presented by:

$$-[r_k(P + L_k - S) + (1 - r_k)P] > -r_k L_k \quad (3)$$

In the prospect theory, people may exaggerate or ignore the probabilities of some events, particularly those of low occurrence probabilities and extremely high gains/losses. Based on the designed scenarios, the survey can experiment and capture the heterogeneity of human behavior and identify the key factors that affect people's attitudes towards earthquake disasters. Moreover, in order to make the experiment more realistic, the actual data of earthquake probability, possible loss and catastrophe insurance are used for designing the questionnaire. For instance, the probability of earthquake in scenario 1 r_1 is related to the seismic design regulation for general buildings in Taiwan.

The influence of information is also included in the survey. The part of "information reception" is designed to investigate respondents' frequently-used approach to obtain or receive information and how much they trust messages via different media or societal networks. In addition, respondents' attitudes toward disaster prevention warning message are also taken into consideration. The possible consequence of information reception which may lead to different framing effects will be explored in the section.

Data Collection

The questionnaire survey is planned to be implemented online using Survey Cake, which is a convenient and commonly-used survey administration application. The double-bounded dichotomous choice method can be easily applied in Survey Cake by its skip-to link function. Also, there are several advantages of using this online platform. Data analysis can be applied more efficiently, and statistics can be automatically visualized that help quick comprehension of potential behavioural patterns at an aggregate level. Moreover, the respondents can be free to answer the questionnaire through online survey, and it does not require interviewers, which may still induce sampling bias. The questionnaire survey is sent out via the internet, including societal network and e-mail. However, using the internet to distribute questionnaires may lead to sampling error because the distribution of major users of the Internet may not represent the social structure in Taiwan. Hence, the questionnaire may also be sent out personally in order to capture more complete sampling data. Also, whether the respondent owns a house may cause different risk perception toward property loss, and this aspect is considered in the survey by filtering appropriate respondents at the beginning of the survey. We expect to collect responses from over 500 respondents, and Taiwan, an earthquake-vulnerable island, is the study region of this research.

Model

A model to factor WTP for earthquake insurance is established to distinguish people's risk attitudes across the three scenarios. For Respondent i, the WTP in Scenario k can be represented as:

$$WTP_i^k = \beta_1^k x_i + \beta_2^k r_k + \beta_3^k L_k + \beta_4^k S_i + \varepsilon_i \quad (4)$$

where x_i is the vector of personal characteristics, r_k is the probability of earthquake, L_k is the estimated loss, S_i is the risk reduction level associated with the payment acceptable to Respondent i, and ε_i is the error term.

When forming the log-likelihood function, we let P_i^F be the first payment, P_i^H be the higher second payment, and P_i^L be the lower second payment for Respondent i. The respondents' answers can be grouped into four categories: (i) answering "yes" to the first payment and "yes" to the second payment; (ii) answering "yes" to the first payment and "no" to the second payment; (iii) answering "no" to the first payment and "yes" to the second payment; (iv) answering "no" to the first payment and "no" to the second payment. The log-likelihood function is written as follows:

$$\sum_{i=1}^{N} a_i^{yy} ln\pi^{yy}(P_i^F, P_i^H) + a_i^{yn} ln\pi^{yn}(P_i^F, P_i^H) + a_i^{ny} ln\pi^{ny}(P_i^F, P_i^L) + a_i^{nn} ln\pi^{nn}(P_i^F, P_i^L) \quad (5)$$

where a_i^{yy}, a_i^{yn}, a_i^{ny}, and a_i^{nn} are four binary-valued indicator variables to represent the belonging to the four groups:

i. $a_i^{yy} = 1$ if Respondent i answers "yes-yes"
ii. $a_i^{yn} = 1$ if Respondent i answers "yes-no"
iii. $a_i^{ny} = 1$ if Respondent i answers "no-yes"
iv. $a_i^{nn} = 1$ if Respondent i answers "no-no"

and $\pi^{yy}(P_i^F, P_i^H)$ is the probability of answering "yes-yes", $\pi^{yn}(P_i^F, P_i^H)$ is the probability of answering "yes-no", $\pi^{ny}(P_i^F, P_i^L)$ is the probability of answering "no-yes", and $\pi^{nn}(P_i^F, P_i^L)$ is the probability of answering "no-no".

The four groups are used to represent different risk behaviors among people in order to further explore different risk attitudes. People who accept the first payment and also accept the higher second payment may be more risk-averse than people who choose other options. On the other hands, people who do not accept the first payment and also reject the lower second payment may have more risk-seeking behavior than those who accept the payments. In other words, people may be more risk-averse if they are willing to pay higher payment for more risk reduction in the same disaster scenario. According to the described modelling procedure, people's heterogeneous risk attitudes toward earthquake disaster can be analyzed by the double-bounded structure of survey.

In different earthquake disaster scenarios, the willingness to pay functions may be distinct from each other, which is used to distinguish risk behaviors in regard to different levels of risk probabilities. The prospect theory is used to illustrate the behavioral realism that cannot be explained by the expected utility theory in this research. The scenarios with same expected outcomes but different risk probabilities may induce diverse utility for people, and this research aims to identify the factors that affect people's risk attitudes based on the estimation of Eq. (4). The difference of the certainty equivalent between different scenarios is the main concern of this research, and the risk-averse/risk-seeking behavior toward different scenarios can also be better taken into account for relevant disaster management strategies.

4. Expected Result and Discussion

This research develops three disaster scenarios with different earthquake magnitude scales and probabilities. The expected outcomes of the three scenarios are designed to be the same in order to explore different risk perceptions when facing different risk probabilities. The factors that contribute to the difference in WTP for risk reduction across the scenarios can be captured by the WTP models. The significant characteristics that may affect people's attitudes toward disaster loss are expected to be

presented in the models, where the effect of information is included, which can be used to determine more effective resilience strategies. People's perception of the dissemination of information can be better understood, which can further benefit resilience-relevant policy-making.

Human's behavior when facing low-probability high-loss events is expected to be identified in the research which focuses on earthquake damages. According to the prospect theory, whether irrational behavior regarding to hazardous earthquake exists is the major concern of this research. The impact of loss aversion will also be analyzed, and the exaggeration or ignorance behavior can be manifested through the scenarios designed in the SP survey and the data analysis thereupon. The attributes leading to such perception bias can also be further discussed.

The research findings derived from this study are expected to be used for better understanding of risk perception and relevant attitudes; also, it can be insightful for the development of a solid resilience-enhancement program with improved disaster management strategies. Furthermore, resilience enhancement strategies, such as structural reinforcement policy, can be taken into account in the future, which can investigate human behavior toward disaster loss in an extended context. Accordingly, the relevant authorities are able to determine more effective strategies based on the understanding of the relationship between risk probability, risk reduction, and risk perception. This may additionally improve the performance of societal resilience by potentially minimize damages and injuries caused by disaster in the future. In addition, the built environment may be strengthened to enhance disaster preparedness, and thereby the disaster response efficiency can be increased.

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Urban climate impact on indoor overheating – a model chain approach from urban climate to thermal building simulation

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Abstract

Does microscale climate conditions in urban districts vary severe enough that indoor overheating depends on the location of the building within the district? Especially in big cities heat stress for residents will increase in future summers in intensity and duration caused by the global warming trend. To quantify this load for urban dwellers, the resulting room temperatures in residential buildings are to be evaluated. More precisely, the possibility of passive cooling measures, especially nighttime cooling by window opening and cross ventilation, applicable for typical Central European summers, is to be analysed. To evaluate the impacts of nighttime cooling, the knowledge about the diurnal variation of outdoor air temperature and wind speed at the facade of the individual dwelling is highly relevant and depends on window orientation, floor level of the dwelling and the location in the urban setting. To provide the required data, we present a method of combining two time-resolving simulation techniques: First, calculating the diurnal variation of meteorological quantities like the local air temperature and wind vector near the building applying the urban climate model ENVI-met to the interaction between the 3D modelled environment with buildings, vegetation, soil and atmosphere. Second, implement the obtained local meteorological data as input for a 3D building model in the thermal building simulation tool IDA ICE evaluating the thermal comfort of residents in the individual rooms of the dwelling. As reference, a five storey multi-family house from the „Gründerzeit“ epoch in Erfurt (Germany) was chosen and simulated for the daily course of a hot summer day. The district of the building was modelled in the 3D urban climate simulation, taken into account surrounding buildings, trees and infrastructure with a high horizontal resolution of 4 m. Combining both simulation tools, we are able to show that the low differences in outdoor air temperature within the district (around 1 K) shows only low impact of the room temperatures in the building. However, the wind speed variation of West-East wind component in the district is more significant (0.3 m/s to 1.4 m/s in 16 m height above ground) depending on the orientation of obstacles and lead to high differentiations in nighttime cooling efficiency by window ventilation in combination with cross-ventilation. Thus, the indoor temperatures and overheating depends on the location of the building in the city and the orientation of windows, especially when cross ventilation is applied. Finally, the wider opportunities as well as limitations of the applied model chain from urban climate to thermal building simulations are discussed.

Keywords: Model chain, urban climate simulation, thermal building simulation, overheating

1. Introduction

The global warming trend will lead to heat wave events projected to increase in frequency and severity in future (IPCC, 2014). Hence, overheating risk in buildings is expected to increase in strength and duration in the next decades leading to discomfort, restricted concentration abilities, increase in health risk up to heat mortality (Head et al., 2018; Toulemon & Barbieri, 2008). Especially in large cities with a high degree of sealed surfaces additional heat burden by high night outdoor air temperature for inhabitants is induced by the urban heat islands (Manoli et al., 2019; Mohajerani, Bakaric, & Jeffrey-Bailey, 2017). This is particularly critical because residential buildings in urban settings located in moderate climate are usually cooled not mechanically but by passive measures, especially nighttime cooling. The efficacy of this measure depends on various conditions like opening profile of the windows and opportunities for cross ventilation on the building side or wind speed, wind direction and outdoor temperature at the individual window position of the dwelling.

However, recent overheating analysis by thermal building simulation commonly uses meteorological input from hourly resolved meteorological data of test reference or design years (Brotas & Nicol, 2017; Hamdy, Carlucci, Hoes, & Hensen, 2016; Schünemann, Olfert, Schiela, Gruhler, & Ortlepp, 2020) or from meteorological measurement stations (Taylor et al., 2014). On the one hand, this method is accurate enough when comparison of overheating risk of different building types, inhabitant behaviour or climate conditions are in focus. On the other hand, this approach is insufficient to examine the impact of urban structure on overheating risk in buildings. For this reason, we extend overheating analysis by applying a model chain method starting from urban climate simulation for 3D modelling of the district and implement the local meteorological data into the thermal building simulation for 3D modelling of a residential building. The focus of this article is to present the details of this method, its opportunities and limitations.

For our study we model a district of the city of Erfurt (Germany, 50°58’43.5’’ N, 11°02’44.3’’ E) using the micro-scale climate model ENVI-met (Bruse & Fleer, 1998; ENVI-met, 2020) with a horizontal resolution of 4 m and an increasing vertical resolution with increasing height (beginning with 1 m above the soil surface). The Federal State of Thuringia, where the city of Erfurt is located in, was hit by strong heat and drought waves in 2018 and 2019 and increasing summer temperatures are projected for the next decades (TLUBN, 2020). Based on the fact that most residential buildings in big city centres are multi-family housings (MFH), we chose this building type for the indoor temperature analysis in building simulation. A common building type of MFH in Central Europe is the so-called “Gründerzeithaus” (GZH), erected in the “Gründerzeit” epoch between the years 1870-1918 especially in old town centres and originally equipped with stucco facade and saddle roof with dormers. This building was modelled in 3D in the thermal building simulation IDA ICE (EQUA, 2018). The procedure of generating the daily course of meteorological data by ENVI-met, subsequent transfer of the data as meteorological input to IDA ICE and indoor overheating analysis using this tool is described in detail in the method section.

2. Methods

2.1. Reference district and building

The city of Erfurt is located in the middle of Germany in a moderate cooling load zone (category B in DIN 4108-2 (DIN4108, 2013)). The urban district in the eastern part of Erfurt, see Figure 1, was selected to be modelled in the urban climate model ENVI-met. The model domain is about 950 m from West to East and 970 m from North to South. The western part of the district is dominated by MFH of the GZH type constructed in the turn of the 20th century in closed block development. The south-eastern part represents a mixed building area with different new and old MFH types, office, industry and public buildings. In Figure 1, the location of the GZH reference building chosen for building simulation is marked at receptor point 1. The other two markings in the figure represent positions where the GZH building from receptor point 1 is virtually positioned to investigate the impact of higher outdoor temperatures and different building orientation (receptor point 2) and higher wind speed (receptor point 3) in the district on the overheating intensity in the dwellings of the MFH. Thus, we can discuss the influence of different location in the district on indoor overheating.

The chosen GZH building type is a common representative for MFH types (Schünemann et al., 2020) in Central European cities without the use of mechanical cooling systems. Figure 2 illustrates the West and East façade of the selected GZH reference building including the floor plan of the attic floor. The MFH consists of eight dwellings on four full floors and the converted attic floor. On the courtyard (west) side, balconies have subsequently been installed for each floor ensure window shading on this façade for the four full floors. In this article we only focus on the room temperatures resulting in the attic floor because previous investigations show that overheating in this GZH building type is most relevant for this top floor, caused by low thermal storage capacities and solar heat gains transmitted through the roof and by the unshaded window front at west façade (Schünemann et al., 2020). Further details like structural components of the building can be found elsewhere (Schünemann et al., 2020). Here, we present a detailed overheating analysis of the bedroom (east façade) and the kitchen living room (west façade) of the attic dwelling (cf. Figure 2c). As shown previously, applying nighttime cooling of the room by opening windows during chilly nights is very effective to keep the overheating in the dwelling at a low level (Schünemann et al., 2020), best combined with cross ventilation by opening the room door. Both scenarios have been evaluated by implementing wind and temperature gradient driven window ventilation in the building simulation IDA ICE.

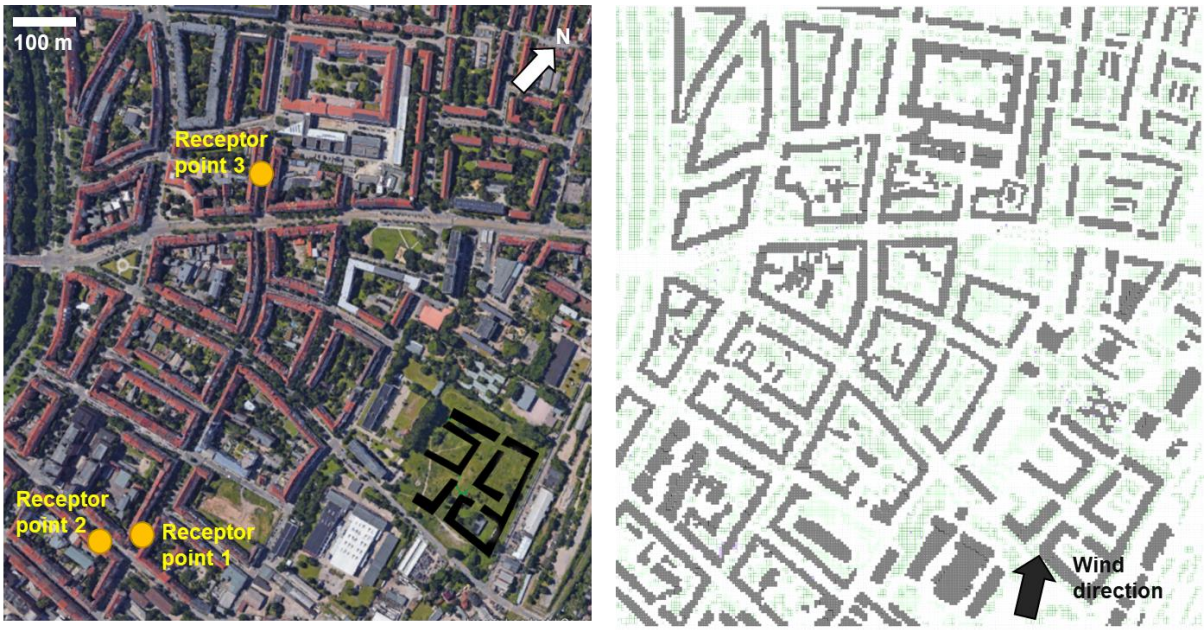

Figure 1: *Aerial photograph (left, Google Earth, downloaded at 2020-04-03) and ENVI-met overview of the area input file with environmental information (right: grey - building, green - vegetation) of the investigated district in the eastern part of Erfurt (Germany). At position 1 the GZH reference building is located. Position 2 marks the virtual location of the GZH with high outdoor temperature and position 3 of high wind speed. The building textures in black located South-East in the district represents a new development area for MFH completed in the year 2020 and thus already implemented in the ENVI-met model.*

Figure 2: *a) East-facing and b) west-facing façade of the GZH building; b) floor plan of the attic floor of the GZH.*

2.2. Climate simulation within an urban environment

To investigate the impact of climatic effects on the district scale on thermal building simulations, the urban climate model ENVI-met (Bruse & Fleer, 1998; ENVI-met, 2020) was applied. ENVI-met is a three-dimensional small-scale model of the atmosphere solving the basic equations of flow mechanics and thermodynamics. It was developed to simulate the interaction between urban structures like buildings, trees and other kinds of vegetation and the micro-climatic situation. ENVI-met has been used and validated in recent studies (Goldberg, Kurbjuhn, & Bernhofer, 2013).

In the presented study, ENVI-met was used to generate a typical daily cycle of meteorological variables at a hot summer day. The investigations are adapted to one district of Erfurt. The model input datasets were the spatial arrangement of buildings with realistic building heights, the vegetation structure in its spatial extent and with different vegetation parameters (different kinds of trees, shrubs, grassland), as well as sealed areas considered as asphalted surfaces, partly sealed areas as cobbled, paved or gravel covered, and unsealed surfaces as areas of loam. Freely available object model data and Aerial pictures (data source 'Geoportal Thueringen': https://www.geoportal-th.de/de-de/) as well as satellite pictures (Google Earth) were used as data base for the manual digitalization of al environmental objects. Figure 1 (right side) shows the prepared area input file for model simulations with ENVI-met using a horizontal resolution of 4 m.

The model was set up for July 15, a rather hot, cloudless midsummer-day with high potential for solar irradiation and the development of an autochthonous weather situation. The following initial and boundary conditions were used for the model simulations with ENVI-met: soil temperature (0-50 cm depth) 294 K (21 °C), soil moisture (0-50 cm depth) 20 % (related to

field capacity), soil type: loam, air temperature in 2 meters above the ground 301 K (28°C), air humidity in 2 meters above the ground 50 %, horizontal wind speed in 10 m above ground 3 m/s, wind direction of 150 degrees (i.e., south-east wind direction, see Figure 1b), initial time: 20:00 local time (due to nearly neutral stratification of the atmosphere for initialization). The model runtime was set to 28 simulation hours, starting in the evening, whereby the first hours were needed to adapt the model to the environmental set-up.
Especially the daily course of air temperature, wind speed and wind direction was evaluated at different receptor points for different heights above ground every five simulated minutes as well as for the total model area every simulated hour. A data set of 237x243x29 (x-y-z direction in a Cartesian coordinate system) spatial points in horizontal and vertical direction results for one meteorological variable at one output time step (one hour). To optimise the data amount, receptor points near the reference buildings were used with a higher time step of generating output data for one grid cell (4 x 4 m²) and at all simulated height levels (number of height levels: 29, central height of the level above ground surface: 1.00, 3.00, 5.12, 7.49, 10.15, 13.13, 16.47 ,…, 362.07 m).

2.3. Data transfer from local urban climate to building simulation

As the models of urban climate and thermal building simulation are not directly linkable in sense of interaction and feedback, the data output of ENVI-met is transferred into IDA ICE in a non-automated procedure. More precisely, the meteorological data of the receptor points in the district generated by ENVI-met were manually implemented into IDA ICE. These meteorological data are direct solar irradiation, indirect solar irradiation, both to the horizontal surface, outdoor air temperature as well as wind speed and wind direction. In more detail, the following steps were done:

1. Time step adjustment of meteorological output from ENVI-met:
   Averaging of the meteorological results from the time step size of 5 min (defined step width of the results in ENVI-met) to 1 h was done which is the desired meteorological input data step width for IDA ICE, although the step width of simulation in IDA ICE and ENVI-met is much lower. The effect of the averaging on the meteorological data is negligible because the daily course of the meteorological data show smooth progression.
2. Chosen height of meteorological data from ENVI-met for IDA ICE:
   Receptor points of ENVI-met contain meteorological data in the different vertical layers of the 3D model. Figure 3 shows the low variability of the outdoor air temperature and wind direction with the height above ground. Contrasting, the wind speed significantly increases with height, expected and caused by the 3D elements in the model. Translated to the building, this implies low wind speed for the first floor of around 1.0 m/s and higher wind speed for the top floor (16 m height) of around 1.7 m/s. As a result lower air exchange of dwellings in the first compared to the top floor. As mentioned, we focus on the dwellings at the top/attic floor. Thus, the meteorological data of the receptor points from ENVI-met at 16 m height above ground, corresponding to the altitude of the top floor, was used for implementation into IDA ICE. Deviating from this, the solar irradiation data was used from the height of 20 m to avoid the reduction of irradiation by shadings in ENVI-met (for some receptor points obtained up to 16 m due to, e.g., trees) into IDA ICE. Shading effects on the building were considered in the building simulation and set equal for the receptor point comparison in this article.
3. Synthetic meteorological data set for month of July:
   Overheating assessment using thermal building simulation is typically done for a whole summer period or year. However, the model structure (ENVI-met is not running in a climate mode) as well as the CPU-intensive calculations of the 3D atmospheric flow model of ENVI-met limit the meteorological data output to one day. Thereby, we are focusing on a warm summer day with maximum temperature near 30 °C to study general processes and dependencies between the outdoor meteorological situation and the indoor temperature development. However, the simulation of the building for one day would be unreasonable since thermal inertia of buildings are not represent in a realistic modality. Thus, we created a synthetic month (July) consisting of the meteorological daily data of the simulated day in ENVI-met. Accordingly, every day of this month is equal. This data set was imported into IDA ICE for building simulation. The results show that after one week of daily increase in room temperature (caused by thermal inertia of the building components), the room temperature curve was the same each day. Finally, the 14th simulation day in the thermal building simulation was used as result and for further comparison.
4. Wind driven air exchange parameters in IDA ICE:
   The air exchange of rooms driven by horizontal and vertical wind as well as temperature gradient at building openings must be represented as realistically as possible for the analysis. Therefore, IDA ICE enables the opportunity to take into account wind flows in or through a building by considering pressure coefficient (calculated by a simplified algorithm using the method of the AIVC (Air Infiltration and Ventilation Centre) (Cóstola et al., 2009) in IDA ICE) of the façade and roof elements based on the air exchange modelling used also for COMIS (Feustel, 1999). The location of the investigated GZH building was assumed to be semi-exposed for the calculation of the pressure coefficients according the method of the AIVC. The pressure coefficients calculated for the façade and the approach enables the opportunity to evaluate wind driven air exchanges in the building as well as the effect of cross ventilation. Besides this, temperature gradient driven air exchange by different indoor to outdoor or adjacent room air temperatures was considered as well (according to air exchange modelling used also for COMIS (Feustel, 1999). The validation of the air exchange was proven by comparing simulation with measured temperature data of individual rooms with natural ventilation (Schünemann et al., 2020). Finally, in IDA ICE the parameter “wind measurement height” had to be set to the same height as the layer height of the implemented meteorological data from ENVI-met, in this case 16 m, because a height dependent wind profile was used in IDA ICE.

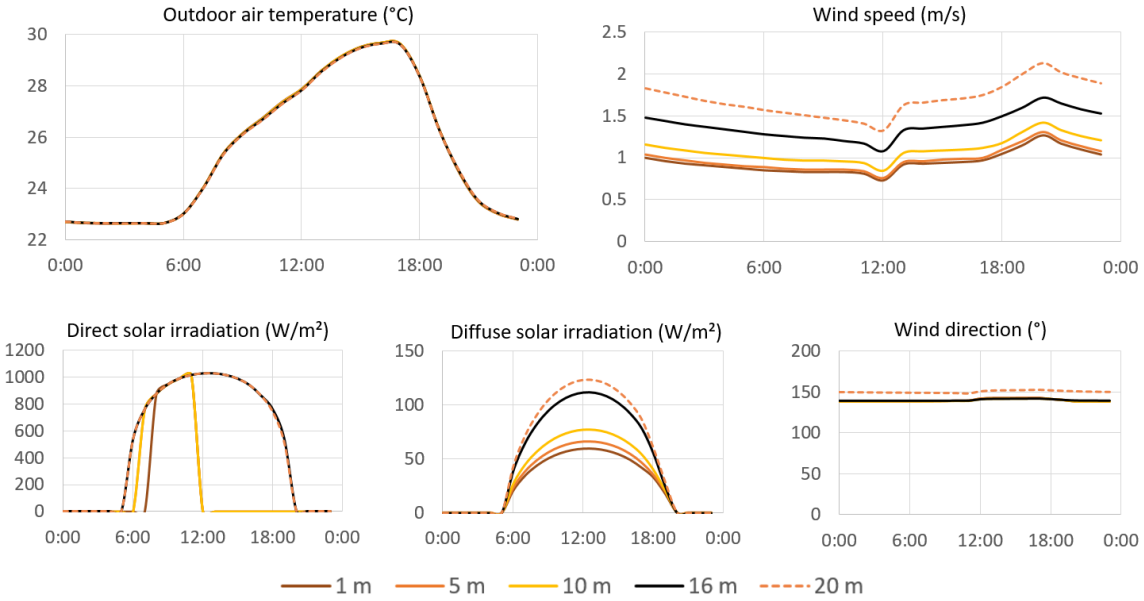

Figure 3: *Height dependent meteorological data of the receptor point 3 gained by ENVI-met simulation (heights above ground 1/5/10/16/20 m).*

2.4. Thermal building simulation

To analyse the evolving indoor room temperatures by the outdoor meteorological conditions gained from the outdoor urban climate simulation, the GZH was modelled including all rooms using the validated and certificated thermal building simulation software IDA ICE 4.8 (EQUA, 2018, 2020). Figure 4 illustrates the 3D model of the GZH building in IDA ICE. The simulations were run at a time step of less than one hour to allow detailed analysis of the evolving operative room temperatures for each room. Building components and material layers of the GZH were implemented to gain realistic heat storage capacities and transmissions of each room to the building exterior as well as to neighbouring rooms. For the thermal building simulation, the following general boundary conditions were applied:

- Buildings location: Erfurt, Germany
- Shading: the neighboured building on the opposite side of the street (east façade) was taken into account; shading of trees are not considered
- Minimum room air temperature (heating): 20 °C except unheated corridors, staircases and bedrooms
- Local meteorological data in the district gained from receptor points in ENVI-met

The individual internal loads from the presence of inhabitants and electrical devices depends on the room use. We assumed that two adult persons inhabit the dwelling, sleeping from 22:00 to 6:00 and are outside the home from 8:00 to 16:00. The course of the day for the assumed hourly defined heat gains for the presented bedroom and kitchen living room are depicted in Figure 5.

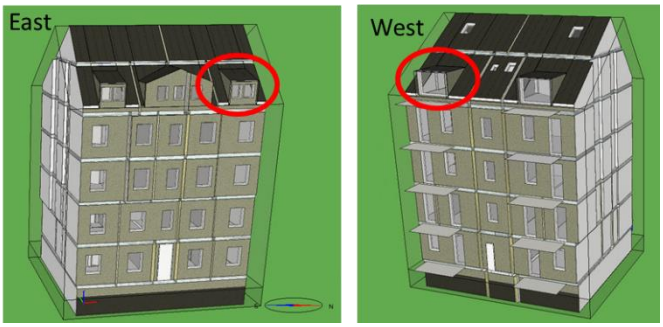

Figure 4: *3D model of the selected GZH building in the thermal building simulation tool IDA ICE. The analysed bedroom (east façade) and kitchen living room (west façade) are labelled with red circles*

As mentioned earlier the kind (tilted, fully open) and duration of window ventilation during chilly nights has significant impact on the overheating of rooms. IDA ICE enables the opportunity to depict realistic wind- and temperature gradient driven air exchange through windows and room doors, taken into account the pressure coefficient of the façades and the altitude layering of the wind speed. That this has been done in a realistically was proven by comparing modelled room temperatures and measured room temperatures of the GZH building in the kitchen living and bedroom on different storeys (Schünemann et al., 2020). The assumed window ventilation conditions are:

- Windows fully open in both kitchen living room and bedroom during the whole night from 18:00 to 7:00
- Degree of window opening: defined by opening profiles of the installed windows (ventilation area in kitchen living room 1.62 m² and in bedroom 1.04 m²)
- Cross ventilation: room door between kitchen living room and bedroom only open in the scenario of cross ventilation during bedtime from 22:00 to 6:00

According to own surveys on ventilation behaviour of residents in MFH (publication in progress), the assumed ventilation behaviour can be definitely regarded as above average and as exemplary behaviour to expect the full potential of nighttime cooling. This behaviour was chosen to illustrate the potential of different climatic conditions in the district gained by ENVI-met. Of course, the difference between the locations in the district will decrease if window ventilation is or can be implemented only at a lower level.

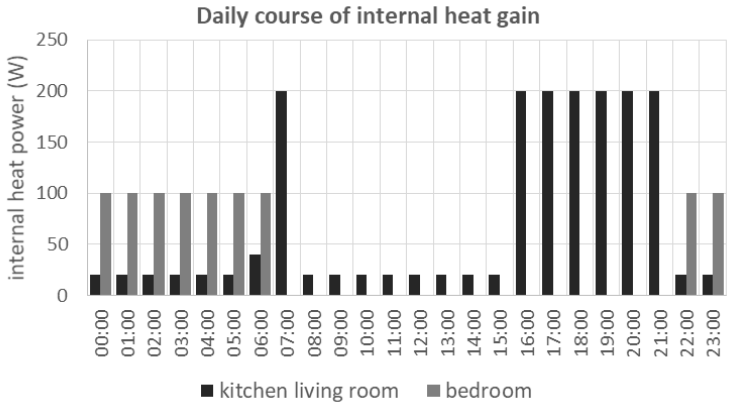

Figure 5*: Daily course of the assumed heat gains from occupants and electronic devices for the analysed bedroom and kitchen living room.*

3. Results and Discussion

3.1. Urban climate simulation

The daily course of meteorological variables was simulated by ENVI-met and evaluated for the district at every full hour of the 15th July. Figure 6 demonstrates exemplarily the spatial variability of the temperature and wind field in the early morning (temperature minimum) and in the afternoon during the temperature maximum at a height of 1 m above ground (first grid layer of ENVI-met with a height level between 0-2 m).

The air temperature varies rather slightly throughout the district: ca. 0.7 K at 4:00 in the morning up to 1.4 K in the afternoon at 16:00. The largest contrast between night- and daytime temperature can be found over short grassland sites without shaded areas and without limitations of horizon. At such places, the air temperature is minimal at night because the outgoing radiation leads to air temperature values smaller than between buildings and over sealed areas with a higher heat capacity. The thermal stress at night is maximum in densely built and sealed areas with great limitations of horizon (decreasing outgoing radiation caused by surrounding objects). A secondary maximum of air temperature occurs during the day between buildings where the ventilation is additionally very small. In general, it has to be noted, that the expected impact of air temperature differences on the thermal building simulation would be low due to the small spatial contrast of air temperature.

In comparison to the temperature, the wind field shows more spatial variability. The wind field in Figure 6 illustrates the inflow at the boundaries of the modelled area (horizontal wind speed: 3 m/s, South-East direction). Please note, that the first grid cells around the simulated area are unsealed and undeveloped. Due to the mechanical roughness of the urban structures within the district, especially buildings and trees, the wind speed is decreasing significantly. The smallest wind speed values occur between buildings and at backyards. Depending on the orientation streets with respect to the wind direction, the wind speed is significantly decreased, especially for streets in West-East direction. The incoming airflow is significantly slow down up to values of 0.5 m/s for horizontal wind speed due to higher buildings. This influence of street canyon orientation on the properties of the wind field can also be studied at single receptor points, see Figure 7. It is expected that the spatial differences in wind field influence significantly the thermal building simulation especially in the case of nighttime ventilation (see section 3.1).

Compared to the spatial variability, the daily cycle of the wind speed was found to be rather smooth for the total district.

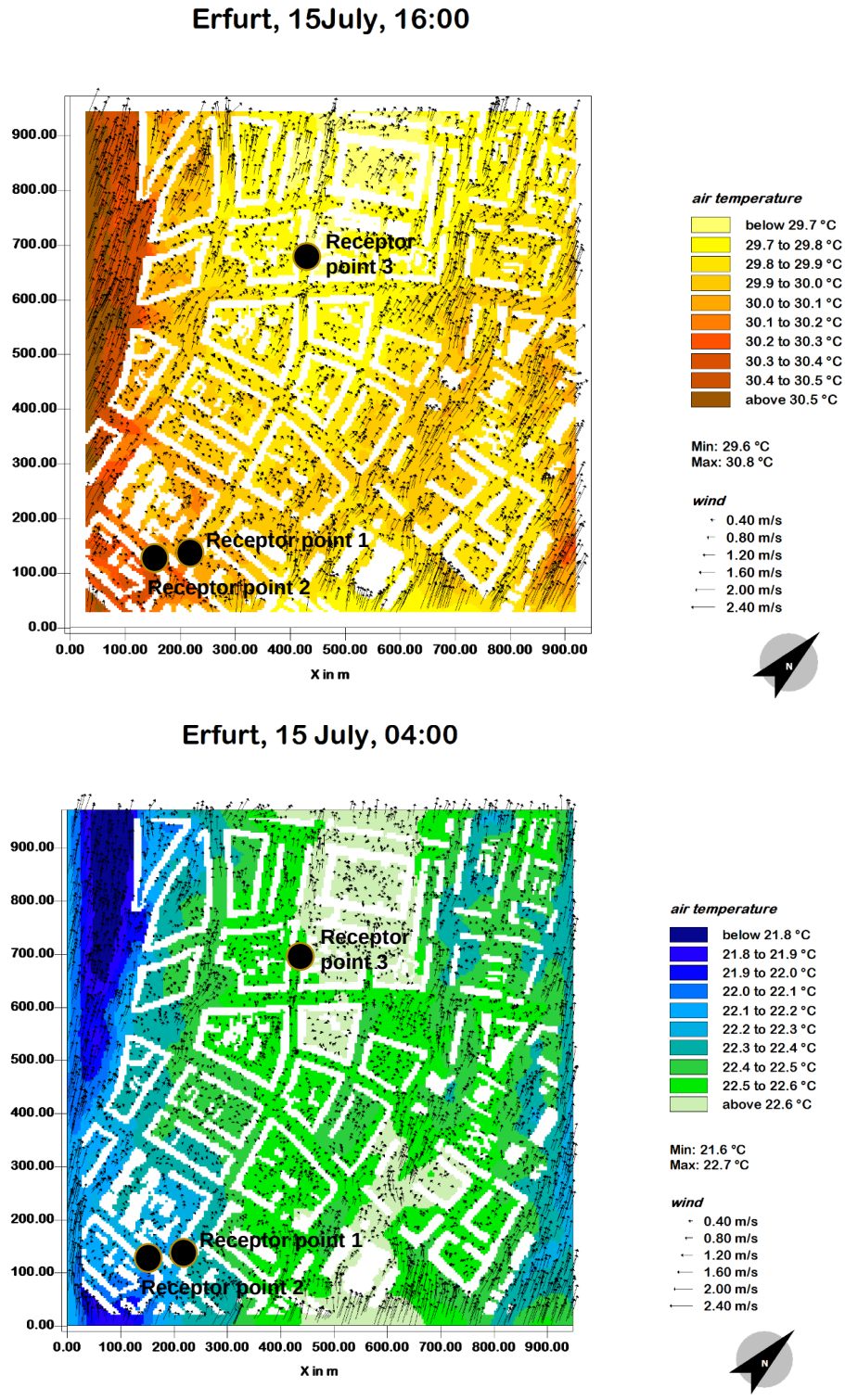

Figure 6: *Meteorological conditions in the district of Erfurt: Air temperature (potential temperature in Kelvin) and wind field (arrows for wind vector, length/direction of the arrow shows horizontal wind speed/wind direction) near the ground surface simulated by ENVI-met (first model level at 1 m) on the 15th of July at 04:00 and 16:00 Local Time. Please note the different range of air temperature values at 04:00 and 16:00 due to small spatial variability. The three receptor points are highlighted.*

3.2. Thermal building simulation

In the urban climate model more than 40 receptor points were analysed. Three receptor points (location see Figure 1) with different meteorological conditions were selected for further investigations:

- Receptor point **1** located at the east (street) side of the reference GZH building
- Receptor point **2** located in front of a south façade of a building block of comparable GZH buildings. For this receptor point the GZH reference building was tilted horizontally by 90° clockwise to its original position of receptor point 1 to be aligned to the other buildings of the block (the east façade at receptor 1 now facing to the street turned into a south façade).
- Receptor point **3** showing one of the highest wind speed in the urban climate model, situated in front of an east façade of a building block of GZH types. Here, the orientation of the GZH was set the same as for receptor point 1 for simplification

While wind direction and solar irradiation are comparable at 16 m height for all receptor points, Figure 7 illustrates the small differences of outdoor air temperature of max. 0.5 K for the different receptor points. For all receptor points, the temperature rises from around 22 °C in the (tropical) night to 30 °C at 16:00 in the evening. In contrast to the small local differences in air temperature, the wind speed varies significantly between receptor point 1 and 2 with 0.3 m/s and receptor 3 with 1.4 m/s as a daily average without strong intraday changes.

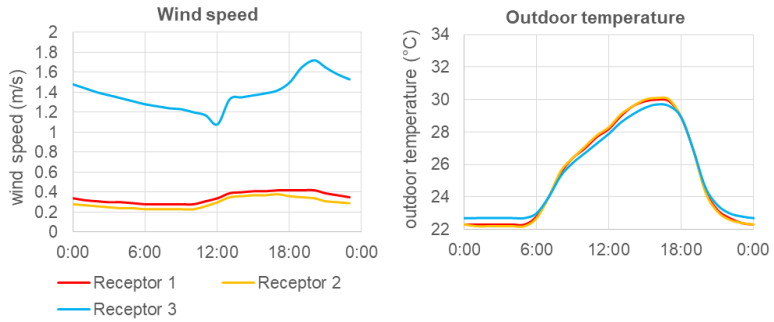

Figure 7: *Meteorological conditions at three receptor points in the district: Wind speed and outdoor air temperature in 16 m height above ground (position of the attic dwellings).*

To estimate the impact of the spatial differences in outdoor temperature and wind conditions, the meteorological data of these three receptor points were implemented into the thermal building simulation and the resulting temperatures of the bedroom and kitchen living room of the attic dwelling in the GZH building were analysed. Two scenarios were distinguished: a) without the use of cross ventilation by keeping the room door of the bedroom closed and b) applying cross ventilation by open the door when windows in kitchen living and bedroom are opened between 18:00 and 7:00. The results are compared in Figure 8 a) and b).

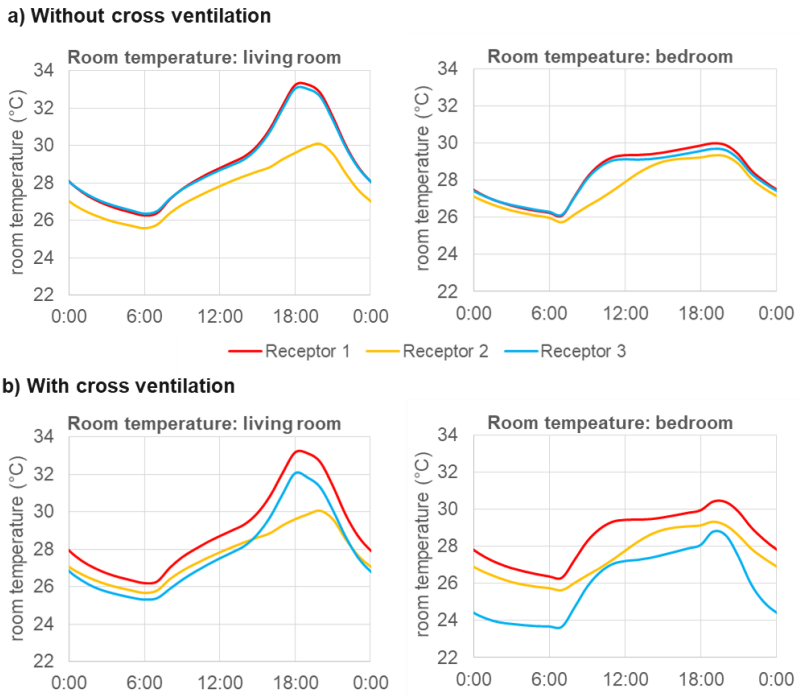

Figure 8*: Room temperature of kitchen living room (left) and bedroom (right) for the GZH attic dwelling virtually located at three different receptor points in the district a) without cross ventilation and b) with window cross ventilation applied.*

Without cross ventilation the differences in room temperature caused by variations in wind speed and outdoor air temperature of receptor 1 and 3 are negligible. However, the changed orientation of the building from east-west façades for receptor 1 and 3 to south-west façades for receptor 2 shows remarkable influence. Here, the lower room temperatures of the kitchen living room are caused by lower solar irradiation through the north oriented windows. For the bedroom with south oriented windows (at receptor 2 position) the more evenly distributed solar irradiation results in a lower increase in room temperature in the morning but saturates nearly at the same room temperature level as for receptor 1 and 3.
Contrasting, if cross ventilation between both rooms is realised (Figure 8b), the small differences in wind strength lead to significant differences in room temperature and overheating of the rooms. For receptor 1 and 2 with almost calm wind conditions (see Figure 7) the temperature course is comparable to the case without using cross ventilation in Figure 8a. In contrast, for receptor 3 the higher (but still low) wind speed of around 1.4 m/s leads to a significant increase in air exchange if cross ventilation is applied. Thus the room temperatures in the small bedroom is around 2 K lower and in the kitchen living room around 1 K lower compared to the case without cross ventilation. This underlines that cross ventilation is very effective even for low wind at nearly calm summer nights.
The receptor points 1 and 3 differs in both, outdoor air temperature and wind speed. To analyse the sole impact of different outdoor air temperature (without wind influence) within the district, the meteorological conditions of receptor 1 were modified by exchanging the outdoor air temperature from receptor 3. Thus, the meteorological input for the comparison in Figure 9 only differed by the outdoor temperature, not by wind. As discussed above, the impact of the small differences of outdoor air temperature in the district on room temperatures is negligible. More precisely, the differences in room temperature are even smaller (less than 0.5 K) than the differences in outdoor air temperature. Thus, the differences in outdoor air temperature on indoor climate are negligible for the chosen district.

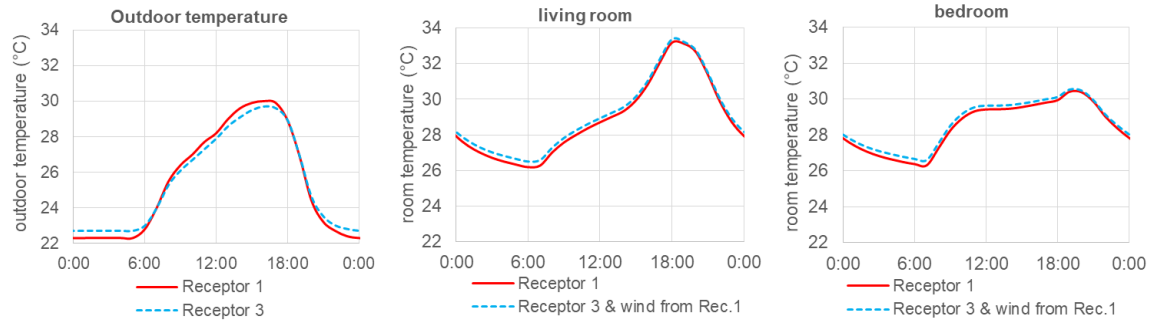

***Figure 9**: Outdoor temperature (left) influence on the resulting room temperature for kitchen living room (middle) and bedroom (right) for the GZH attic dwelling by comparison of receptor 1 with receptor point 3 but with same wind conditions as receptor 1 to equalize the different wind conditions on the receptors (using cross ventilation).*

For analysis of the sole impact of different wind conditions in the district, the meteorological conditions of receptor 1 were modified by exchanging the wind conditions from receptor 3 with higher wind speed. Figure 10 underlines, that the effect of small changes in wind conditions in the district shows a distinct impact on the resulting room temperatures using cross ventilation, even for low wind speeds of around 1.4 m/s.

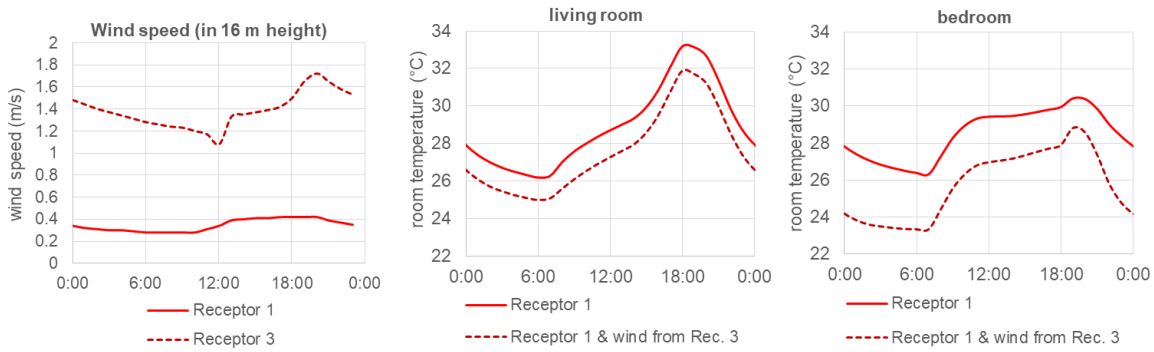

***Figure 10**: Wind speed (left) influence on the resulting room temperature of kitchen living room (middle) and bedroom (right) for the GZH attic dwelling by comparison of receptor 1 with wind input from receptor point 3 but (both have same outdoor temperature conditions) using cross ventilation.*

3.3. Opportunities and Limitations of the model chain approach

The applied model chain of implementing meteorological conditions from urban climate simulations of districts to thermal building simulation of residential buildings provides new understandings of the impact of spatial variations in urban climate on the efficacy of night cooling in buildings and thus on thermal comfort of residents. The scheme in Figure 11 visualises the model chain approach.

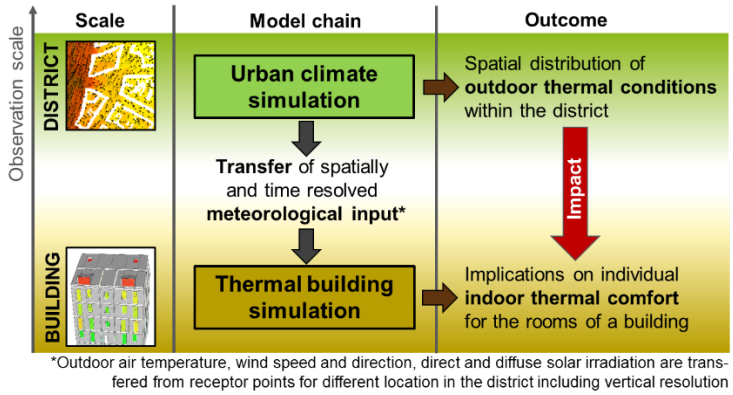

Figure 11: *Schema of the developed model chain approach, starting from urban climate simulation of a district and transferring the resulting local meteorological conditions into thermal building simulation. The model chain enables the opportunity to investigate the impact of urban structures and resulting microscale climate on indoor thermal comfort conditions (including overheating) in buildings.*

However, also for this approach feasible conclusions are limited caused by different model approaches. Here, we state the opportunities and limitations of the model chain.

Opportunities of the urban climate – building simulation – model chain:

- The impact of urban climate on resulting room temperatures (indoor thermal comfort) can be analysed in high spatial and temporal resolution. Thus, the effect of small differences in outdoor air temperature and wind on overheating in buildings can be demonstrated in a realistically manner.
- The described model chain allows sensitivity studies of parameters or variables within a kind of a 'virtual' laboratory.
- Using urban climate simulation, the influence of urban structures like buildings, sealed surfaces or trees on thermal performance in buildings can be examined. The closer the information to urban structures are to reality, the smaller are the uncertainties of estimating the interaction between structural factors, airflow and energy exchange.
- The model chain can assist planners to estimate the impact of projects on the thermal comfort for inhabitants in the district as well as in its buildings. This might help to develop locally adapted measures for heat resilient cities.

Limitations of the urban climate – building simulation – model chain:

- Using ENVI-met, only short periods (usually one or two days) can be simulated as connected time series and used for the thermal building simulation. Nevertheless, for building simulation the analysis of the whole summer or at least heat waves is more reasonable but not possible with this approach.
- The impact of urban climate on indoor temperatures depends on numerous conditions in the thermal building simulation like window ventilation behaviour, the use of cross ventilation, building type or storey as well as in the urban climate simulation like initial parameter setting, resolution, model size.
- Even if the horizontal resolution in the urban climate simulation is high (4 m x 4 m), the effect of high temperatures developing on surfaces with high solar irradiation and its effect for window ventilation of such heated façades or roofs is irresolvable with this method.
- In ENVI-met TKE-epsilon turbulence closure is used (i.e., equations for turbulent kinetic energy and turbulent energy dissipation are solved) producing strong mixing of the lowest atmospheric boundary layer. This fact combined with a rather coarse vertical resolution of the laminar boundary layer above the ground leads to an underestimation of daily cycles of temperature and humidity in the lower urban canopy.

4. Conclusions and outlook

The focus of this article is to introduce a method of applying a model chain, starting from urban climate simulation of a district and implementing the resulting local meteorological conditions in the thermal building simulation, depicted in Figure 11. Using this method it is possible to investigate the impact of spatial climate differences in a district on thermal comfort for different rooms of buildings. This was done combining the simulation tools ENVI-met and IDA-ICE. The practicability is demonstrated by comparing the effect of different meteorological conditions for several receptor points in a district of Erfurt (Germany) for a GZH MFH type. Doing this enables opportunities to examine the implications of spatial differences in wind and outdoor air temperature conditions on the building. As first results of this model chain, it was found that small differences in outdoor air temperatures in the district have negligible influence on the room temperature, whereas different wind conditions even for low wind speed of around 1.4 m/s lead to significant changes in indoor thermal comfort by using window and cross

ventilation. The orientation of the building also plays a decisive role mainly caused by changed solar irradiation and wind flow. In sum, the proof of concept of urban climate to building simulation model chain is performed successfully and more profound investigations applying this model chain are intended. As an example, analysing the impact of different ventilation behaviour will lead to significant changes. In this article, the assumed ventilation behaviour is nearly ideal for effective nighttime cooling. Also comparing different district types or changes in urban structure can help to generalise the findings and understand the urban climate – indoor climate correlation.

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Social Foundations of Sustainability: Gender, Inclusivity and Human Rights; Health and well-being

Gender-based Differences in Myanmar's Labor Force

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Abstract

Gender-based differential treatment is an unquantified burden in Myanmar labour markets. Closing this literature gap, this paper uses the Labour Force Survey 2015 to provide the first study that performs an in-depth quantitative analysis of the gender gap. Besides outstanding descriptive facts, this paper adapts Oaxaca-Blinder decomposition into quantile linear models and, using Heckman corrections to adjust for unobservable skills, visualizes gender discrimination in Myanmar across seven facts. The first two facts show that Myanmar's women labour force participation and unemployment rate gap is remarkably high among the region. However, the third fact reveals that both genders have a similar strategy to engage in the labour markets. Regarding the employed population, the fourth fact analyses the distribution of occupations and industries. It provides a first glance into the way the social norms and market dynamics create gender segregation in specific economic sectors. The fifth fact complements this landscape and statistically compares gender wage differences by education, location, age, sector, industry, and occupation. By doing so, it presents the demographic profiles that face higher gender gaps. The sixth fact decomposes the wage gap by quantiles making a case for glass ceilings and progressive pricing discrimination, both between and across industries and occupations. Finally, the seventh fact reflects over discrimination in the opportunities that women face to occupy different positions in their companies. Gender discrimination in the labour markets is a substantial barrier to the economic development of the countries. Hence, by identifying it, this paper aims to give quantitative support to the gender debate in the country, provides evidence-based suggestions for the country to improve each performance across the facts.

Keywords:

Social norms, gender-wage gaps, occupational segregation, glass ceilings, unobservable-skill biases.

1. Introduction

Ending all forms of discrimination against women is not only a basic human right, but it also has a multiplier effect across all other development areas (Cavalcanti and Tavares, 2016). For that reason, Agenda 2030 recognizes gender equality and women empowerment as a cornerstone to achieve sustainable development. Unfortunately, for many developing countries, the economic growth experienced in the last decades has not been associated with an improvement on gender equality and thus, its economic progress has been limited (Cuberes and Teignier, 2014; 2018).

In this context, Myanmar presents itself as an insightful and unexplored case study. During the last decades, the country has been experiencing abrupt socio-economic changes which included a military rule (1988-2011) during which the country was closed to the world, followed by an economic liberalization (2011-) when by most of the social rules and professional goals of its inhabitants changed (Lall, 2016). Among these changes were a reduction in the role of the state and a rising relevance for the market economy in the development of the country. In this transition, the country has experienced an unprecedented economic growth that ranged between 5-10% during each of the years of the last decade (IMF, 2018). However, this economic improvement has not been reflected in tremendous progress on the gender equality front. For example, the country ranked 148 out of 189 countries in both the Gender Inequality Index and the Gender Development Index of UNDP in 1997 (UNDP, 2018). In the recent years, this topic has earned more spotlight from international agencies such as UN Women which published numerous reports tackling the approaches adopted by current institutions in Myanmar towards gender equality (Forster, 2017). Nevertheless, in-depth studies that describe and quantify the gender issues are still scarce. For the particular case of labor markets, the few existing reports (such as Asian Development Bank (2016) and UNFPA (2017)) are limited to aggregated information for policy purposes. On a positive side, in the recent years Myanmar has been proactive in the implementation of labor force surveys (2015 & 2017) and in particular, its first edition allows a detailed analysis of the gender differences in the labor market. Thus, by understanding the current gap in the literature, its relevance for policy-making, and the existence of available information, this study pioneers a systematic analysis of gender discrimination in the labor market of Myanmar. By doing a systematic analysis of Myanmar's Labor Force, this study contributes with seven key facts to the literature.

2. Data

This study mainly uses the Labor Force Surveys (LFS) conducted by the Myanmar's Ministry of Labor, Employment and Social Security jointly with the Central Statistical Organization in 2015.1 It is a nationally representative survey dataset covering all states and regions of Myanmar disaggregated by urban and rural areas. The LFS (2015) includes 24,000 households, which represent 101,290 individuals. The LFS (2015) adopts a stratified two-stage sampling design, with enumeration area (EAs) blocks in the first stage and the households in the second stage.

In this research, the sample is restricted to individuals whose age ranges between 15-64 years. This is done to match the ILO standard definition of workforce and avoid mixing the effects of child labor and retired population.2 LFS (2015) contains 69,372 individuals satisfying this restriction and they are further categorized into three groups: i) those who are employed in any other organization or self-employed (employed), ii) those who are unemployed and looking for a job or running a business currently (unemployed), and iii) those who are not doing any income-generating activity and have not searched for an income generating activity in the last thirty days (i.e. out of the labor force, or OLF). In the study sample, 66.58% of working age population is employed, only 2.15% is unemployed and 31.27% is out of the labor force.

[1] Currently Myanmar has conducted two labor force surveys. The first one was done in 2015, and its subsequent edition was done in 2017. The present research only relies in 2015 due to two reasons. First, some official reports regarding 2017 survey have not been published yet, and therefore not all the data is available for the research. Second, 2017 survey covers less themes than 2015; and in common topics, such as job searching mechanisms, it changes certain definitions, thus making it difficult to create direct comparisons between the years. As such, this study focuses only in 2015 survey, but future work is expected using the two surveys once the second one is fully released by the government authorities.

2 In Myanmar, the official retirement age for government workers is 60 years. However, there is no specific regulation for workers from the private sector. Therefore, and for comparison purposes, the workforce age was kept at 64 years.

3. Results and Discussion

3.1 Out of the labor force population

This section provides a first glance at the labor force participation in Myanmar and the corresponding gender differences.

Fact 1: Significantly lower participation rates of women, mostly due to household work

Figure 1 presents the labor force participation rates for Myanmar and its neighboring countries. Using the models estimated by the ILO for 2018, two elements stand out from the graph. First, men participation is similar across all the region and ranges between 80-85%. Second, women participation presents a large variation and for the case of Myanmar, it is 28.82 percentage points lower than that of men. This level of participation is significantly lower than that in Vietnam, Cambodia and Lao PDR, countries that are commonly used to benchmark the performance of Myanmar.

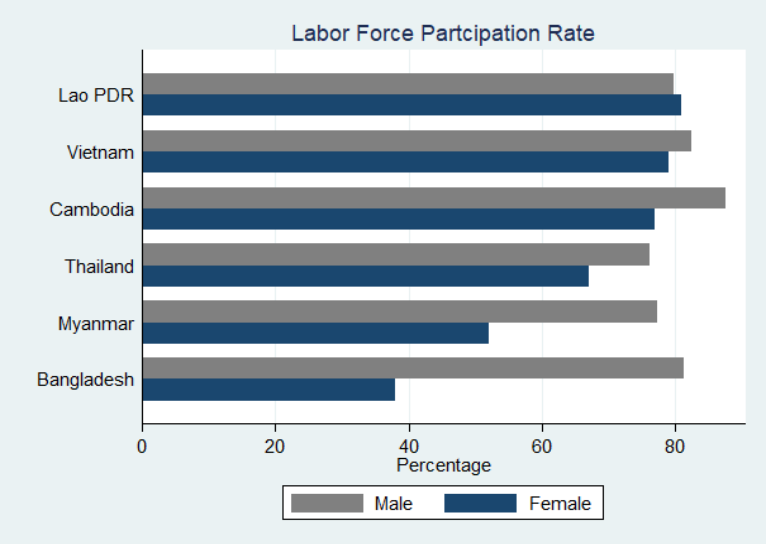

Figure 1. *Labor Force Participation. Source: ILO Models (2018)*

Figure 2 zooms into the case of Myanmar and disaggregates the participation rate by location, age groups, and educational levels. For each classification, a mean comparison test was performed and in all the cases the participation rates were statistically significant at 5%. Regarding location, labor force participation is higher in rural areas, but the difference with urban areas is lower than 5.37 percentage points. Regarding the age groups, the tendencies are similar to both groups. Participation rates are lower for the youngest and oldest cohorts, and higher for the middle cohorts replicating an inverted-u shape. This is an expected trend as the younger populations are still studying while some members of the oldest groups are already retired. However, it is in the youngest cohort that the gap is the lowest (the gap is of 14.93% for the15-24 years age group; while for the other groups the gaps are 29.08% (25-34 years), 30.29% (35-44 years), 34.52% (45-54 years), and 36.94% (55-65 years)). This result suggests that the gap might become smaller for the new cohorts (those that have lived during the period when Myanmar joined the world markets) and that the new institutions are addressing the existing gender-based heterogeneity in employment. Finally, regarding education, the higher education level implies higher participation rates and lower gender gaps. However, this trend is not followed by individuals with training and vocational (TVET) education. For them, the participation rates are the lowest among all the categories.

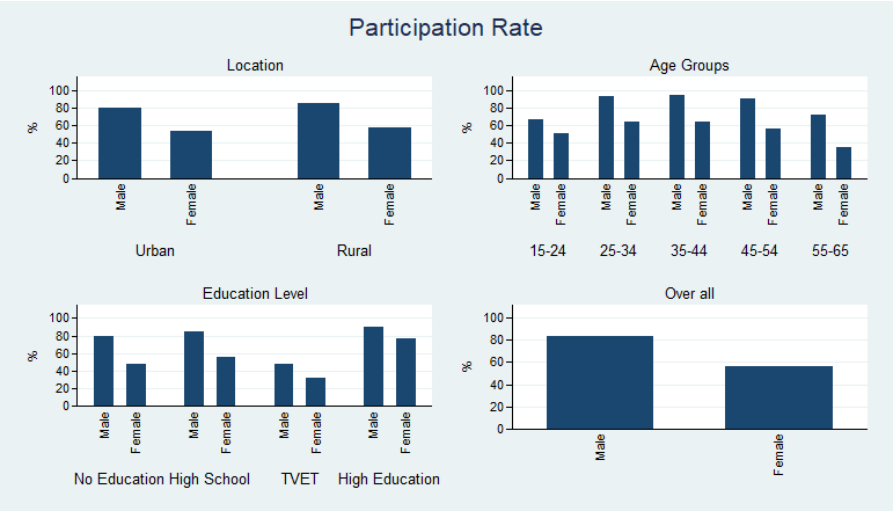

Figure 2. *Disaggregated Participation Rate. Source: LFS (2015)*

Finally, Figure 3 decomposes the reasons provided by OLF individuals to explain their lack of engagement with income generating activities by age group. For the younger population, the main reason is their studies. This reason is considered positive as it reveals that the population is improving its skills and with this, its human capital. However, it is also evident from the graph that education is more common for men than for women. Complementing this observation, 2014 census showed a significant and increasing literacy rate gap in Myanmar (UNFPA, 2017). These observations, added to the claim of Figure 2 regarding the way in which education closes the gender gap, show how gender equality policies require education involvement as a core target. Continuing with Figure 3, middle age cohorts present a landscape where women are out of the labor force almost exclusively because of the housework, whereas for men there are other reasons such as having unfavorable working conditions and attending schools. Finally, the tendency persists for older age groups, and although retirement becomes an important element, still most of the women are performing household duties.

Figure 3 Reasons Not to Work. Source: LFS (2015)

3.2 Unemployed population

This section analyzes the characteristics of the unemployed population in Myanmar and the different ways in which men and women seek to engage in the labor markets.

Fact 2: Significantly higher unemployment rates for women, in particular for those with TVET education

Figure 4 compares the unemployment rates of Myanmar with its neighbor countries. In general, countries in Southeast Asia are recording high economic growth rates which corresponds with more employment opportunities. In this perspective, Vietnam, Lao PDR and Cambodia present higher unemployment rates for men, and Thailand presents a smaller gap in favor of men. In contrast, Myanmar's unemployment for women rate is 1.67 times higher than that of men, only second to Bangladesh with a magnitude of 1.95 times. As in fact 1, this evidence suggests that the gender-based heterogeneity featured in Myanmar is not aligned with the countries Myanmar is typically grouped with and is instead more similar to Bangladesh.

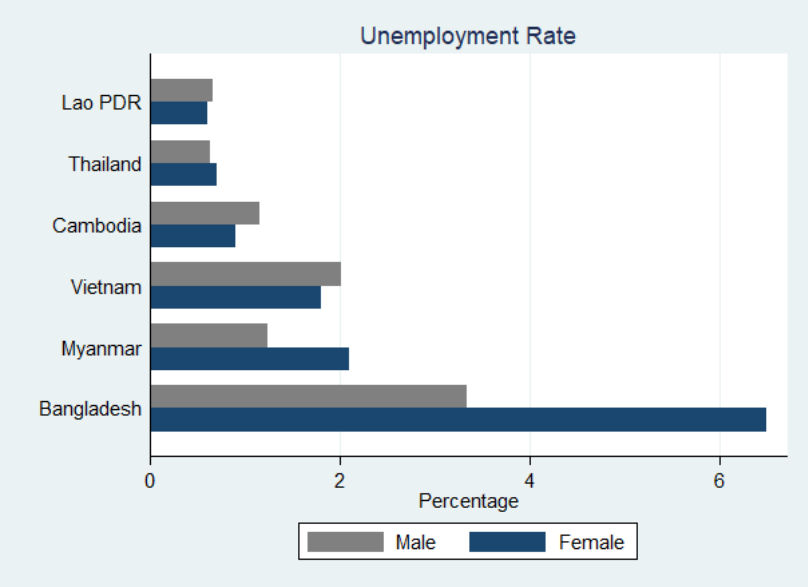

Figure 4*. Unemployment Rates. Source: ILO Models (2018)*

Analogous to Figure 2, Figure 5 analyzes the unemployment rates along multiple dimensions. In general, all dimensions feature gender-based disparity in the unemployment rates. These gaps were tested using mean comparison tests and all differences were significant at 5%. Results are complementary to those in fact 1. Unemployment is higher in urban areas and it resembles a u-shape for different age groups. However, in this case, the gap is not reduced by more in the youngest cohorts. Regarding education levels, it is remarkable that the highest unemployment rate is among people with TVET education. Relating to fact 1 on this aspect, the purpose of TVET education is to train the population with a practical skillset useful for any job as well as basic entrepreneurial tools to guarantee self-employment (Billett, 2011). Thus, it is shocking that individuals with this training are the least engaged in the labor markets, and at the same time are the ones facing more difficulties with carrying on economic activities. Whereas the comment holds for both men and women, the unemployment level for the case of women is the only category that has a double-digit number.

In Myanmar, TVET education starts at the age of 14 when students have completed lower secondary studies. These institutions provide technical degrees that range between two and five years and are run with government-set curricula only with limited feedback from the private sector (UNESCO, 2019). From Myanmar's students' perspective, TVET education is an economic option for those individuals who were unsuccessful in formal education. Thus, it is not seen as a path to get a desired job, but a way to continue in the education system and get a wage premium from the title. From the point of view of the employers, TVET graduates are considered too young to be hired and their skills are not considered relevant for the work, ergo, hiring them is paying a premium for skills that are not desired by the market (San and Lwin, 2019). Under these considerations, the previous results highlight that TVET is seen as a negative indicator of their academic skills, and the disconnection between the curriculum and the labor market creates a mismatch between the expectations of the TVET graduates and the potential employers. This evidence suggests the need for policies that create room for discussion between the TVET institutions and the

labor markets that have gender affirmative actions. Examples of such policies have been done in Burundi, India, Peru, Philippines, and Ukraine (UNEVOC, 2019).

Figure 5. *Disaggregated Unemployment Rates. Source: LFS (2015)*

Fact 3: Women and men use the same strategies to search for income-generating activities.

Table 1 introduces a striking element about the unemployed population. In Myanmar, most of the unemployed individuals are planning to start their own business, and only less than one percent of them are solely looking for a job. As suggested in the previous fact, Myanmar is a growing economy, therefore it is relatively easy to find a job. Therefore, most of the reasons behind the prevailing unemployment are due to individuals having different expectations compared to the posts offered by the market. This element also sheds light on the fact that in Figure 5, youngest age cohorts have the highest unemployment rates. This cohort was born in an economy that was open to the world and therefore, their career expectations (Lall, 2016). Thus, people prefer to search for better options or to create their own income activities.

Table 1. *Ways to engage in labor markets. Source LFS (2015)*

Type of Economic Activity	Gender	
	Male (%)	Female (%)
Looking for Job	0.55	0.53
Own Business	99.45	99.47
Number of Obs.	32,136	37,236

Table 2 complements the previous comment by describing the strategies used by that half percent that is exclusively looking for jobs. The results display how social networks are the most important way for individuals to find a job. The second job search action used is contacting employers directly. These two actions cover three quarters of the sample and show that due to the episode of rapid economic growth Myanmar has undergone, vacancies were abundant, and people were able to find a job by inspecting their local context and social connections. Doing a Fisher Exact test to compare the distributions of actions by gender, the p-value was 0.774 providing statistical evidence that there are no differences between the search actions of men and women.

Table 2. *Job search actions. Source: LFS (2015)*

Job Search Actions	Gender	
	Male (%)	Female (%)
Contacted Organization	27.12	25.38
Checked Worksite	19.21	23.35
Advertisements	3.39	2.54
Friends and Relatives	50.28	48.73
Number of Obs.	177	197

3.3 Employed population

This section analyzes the characteristics of the employed population in Myanmar having a special focus on wage differentials among industries and occupations. For this purpose, industries were identified by a four-digit numeric code using the International Standard Industrial Classification (ISIC) system which is also known as a United Nations Industry classification system, and occupations were identified using four-digit numeric code using the International Standard Classification of Occupations (ISCO) developed by International Labor Organization (ILO). These codes were directly used in the survey, which facilitated their use in the analysis.

Fact 4: Urban women are highly concentrated in specific occupations and sectors that induce a degree of labor market segregation.

Figure 6 presents the distribution of workers by industry. Myanmar workers are mainly focused in "agriculture, forestry and fishery" sector which encompasses 49.64% of employed men and 45.74% of employed women. This fact is not surprising as Myanmar is mainly an agricultural country and by the years of the labor force survey, this sector constituted 26.77% of GDP (Central Statistical Organization, 2018). However, large gender differences appeared for the second largest sector. For working men, "manufacturing and construction" was the second largest sector with 19.06% of the men working population. In contrast, the second largest sector for women was "trading" with 21.95% of their labor force.

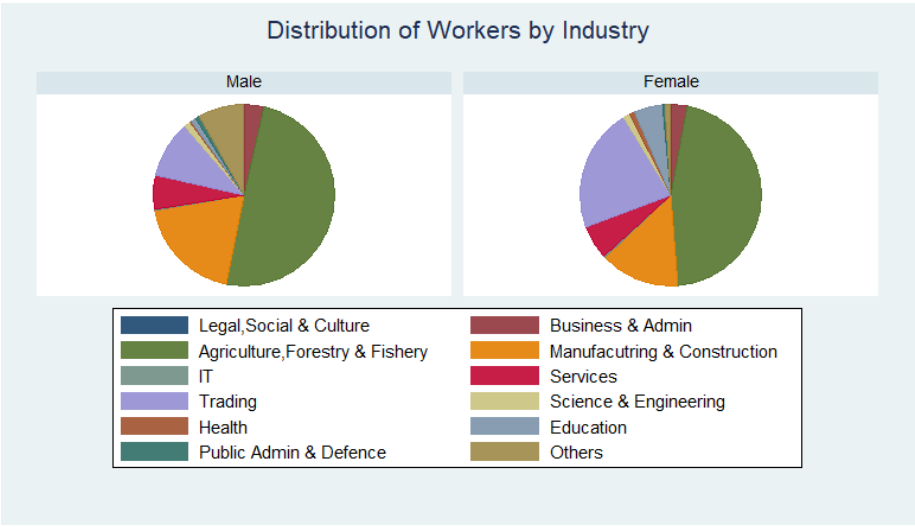

Figure 6. *Distribution of workers by industry. Source: LFS (2015)*

Given the large share of rural activities in Myanmar's economy, in order to better understand the situation in the other labor market, Figure 7 is limited to urban population. In this specific context, "manufacturing and construction" is the largest industry for men (29.77%) while "trading" is the largest one for women (36.95%).

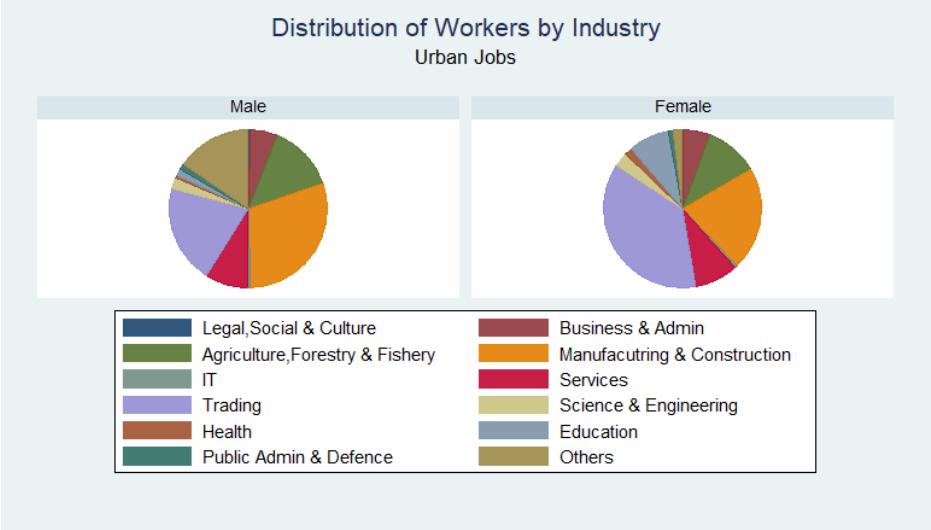

Figure 7. *Distribution of Urban Workers by Industry. Source: LFS (2015)*

Table 3 complements the previous results by displaying the Hirschman-Herfindahl index (HHI) to measure the market concentration of the sectors in which both genders work, and evaluates if there is a significant gender-based difference. As suggested by Figures 6 and 7, the rural area is highly concentrated, which is mostly explained by the agriculture, forestry and fishery sector. In contrast, industry concentration in urban areas does correlate with the gender breakdown of the labor force. For men, HHI is 1402 points, which is equivalent to an unconcentrated distribution. In contrast, for women, HHI is 2111 which reflects a moderately concentrated distribution. The difference in values suggests that women are concentrated in very specific sectors (e.g. trading, and manufacturing and construction) while men are spread along a larger range of industries.

Table 3*. Industry Hirschman-Herfindahl Index. Source: LFS (2015)*

Industry Concentration	*HHI*		*Gender Difference**	
	Male	Female	90% Confidence Interval	
Urban	1402	2111	-779	-636
Rural	4537	3929	498	712
Total	2722	2532	129	251

**The confidence interval was calculated via 1000 bootstraps replications over subsamples that covered 90% of the relevant sample. The results are robust for changes in the subsample size.*

Complementing the distribution of the industries, Figure 8 displays the distribution of genders in different occupations. At the country level, for both genders, "skilled workers" has the largest occupation share: 37.76% of women labor force and 42.99% of men's are in this occupation group. However, once the other occupations are considered, women are more likely to sort into occupations like services and sales and professionals, while men are frequently observed in craft work and plant operators.

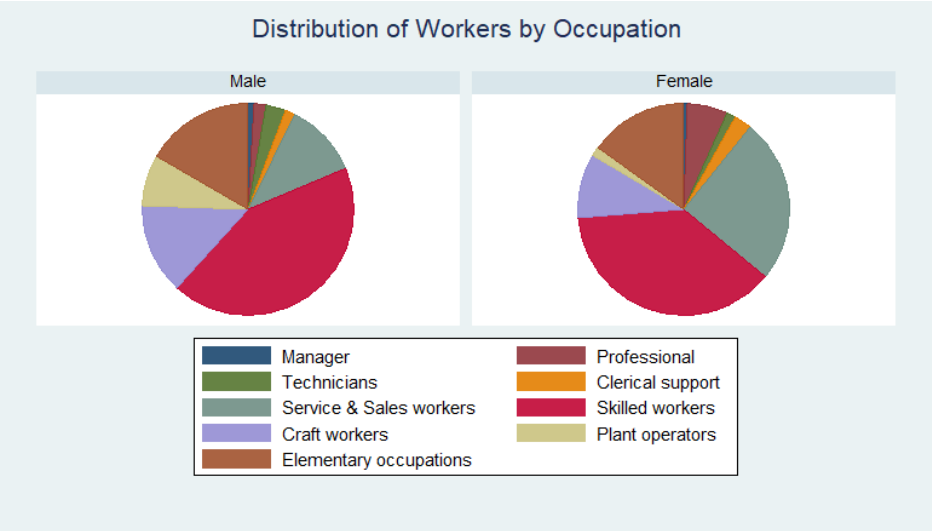

Figure 8. *Distribution of Workers by Occupation. Source: LFS (2015)*

Similar to the industry analysis, Figure 9 evaluates the distribution of occupations for urban areas. In this case, there is a striking difference between both genders. Most of the women labor force is concentrated in services and sales (42.84%) distantly followed by craft workers (14.82%) as the second largest share; meanwhile, men distribution is balanced between services and sales (22.19%), craft workers (23.10%), plant operators (13.56%), elementary occupations (13.57%), and skilled workers (12.11 %).

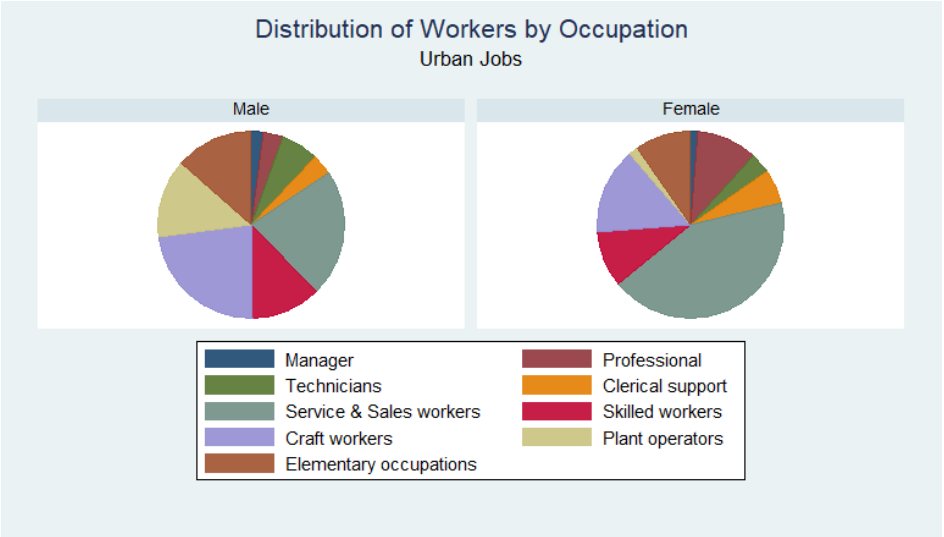

Figure 9. *Distribution of Urban Workers by Occupation. Source: LFS (2015)*

Regarding the concentration element, Table 4 tackles that via HHI. As in the industrial comparison, urban female occupations exhibit high concentrations (2386 HHI points) in contrast to urban men occupations (1600 HHI points). At the overall level, the concentration is very high, but the difference among genders is minimal due to the prevalence of skilled workers, and the large fraction of the labor force that is based in rural areas.

Table 4. *Occupation Hirschman-Herfindahl Index. Source: LFS (2015)*

Occupation Concentration	HHI		Gender Difference*	
	Male	Female	90% Confidence Interval	
Urban	1600	2386	-867	-713
Rural	3974	3436	451	625
Total	2506	2406	50	151

**The confidence interval was calculated via 1000 bootstraps replications over subsamples that covered 90% of the relevant sample. The results are robust for changes in the subsample size.*

Common to both analyses, it is remarkable that rural and urban localities have opposite behaviours. In the urban areas, women are highly concentrated in particular industries and occupations, while men have a more homogeneous spread. This situation is inverted in the rural areas, notwithstanding that the concentration difference is smaller than the urban gap. As explained by Das and Kotikula (2019), gender segregation along industries and occupations are a consequence of access to education, household time allocation, role models, and safety conditions at the workspace. The previous three facts discussed the role of education and household time allocation and argued their relevance to improve gender equality. While the new evidence provided by this fact supports the previous claim, it also shed lights on other sources of gender inequality. Regarding safety environments, Myanmar's rates of bullying are particularly high for women, where its main manifestations are being gossiped about, shouted at by the supervisor, inappropiate teasing, and being excluded from work-related social events (IFC, 2019). Hence, adapting to these issues, women began to cluster into specific industries. Regarding role models, and to the best of the knowledge of this research, there are no relevant studies for Myanmar. In the recent times, under the leadership of Daw Aung San Suu Kyi, it seems that women are taking more important leadership positions. However, the participation of women in leadership positions in Myanmar is still quite scarce (Sein Latt, Ninh et al.,2017; Nyunt, 2018). Moreover, and specially during the period when the country was closed, the main institutions that determined the life of the citizens were the military and the Theravada Buddihst leaders. While there is no particular study for the case of Myanmar, in other parts of the world, both institutions had specific gender roles and responsibilities which can support industry and occupational segregation (Sidwell et al., 2006; Waylen, 1994; Cadge, 2004).

Fact 5: Raw wages differences are systematic across demographic characteristics and the type of job.

Table 5. *Raw income differences based on Demographic Categories. Source: LFS (2015)*

		Linear Regression		Quantile Regression	
Demographic Categories	Number of Observations (1)	Average Male Income (2)	Wage Difference (3)	Median Male Income (4)	Wage Difference (5)
		Education Level			
No Education	7,232	527.3	-138.8	90	-6
K-12	56,029	848.4	-649.9***	120	-30***
TVET	1,047	140.4	-16.27	125	-7
High Education	5,064	1,063	-806.7	134	-11***
		Age-group			
15-24	16,947	564.0	-397.8***	90	0
25-34	16,206	525.8	-345.1***	120	-30***

35-44	14,826	1,218	-1,051***	122	-32***
45-54	12,180	994.4	-538.4	120	-30***
55-64	8,387	1,571	-1,046	120	-30***
		Location			
Urban	25,866	359.4	-192.3	126	-16***
Rural	43,506	1,191	-920.9***	100	-10***

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 5 displays the mean and median differences in income[3]. Independent of the categories, the gap between the mean and the median proves that it is more common for men to observe atypically higher incomes. For the case of women, there are also women with higher incomes as reflected by the mean-median gap once again, however the dispersion is significantly smaller than that in males. Regarding education, Table 5 highlights that with the exception of No Education and TVET education, in each of the demographic characteristics the difference in either the mean or the median between the two genders is statistically significant. As mentioned before, the wage distribution is highly skewed with a large mass of individuals around low wages and few individuals, mostly men, with atypically higher incomes. In the cases of the distributions with many individuals with low wages (truncated by the minimum wage), the median difference reduces its power. In contrast, for those groups with highly influential outliers, the mean differences are not informative. Thus, to compensate in both ends, this research suggests that as long as one of these tests is significant, there is evidence to support the existence of a gender wage gap. Finally, the case of No Education and TVET are meaningful in themselves. As it has been discussed before, TVET education in Myanmar is not fully appreciated by the employers who believed that the wage premium is not compensated by the skills provided by TVET alumni. Moreover, the fact that this category presents the highest unemployment rates for both genders means that there prices tend to be as low as possible, and given that price differentials are not possible at the lower bound, the gender discrimination becomes visible in the unemployment rate. For the case of individuals without education, the analysis is qualitatively similar as the previous case.

Table 6. *Raw income differences based on Job Type. Source: LFS (2015)*

		Linear Regression		Quantile Regression	
Job Type	Number of Observations (1)	Average Male Income (2)	Wage Difference (3)	Median Male Income (4)	Wage Difference (5)
Sector					
Public	3,081	278.8	-136.7	121	2
Cooperative	44	105.8	26.01	120	0
Joint Venture	857	2,151	-1,998	135	-25***
Private	41,457	834.2	-580.7***	120	-36***
Other	504	5,910	-5,073	100	-15
Occupation					
Manager	333	262.5	15.96	173	27***

[3] Appendix A.1 explains the methodology used for the calculation of Table 5 and Table 6.

Professional	1,701	1,203	-925.3	128	-5
Technician	1,108	2,118	-1,981	130	-1
Clerical Support	921	148.3	-20.99	120	0
Service and Sales Workers	7,937	760.7	-676.5**	105	-35***
Skilled Workers	18,742	2,171	-1,734***	90	-15***
Craft Workers	5,577	171.2	-0.368	150	-60***
Plant Operators	2,313	182.7	-87.69***	150	-60***
Elementary Occupations	7,364	742	-525.9***	90	-6***
Industry					
Legal, Social & Culture	263	2,925	-2,767	129	21*
Business & Admin	1,291	147.7	-13.17*	124	-1
Sales & Marketing	7,001	1,005	-916.8	100	-25***
Agriculture, Forestry & Fishery	20,837	1,887	-1,436***	90	-6***
Manufacturing & Construction	1,743	493.1	-388.4	120	-30***
IT	82	195.4	-5.717	190	-60***
Services	2,233	439.7	-330.8*	120	-37***
Trading	5,029	174.8	-3.105	150	-60***
Science & Engineering	807	2,303	-2,160	127	1
Health	278	171.1	-45.92***	150	-30***
Education	1,193	138.9	162.2	124	-1
Others	5,230	514.8	-399.6***	112	-34***

*** p<0.01, ** p<0.05, * p<0.1

Table 6 considers the income differences depending on the sector, occupation, and industry of the individuals' job. As in the previous case, most of the examples suggest a significant gender gap as well as a prevalence of heavily skewed distributions. However, there are few exceptions worthy to be highlighted.

Regarding the sector, it is remarkable that the public sector exhibits no wage discrimination. In Myanmar's Civil Servant Regulation, the salaries of the public servants are determined by wage tables which consider, almost exclusively, the amount of years that the individual has been in a given position. Therefore, this practice has indeed contributed to the equalization of wages. However, the fact that the mean gap between genders is wider than the median gap suggests that discrimination in the public sector can be about the position rather than the salary. This point is expanded in later facts. Cooperatives also present a positive result. However the small sample size reduces the inference capacity of the results.

As to occupations, it is remarkable that only managers have a significant wage gap in favour of women. It is noteworthy that managerial positions are the most selective occupations in a company and thus, the ones that require most skills. Hence, this result suggests that, conditional on being accepted as a manager, women might have better skills than their male counterparts. Indeed, this fact opens the discussion about the characteristics that the labor markets are recognizing at the moment of

determining wages. Due to its length and relevance, this discussion is covered in the next fact.

Finally, wage gaps in favour of men are prevalent across industries. The sole exception is education, where the average income is insignificantly higher for women. However, considering that the median income is higher for men, this particular result is considered to be driven by a small set of women in education with particularly high incomes.

3.4 Wage Composition and Occupational Segregation

Table 5 and Table 6 provide an important illustration of the gross salary differences between genders highlighting some particular cases that exhibit outstanding dynamics, such as the TVET alumni and the public sector. However, in these analyses, it is unclear how the market values these characteristcs at the moment of determining wages. For that reason, the next facts analyze the wage and promotion structure of the labor markets. To facilitate the description of the main findings, the methodology used for Fact 6 is presented in appendix A.2, and the methodology used for Fact 7 is presented in appendix A.3.

Fact 6: Wage discrimination steeply increases along the income level and require women to be significantly more prepared than men in equivalent jobs.

Gender-based wage differentials can occur due to two different reasons. Following Oaxaca Blinder philosophy, either men's salaries are higher than those of women because men are better prepared for the tasks required by the job (endowment effect) or because the market prefers men independently of whether there are women with equivalent skills (coefficient effect). The current fact uses an expanded version of Oaxaca Blinder Decomposition (explained in appendix A.2) to understand the degree to which the endowment and coefficie nt effects are affecting Myanmar's labor force.

Figure 10 presents the endowment effect under four different perspectives. The red line represents the endowment effect across industries and the blue line represents the endowment effects within industries. Aligned with Hara (2018), the fact that the endowment effect is higher across industries suggests that differences in endowments are taking place in specific industries. Indeed, this claim is corroborated by the previous facts that highlight the segregation of women in particular sectors. Moreover, given these two perspectives, the gap seems to be stable along income percentiles. However, as Ahmed and McGillivray (2015) explained, this approximation does not consider the fact that individuals being employed already implies a selection procedure based on observable and unobservable skills that induces biases in the decomposition. Correcting for that issue, the yellow and green lines present the correspondent selection-bias corrected effects. This correction qualitatively preserves the claim that most of the endowment gap is present across industries rather than within industries. Nevertheless, it describes a radically different picture regarding income quantiles. In this case, it is visually clear how women are better prepared than their men counterparts at higher income levels. This fact is represented by the increasingly negative endowment effect along the income percentiles. In particular, the difference between the corrected and the base model suggested that women need to excel in unobservable traits in order to acquire high positions.

Using the same logic as Figure 10, Figure 11 presents the coefficient effect that is frequently used in the literature to visualize discrimination. In this case, within and across differences are minimal along industries. Regarding discrimination, it steeply increases along income percentiles. However, the coefficient effect is reduced due to the explicit inclusion of unobservable characteristics that affect the employability of a person and thus transfer part of the coefficient effect to the endowment effect. Nevertheless, the discrimination is still high, and its explanatory capacity of the wage determination is between four and five times higher than the endowment effect.

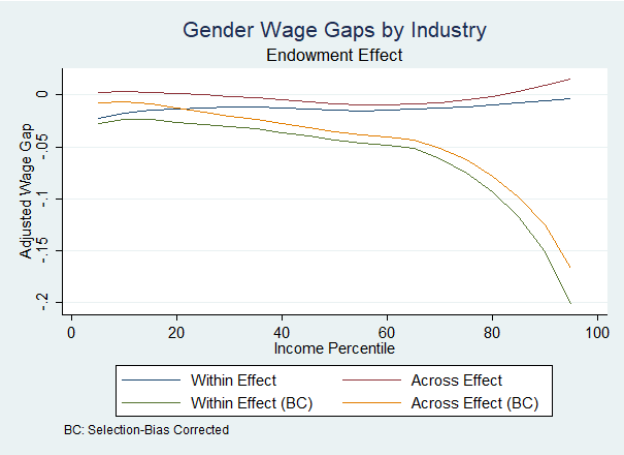

Figure 10. *Endowment Effect by Industry. Source: LFS (2015)*

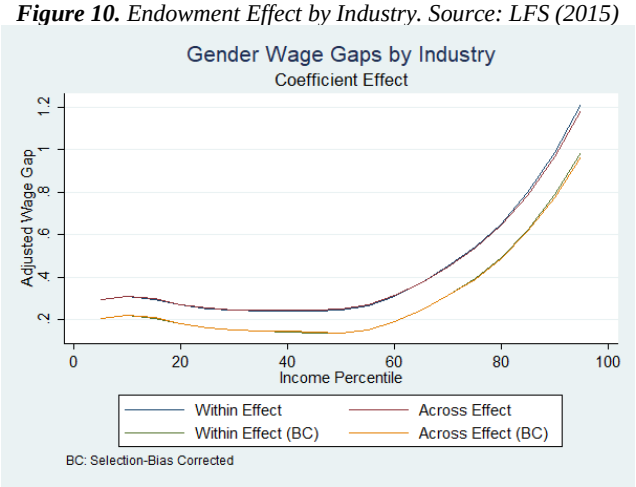

Figure 11. *Coefficient Effect by Industry. Source: LFS (2015)*

In contrast to the industry analysis, Figure 12 shows that when it comes to occupation analysis, the largest endowment effect takes place within occupations. Thus, in each of the occupations, women are expected to be better endowed than men, and this difference increases along the income distribution. Besides that, the effect of the correction is qualitatively similar to that in the industrial case.

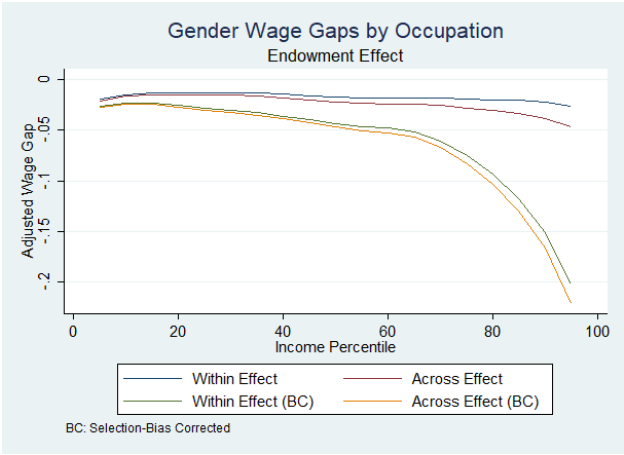

Figure 12. *Endowment Effect by Occupation. Source: LFS (2015)*

Finally, Figure 13 presents the coefficient effect analyzed by occupations. This graph has the same analytical results as Figure 11.

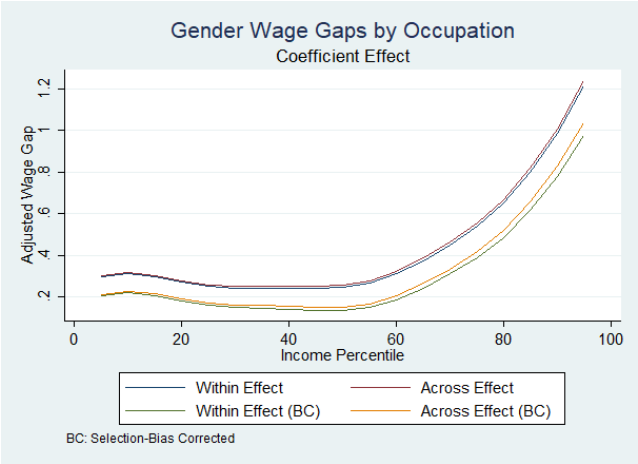

Figure 13. *Coefficient Effect by Occupation. Source: LFS (2015)*

In general, the previous four figures clarify the pricing discrimination in Myanmar's labor markets. Labor markets provide a wage penalty for women employees and this penalty increases with the economic level causing a glass ceiling that requires women to outperform men, especially in unobservable skills in order to acquire relatively high incomes. Furthermore, even when the unobservable are visualized, the market still presents a high preference towards men in middle- and high-income positions. As stated in the first facts, this evidence supports the claim that the current institutions, heavily influenced by Myanmar's recent history, are still supporting social structures that are creating gender discrimination and imbalances in the labor markets. Hence deeper comprehension of these institutions is needed in order to set the country on a path of structural change that promotes gender equality.

Fact 7: There is gender segregation along different occupations that reinforces discrimination dynamics.

The last fact of this study focuses on the differences along occupation distributions in order to identify social norms that affect gender inequality. Aligned with Keller (2019), Table 7 decomposes the occupational distribution using the same logic as Oaxaca Blinder decomposition. In this case, there are four groups of occupations. The first group is composed by professionals, technicians, craft workers, and plant operators. In these groups, the coefficient effect is positive while the endowment effect is negative meaning that men are more likely to occupy this position and that, conditional on getting it, women are better fitted for the job tasks. The second group is clerical support and service and sales workers, where women are better fitted and also preferred. The third group is skilled workers and elementary occupations, where men are better endowed and also preferred. Finally, the last group is managers where men are preferred although women are equally endowed. These differences in preferences showed that there is a gender specialization along different occupations where men are preferred and suited for manual work, while women are preferred in places that require client interaction and support positions. Finally, the market still prefers to allocate men in managerial positions even when women can have the same endowments. As it has been expressed in the previous facts, these results seem to be the consequence of social norms that are shaping the current labor markets. However, this fact goes a step further and shows that adapting to the reality, the individuals do focus on the areas that fit them better. Thus, there are several occupations where a given gender is preferred and is also better endowed. This specialization is likely to create dynamic traps where the status quo shapes the decisions of the individuals, and these actions reinforce the social structures.

Table 7*. Occupational Distribution Decomposition. Source: LFS (2015)*

	Occupation	Difference	95% Confidence Interval	
			Min	Max
Coefficient Effect	Manager	0.07%	0.07%	0.08%
	Professional	0.11%	0.05%	0.17%
	Technicians	2.05%	1.96%	2.14%
	Clerical Support	-0.09%	-0.09%	-0.08%
	Services & Sales Workers	-20.54%	-20.76%	-20.33%
	Skilled Workers	2.78%	2.55%	3.00%
	Craft Workers	5.23%	4.85%	5.60%
	Plant Operators	8.01%	7.84%	8.19%
	Elementary occupations	2.38%	2.26%	2.50%
Endowment Effect	Manager	0.00%	0.00%	0.00%
	Professional	-0.26%	-0.28%	-0.24%
	Technicians	-0.49%	-0.51%	-0.48%
	Clerical Support	-0.02%	-0.02%	-0.02%
	Services & Sales Workers	-1.07%	-1.09%	-1.05%
	Skilled Workers	1.77%	1.75%	1.80%
	Craft Workers	-0.25%	-0.27%	-0.24%
	Plant Operators	-0.52%	-0.55%	-0.50%
	Elementary occupations	0.84%	0.82%	0.86%

4. Conclusions

Due to its recent history, data collection on the status of labor markets has been scarce in the country. However, the recent efforts of the Ministry of Labor, Immigration, and Population started conducting labor force surveys that allow the government to have a better understanding of the country's labor market dynamics. This study is a pioneer in the use of these surveys to comprehend gender differences in the labor market and presents seven facts that highlight its most relevant characteristics.

This study divided the analysis into four parts. The first part reviewed the individuals that are out of the labor force. The first fact of the study showed how social norms and weak welfare institutions are affecting the engagement of women in labor markets at levels that differ from Myanmar's neighboring countries. The second part described the unemployed population and highlighted the larger unemployment rates faced by women. However, it is also shown how unemployment is still low in Myanmar and both unemployed men and women are keener at starting their own business rather than finding a job. The third part provides a glance at the employment force and discusses both the distribution of genders across occupations and industries, as well as the wage differences between men and women. Finally, the fourth part goes deeper into the structures of discrimination in wage and occupation and visualizes the existence of glass ceilings that limit the access of women to middle-

and high-income employments. This fourth part also sheds light on possible labor allocation dynamics that can reflect the current social norms and make equality policies more difficult to achieve.

In general, this research recommends that work needs to be done at the education and the social welfare fronts as well as in creating tools aimed at encouraging women to participate in the labor markets. Nevertheless, it also highlights the need for further work to better understand the social context in which these dynamics are embedded and what policies can thus be implemented to promote gender equality in such context. Finally, it is important to remark that this study is based on the first labor force survey done in the country. As long as labor force surveys are conducted regularly, more trends can be observed, and problems can be identified more accurately.

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A. Methodological Appendix

A.1 Calculation of raw income differences.

Table 5 and Table 6 present the calculation of raw income differences. For this purpose, the following methodology was performed:

Step 1: Variable identification.

Income: This paper used the adjusted monthly income of the individual using LFS (2015). The monthly income is adjusted by multiplying the daily wages by working days if working days are known or 30 days if working days are unknown, multiplying the weekly income by 4 weeks, multiplying bi-weekly income by 2 weeks. The reported monthly income is used directly without any further adjustment.

Location: Under this category there are two dummy variables: individuals living in urban areas (urban), and individuals living in rural areas (rural).

Education Level: Under this category there are four dummy variables: individuals without education (No Education), individuals whose highest degree achieved is either in pre-primary, primary, or secondary (K-12), individuals whose highest degree is in training and vocational education (TVET), and individuals whose highest degree achieved is in tertiary education (Higher education).

Age Group: Under this category there are five dummy variables according to the following age ranges: 15-24, 25-34, 35-44, 45-54, 55-64.

Sector: This category indicates the type of employers where the individuals are working. It includes five dummy variables: 1) public; 2) private; 3) cooperative; 4) joint ventures; and 5) others (not classified).

Industry: This category is developed by a four-digit numeric code using the International Standard Industrial Classification (ISIC) system. It includes twelve dummy variables: 1) legal, social and culture; 2) business and admin; 3) agriculture, forestry and fishery; 4) manufacturing and construction; 5) information technology (IT); 6) services; 7) trading; 8) science and engineering; 9) health; 10) education; 11) public administration and defense; and 12) others (not classified elsewhere).

Occupation: This category developed by a four-digit numeric code using the International Standard Classification of Occupations (ISCO). It includes nine dummy variables: 1) manager; 2) professional; 3) technicians; 4) clerical support; 5) services and sales workers; 6) skilled workers; 7) craft workers; 8) plant operators; and 9) elementary occupations.

Female: This is a dummy variable that assigns a value of 1 if the individual is female, and 0 if the individual is male.

Step 2: Average Difference

For each of the categories mentioned in step 1, consider the model described by equation 1, where Y_i is the income of individual i, C are all the dummy variables of a given category (where the categories are: Location, Education Level, Age Group, Sector, Industry, and Occupation), and β and γ are the linear coefficients of the corresponding dummy and its interaction. Finally, ε_i is the error term.

$$Y_i = \sum_{C \in Category} \beta_c \times C_i + \gamma_c \times C_i \times Female_i + \varepsilon_i \quad (1)$$

Given the omission of the intercept term and the variable $Female$ byt itself, γ coefficients in this regression represent the difference between the genders in each category. Therefore, after calculating them via a linear regression with robust white errors, Table 5 and Table 6 display these values under the column 3.

To provide an example, for the category Location, equation 1 becomes:

$$Y_i = \beta_{Rural} \times Rural_i + \beta_{Urban} \times Urban_i + \gamma_{Rural} \times Rural_i \times Female_i + \gamma_{Urban} \times Urban_i \times Female_i + \varepsilon_i$$

Thus, γ_{Urban} describes the average wage difference between a male and a female urban worker. Analogous, γ_{Rural} describes the average wage difference between a male and a female urban worker. Thus, Table 5, displays γ_{Urban} and γ_{Rural}.

Step 3: Median Difference

Step 3 follows the same procedure of step 2, but instead of using a linear regression, it uses a quantile regression centered in the 50 percentiles. In this way, this regression estimates the median gender wage gap. In this case, the corresponding results are displayed in column 5 of Table 5 and Table 6.

A.2 Wage decomposition by industry and occupation.

Fact 6 presents multiple results regarding wage decomposition between and within industries. This exercise is performed for different income quantiles and corrects possible biases due to unobserved characteristics of the labor force. In order to facilitate the presentation of the methodology, the first step discusses the wage decomposition by quantiles, the second step explains the way in which effects within and across industries and occupations were considered, and the third step discusses about the bias correction.

Step 1: Recentered Influence Function

In this study, the wage is decomposed using a Recentered Influence Function (RIF) regression method as proposed by Firpo, Fortin, & Lemieux (2018). This methodology recreates Oaxaca-Blinder Decomposition at given quantiles of the income distribution and thus, it provides insights of the way in which discrimination changes along economic levels.

Following the presentation of the methodology used by Hara (2018), the core of RIF is the determination of the dependent variable. For this case, let Y_i being the logarithm of the income as it was constructed in appendix A.1. Then, define the τth Quantile (Q_τ) value for individual i as stated in equation 2.

$$RIF(Y_i; Q_\tau) = Q_\tau + \frac{\tau - I[Y_i \leq Q_\tau]}{f_w(Q_\tau)} \quad (2)$$

In this case f_w (.) is the density and $I[.]$ is the function. In the main text, this dependent variable is known as the adjusted wage.

The calculation of the dependent variable is done separately for each of the genders. Once this is done, the Oaxaca-Blinder Decomposition is used over these dependent variables and the corresponding relevant covariates. Following previous literature results such as Ahmed and Mitra (2010), Ahmed and McGillivray (2015), and Hara (2018), the covariates used for Figure 10 to Figure 14 are:

Education Level: A set of dummy variables defined in appendix A.1

Age: The age of the individual and its square form.

Experience: The working experience of the individual and its square form. In this case, experience was approximate as [age – years of schooling –5 + 1] because the enrolment age for elementary school is in Myanmar is five years old by following Hara (2018)

Location: A set of dummy variables defined in appendix A.1

Industry: A set of dummy variables defined in appendix A.1

Occupation: A set of dummy variables defined in appendix A.1

Step 2: Effects within and across industry and occupation

Following Hara (2018), the current research presents evidence on discrimination within and across industry and occupations. For the case of industry, the first part is to run the RIF as stated in the previous step. The second step is to perform the same regression without the industry dummies. Due to the omission of this variable, the Oaxaca-Blinder decomposition reflects discrimination effects across industries. Then, to calculate the within effect, the average per industry of each of the variables used in the previous regression is included. For example, given that age was included in the first regression, this second regression includes age, and the average age in each of the twelve industries. By doing so, the exercise resembles the calculation of fixed-effects in panel analysis and allow the understanding discriminations within industries. In this way, both across and within industry effects can be studied. Finally, the case of occupation is analogous to the previous case, and therefore is not described in detail.

Step 3: Selection Bias Correction

The purpose of this step is to correct for the selection bias caused by unobservable skills that determine the employability and wage of an individual. Following the procedure of Ahmed and McGillivray (2015), the first part of this exercise is to calculate the probability of an individual to be employed. In this first part, a probit model was estimated using as dependent variable the probability of a person being employed against a person who is unemployed. The model used as covariates the education level of the person, its age, and its corresponding square, its marital condition (dummies for married, single, widow, separated, and divorced), and a dummy variable if the individual is the head of the household. The second part of this step gives a score to everyone that measures their probability of being employed. This score is transformed into the inverse Mills ratio using Heckman (1979) correction and it is incorporated as one of the covariates of step 1.

A.3 Structural gender differences in occupations

The purpose of this exercise is to understand the differences of the occupation distributions along the lenses of endowment effects and discrimination. Following Fairlie (2005), the previous objective is achieved by replicating Oaxaca-Blinder Decomposition in a discrete choice regression context. For that purpose, let $O_{t,i}$ be the probability that individual i is in occupation t, and X_i the set of relevant covariates that are associated with $O_{t,i}$. In that case, equation 3 suggest the functional for of the estimation, where F follows a multinomial logit.

$$O_{t,i} = F(X_i\beta_{it}|t) \quad (3)$$

Replicating the steps of Oaxaca (1973) and Blinder (1973), β coefficients of equation 3 are estimated only for the female sample, obtaining the vector of coefficients β_f and then over the male sample, obtaining the vector of coefficients β_m. Finally, let $\overline{X_f}$ stand for the average value of the female covariates, and $\overline{X_m}$ stand for the average value of the male covariates. In this context, equation 4 describes the endowment effect associated with the occupation distribution and equation 5 describes the coefficient effect.

$$Endowment\ Effect = F(\overline{X_m}\beta_m|t) - F\left(\overline{X_f}\beta_m|t\right) \quad (4)$$

$$Coefficient\ Effect = F\left(\overline{X_f}\beta_m|t\right) - F\left(\overline{X_f}\beta_f|t\right) \quad (5)$$

Due to the non-linearity of the discrete selection model, statistical significance of the effects was estimated via 1000 bootstraps replications over subsamples that covered 90% of the relevant sample. The results presented in Table 7 are robust to changes in the size of the subsample. Moreover, other robustness exercises were performed using multinomial probit models, but the qualitative results were not affected.

Finally, for this exercise, the relevant covariates were Location, age and its square, experience, and its square, and education level, all as defined in appendix A.2.

Sustainability and women

- the Hungarian case of underrepresented women in science

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Abstract

Women's rights are human rights and therefore fundamental to sustainability. Although some progress has been made, according to UN statistics there are still 250 Million women who had to undergo female genital mutilation (FGM), 49 countries lack laws aiming to protect women from domestic violence, women do three times more unpaid work and earn 27 % less than men - just to name a few present inequalities and types of violence women are facing globally.

Before we say it's a "problem of developing countries", we should take a look at some data. According to European Commission's She figures 2015 women's average gross hourly earnings (EU-28) were 17.9 % lower than those of men in scientific research and development in 2010. Furthermore, in academic careers the representation of women is only 13 % at the grade A level of academic staff.

The status of women in Hungary is even worse in many fields. Political and academic participation rates are extremely low. We only rank 27th on the EU Gender Equality Index 2019, and our slower rate of improvement has led to an increasing gap with the EU over time. On the 2019 Women, Peace, and Security Index Hungary ranks 49th after countries like the United Arab Emirates, Kazakhstan, Albania. According to the World Economic Forum's Global Gender Gap report 2018 Hungary, out of 149 countries, was ranked no.102 with the worst score of all European nations.

The aim is to show the existing inequalities and to understand the reasons behind. Reasons for the very low participation rates of women at higher level academic careers in Hungary can be found for example in the very strong economic and social agreement that mothers should stay at home until the child turns three. As cultural values and social institutions in patriarchal societies are not supporting women in gaining power, female scientists often also drop out of their careers for more years, or even forever.

The status of women will be shown here, focusing on academic and sustainability research participation particularly on the decision-making level. Statistics from several sources are used to picture women's objective reality. However, the similarly or even more important aspect of sustainable well-being, namely the subjective reality of women's everyday life will be only partly dealt with. Obstacles to sustainable well-being such as victim-blaming, double standards, or long-term mental effects of violence against women are subject for further research.

Understandings and also suggestions will be given here for achieving Sustainable Development Goal 5 particularly in developed countries and in Hungary such as quota systems or gender sensitive budgeting.

Keywords: Women, Sustainability, Gender equality, Human rights, Social reproduction

1. Introduction

According to UN SDGs[1] gender equality is fundamental to sustainable development[2], therefore without successfully dealing with gender issues, SDGs will not be achieved by 2030. Gender equality[3] is still an unresolved issue not just in least developed countries but also in developed countries. The papers focuses on the status of women, globally but also regionally (Hungary) and specifically looks at sustainability science to show how many women are having decision-making positions in helping to establish a more sustainable, less harmful economic system. Both qualitative and quantitative data was taken from scientific papers, public data of scientific institutions, and from statistics and indicators to analyse the involvement of women.

The findings suggest that women are exploited, violated and don't have the same rights as men. Also, women are only involved in an insignificant number in the discussion on sustainability.

Recent study aims to show, that a more sustainable environmental-economic-social system remains an immaterial idea and won't become reality unless patriarchal values cease to dominate.

[1] It is a roadmap for sustainable development, established by the world leaders in 2015. It is called the 2030 Agenda for Sustainable Development (UN SDGs).

[2] The Brundtland Report defined sustainable development as „meeting the needs of the present generation without compromising the ability of future generations to meet their needs." The official UN definition of sustainability has three dimensions: environmental protection, economic development and social equity.

[3] UN Women's defines gender equality as a concept that refers to the equal rights, responsibilities and opportunities of women and men, where equality does not mean that women and men are the same but that women's and men's rights, responsibilities and opportunities cannot depend on whether they are born male or female.

To be a woman

The oppression of women is global phenomenon that have existed for hundreds, if not thousands of years. Women's rights to own land or a job, the right to get divorced or even the right to oppose men's sexual desires were violated for centuries in most cultures such as the Mesopotamian, the Jewish, the Christian, the Islamic or the Indian cultures.

In most of the countries women have gained the right to vote only in the last few decades. In 1893, New Zealand was the first one to allow women to vote.[4] Other countries followed such as Finland in 1906[5], Denmark in 1915[6], Iceland in 1915[7], Russia in 1918[8], Germany in 1918[9], The United Kingdom in 1918[10] and The United States in 1920[11]. Many countries followed much later: European countries such as Switzerland only in 1971[12]. In some countries, women of color and indigenous women only won suffrage decades after white women already did. Saudi Arabia is the most recent country in which women have won the right to vote, in 2015.[13] In Hungary the general, equal and secret right to vote for both men and women only came to reality in 1945. [14]

In the United States women's rights movements started early and had been on the rise since. However, disturbing findings are still coming in from there, such as the high number of female homicide victims (women killed by their husbands or male partners). According to Gloria Steinem[15], a U.S. Bureau of Justice Statistics Report[16] and the U.S. National Consortium for the Study of Terrorism and Responses to Terrorism[17] more women were killed by their partners between 2011 and 2014 then all the Americans who were killed by 9/11, in Afghanistan and in Iraq. It is the exact same rate (1309 female homicide victims/327 million people in the USA per year) as the rate in Hungary in 2018 (40 female homicide victims/10 million people)[18]! Just when finishing this article, United Nations Secretary-General António Guterres has warned on 6th April 2020 about a sharp rise in domestic violence (in some countries – also in Hungary - the number of women calling support services has doubled) amid global coronavirus lockdowns.[19]

According to UN Women and DESA Gender Snapshot (2019) gender equality is still far on the horizon. Women and girls around the world are 4% more likely than men and boys to live in extreme poverty, and the risk rises to 25% for women aged 25 to 34. Women had a 10% higher risk of experiencing food insecurity than men in 2018. In 2017, nearly 300,000 women died from complications related to pregnancy and childbirth. An estimated 15 million girls compared to 10 million boys of primary-school age are out of school. Women spend three times as many hours than men each day in unpaid care and domestic work. Based on data from 2018, 69 countries, only 19% of countries had a comprehensive system to track budget allocations for gender equality. 1 in 5 women and girls between the ages of 15-49 have reported experiencing physical or sexual violence by an intimate partner within a 12-month period. 49 countries currently have no laws protecting women from domestic violence. 750 million women and girls were married before the age of 18 and at least 200 million women and girls in 30 countries have undergone FGM. Women and girls are responsible for water collection in 80% of households without access to water on premises, according to data from 61 developing countries. Women's representation in national parliaments at 23.7 per cent is still far from parity. Only 57% of women married or in a union freely make their own decisions about sexual

[4] https://nzhistory.govt.nz/politics/womens-suffrage
[5] https://finland.fi/life-society/when-everyone-got-the-vote/
[6] https://forside.kvinfo.dk/404-siden-blev-ikke-fundet
[7] https://kvennasogusafn.is/index.php?page=womens-suffrage
[8] https://www.bl.uk/russian-revolution/articles/women-and-the-russian-revolution
[9] https://blogs.loc.gov/law/2018/11/100-years-of-womens-suffrage-in-germany/
[10] https://www.bl.uk/votes-for-women/articles/womens-suffrage-timeline
[11] https://www.britannica.com/event/Seneca-Falls-Convention
[12] http://ohrh.law.ox.ac.uk/womens-suffrage-in-switzerland/
[13] https://www.bbc.com/news/world-middle-east-35075702
[14] http://www.rubicon.hu/magyar/oldalak/a_nok_parlamenti_valasztojoganak_tortenete_magyarorszagon_1919_1945/
[15] https://www.politifact.com/punditfact/statements/2014/oct/07/gloria-steinem/steinem-more-women-killed-partners-911-deaths-atta/
[16] Bureau of Justice Statistics special report, "Intimate Partner Violence: Attributes of Victimization, 1993-2011," November 2013
[17] The National Consortium for the Study of Terrorism and Responses to Terrorism, "Background Report: 9/11, Ten Years Later," 2011
[18] https://nokjoga.hu/alapinformaciok/statisztikak
[19] https://www.npr.org/sections/coronavirus-live-updates/2020/04/06/827908402/global-lockdowns-resulting-in-horrifying-surge-in-domestic-violence-u-n-warns?utm_campaign=storyshare&utm_source=facebook.com&utm_medium=social&fbclid=IwAR1eFn4yQ-SbfAPR8-qgmpQzbMlnbqfTMKviz6bzx7fmAK83sFfouX1WAO4

relations, contraceptive use and reproductive health care. Women are just 13,8% of agricultural land holders. 3 in 4 human trafficking victims are women and girls. In 18 countries, husbands can legally prevent their wives from working; in 39 countries, daughters and sons do not have equal inheritance rights.

According to WHO[20] "maternal mortality is unacceptably high". Every day in 2017, approximately 810 women died from preventable causes related to pregnancy and childbirth.

According to the largest real-time salary survey[21] in the world in 2019 the median salary for men was roughly 21 % higher than the median salary for women. At current rates, it will take 70 years to close the wage gap according to "Women at Work Trends" survey by the International Labor Organization (ILO) (2016). According to ILO, labor policies are critical because inflexible working hours or limited parental leave forces women into part-time employment which exposes them to further inequalities, such as limited access to social protection (for example to old-age benefits).

According to the World Employment Social Outlook (2016) women are concentrated at the bottom of the global value chain, they have the lowest paid jobs and insecure forms of self-employment whilst often having no access to decent work and social protection.

To be a woman in the EU

According to the EU's gender equality database[22] the following data can be found on women's economic state in the EU: The pay and pension gap remains and doesn't show any signs of narrowing. In 2014 women were still paid 16.7% less and women's pension was 40% lower on average. In 2019 women accounted for 31% of parliament members in EU countries. The number of women in business leadership was low, women accounted for just 27.8% of board members of the largest publicly-listed companies registered in the EU in 2019. According to the same database's supervisory board directors, the causes for the under-representation of women in decision-making processes and positions are multiple and complex. Suggestions were made that the main reasons are traditional gender roles and stereotypes, the lack of support for women and men to balance care responsibilities with work, and the prevalent political and corporate cultures.

To be a woman in post-communist countries

LaFonte (2001) argues that the status of women in post-communist countries is full of contradictions. The gender gap has widened through "declines in women's political representation and increases in women's unemployment and underemployment" however "the proliferation of women's organizations and the growth of women's studies programs suggests a more optimistic outlook for the future."

To be a woman in Hungary

Hungarian women suffer one of the lowest equality rates within Europe and we also have poor positions on other international rankings. According to the World Economic Forum's Global Gender Gap report 2018 Hungary, out of 149 countries, was ranked no.102 with the worst score of all European nations. We only rank 27th on the EU Gender Equality Index 2019, and our slower rate of improvement has led to an increasing gap with the EU over time. On the 2019 Women, Peace, and Security Index, Hungary ranks 49th after countries like the United Arab Emirates, Kazakhstan, Albania.

According to Gregor and Kovats (2018) most Hungarian women feel exhausted because beside their paid work, they do in second and third shifts the unpaid care work (child care, cooking, cleaning, caring for the elderly) as well. They don't have time and energy to question gender biased roles or to realize sexism happening.

[20] https://www.who.int/news-room/fact-sheets/detail/maternal-mortality
[21] https://www.payscale.com/data/gender-pay-gap
[22] http://ec.europa.eu/justice/gender-equality/gender-decision-making/database/business-finance/supervisory-board-board-directors/index_en.htm
https://eur-lex.europa.eu/legal-content/HU/ALL/?uri=CELEX%3A52016DC0739

In Hungary 35 000 girls (before the age of 15) experienced sexual violence. 2 million women (before the age of 75) have experienced psychological abuse in intimate relationships, 800 000 women have experienced physical violence and 300 000 women have experienced sexual violence. 200 000 women are living in physically and/or sexually abusive relationships (Wirth, Winkler, 2015). 87 % of the perpetrators of domestic violence are men (ORF, 2010). Every month at least 3 women is killed mostly by an intimate partner. [23]

Council of Europe Commissioner for Human Rights reported in 2019 human rights violations of women[24] in Hungary: according to the report NGO activities are stigmatized and criminalized; women's representation in politics is "strikingly low". She states that "the focus of the newly adopted family protection action plan lies on women as child bearers, which carries the risk of reinforcing gender stereotypes and instrumentalizing women". The Istanbul Convention has still not been ratified that would support the prevention of violence against women.[25]

Beside political participation, also academic participation rate and the number of women in business leadership is also very low (Forbes, 2019). Women leaders are mostly found in the public sphere, whilst men dominate the private sector. Therefore, there is also a gap in the wages and the career opportunities. Female leaders also less likely live in family than male leaders (Nagy, Sebők, 2018). Wages of mothers are lower, than that of women without children. Reasons for that are to be found in employment discrimination, need for flexible working conditions, and the effect of labor market absence (Pistrui, Fülöp, 2019).

Changing women's status– Sustainable development Goals (SDG5)

UN SDGs have 17 Sustainable Development Goals (SDGs). Gender equality supposed to be integral to these goals, as the following motto suggests: "only by ensuring the rights of women and girls across all the goals will we get to justice and inclusion, economies that work for all, and sustaining our shared environment now and for future generations".[26]

Furthermore 85 experts from think tanks[27] have ranked the SDG's and came up with the result that gender equality is the third most important goal among all the 17 goals.[28]

SDG 5 that is "Achieving gender equality and empower all women and girls" has following targets summoned shortly. [29] 5.1 Ending all forms of discrimination, 5.2 Eliminating all forms of violence, 5.3 Eliminating all harmful practices, 5.4 Recognizing and valuing unpaid care and domestic work, 5.5 Ensuring women's full and effective participation and equal opportunities, 5.6 Ensure universal access to sexual and reproductive health and reproductive rights.

This study aims to show the participation rate of women in sustainability science at the decision-making level. This is the field where, although gender equality is fundamental for success (if we accept UN's axiom that gender equality is necessary for sustainable development) but women still are under-represented and that gap might be even wider at higher levels of academic careers.

2. Methods

In order to analyse the involvement rate of women, I took both qualitative and quantitative data from scientific papers and public data of scientific institutions. I refer to several studies, that show the participation rate of women in decision making and science (Nagy, 2019; Nagy, Sebők, 2018; The European Institute for Gender Equality, The National Strategy for the Promotion of Gender Equality Hungary, 2010; Szabó et. al., 2013; Nagy, 2012; Paksi, Nagy, Király, 2016; Pető, 2018; Pistrui,

[23] https://nokjoga.hu/alapinformaciok/statisztikak
[24] and of asylum seekers and refugees; of human rights defenders and of civil society
[25] https://www.coe.int/en/web/commissioner/-/hungary-should-address-interconnected-human-rights-issues-in-refugee-protection-civil-society-space-independence-of-the-judiciary-and-gender-equality
[26] https://www.unwomen.org/en/news/in-focus/women-and-the-sdgs
[27] such as Brookings Institution, United States Institute of Peace, and Freedom House; government and public institutions including OECD, The World Bank, and USAID; universities like Yale University, University of Michigan, and Barnard College; and foundations and civil society organizations including National Endowment for Democracy, The German Marshall Fund, and Open Societies Foundation
[28] https://www.sdgsinorder.org/
[29] https://www.unwomen.org/en/news/in-focus/women-and-the-sdgs

Fülöp, 2019). Going from general to scientific and sustainability related participation rates, I highlight data collected by EIGE (The European Institute for Gender Equality) from January 2017 and by the European Commission, DG Justice to show the percentage of women in different decision-making positions in sustainability related fields such as environment and climate change at national, European and international level. Going from global to national fields, I also examined women's participation rate in 2019 at most Hungarian academic and other scientific institutions that have sustainability related research fields.

Possible reasons behind the impediment of women in science and especially in Hungary are also shown, grounded by qualitative analyses of several scientific papers (Waring, 2018; Katz, 2008; Ruder, Sanniti, 2019; Spéder 2009; Pongrácz, Molnár, 2011; Blaskó, 2005; Xie, Shauman, 2003; Castaño, Webster, 2011; Mason, Wolfinger, Goulden, 2013; Fábián, 2009; Gregor, Kovats, 2018; Palasik, Papp, 2007; Szikra, 2014; Szívós, Tóth, 2013) that refer to this topic.

3. Results and Discussion

Women and sustainability on the international level

The United Nations Framework Convention on Climate Change (UNFCCC), Bureau of the Conference of Parties (COP) had no female member of the Bureau in 2018. In the EU and national delegations to the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP) female delegates were close to 50 %. In the political positions of the environment related DGs of the European Commission, female members of the cabinet were only 34,6 %. Percentage of female members of the environment related committees in the European Parliament was only 39.1 %.

Next figure shows the percentage of women in sustainability related decision-making positions at international and at EU level[30]:

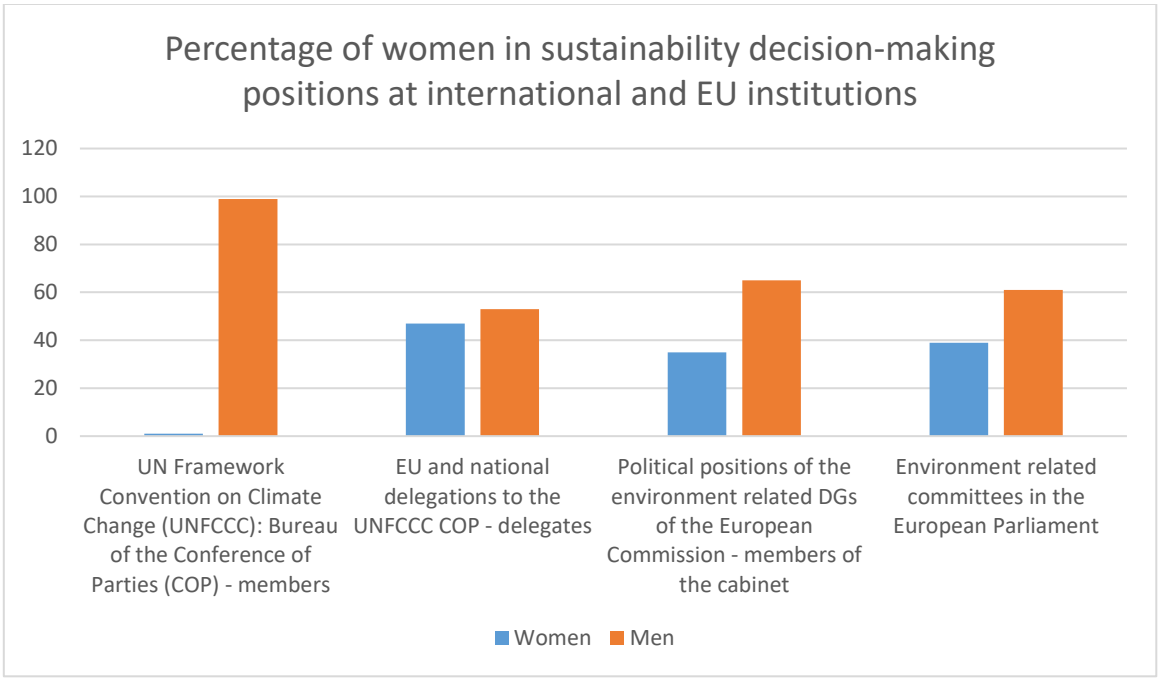

Figure 1: Percentage of women in sustainability decision-making positions at international and at EU level

[30] https://eige.europa.eu/gender-statistics/dgs/browse/wmidm/wmidm_env

Women and science in Hungary

In 2009 strong negative correlation could be seen between per capita expenditures and the rate of women in innovation and research (Szabó et. al., 2013). According to Hungarian National Strategy for the Promotion of Gender Equality (2010) there is a serious horizontal and vertical segregation in science. Women have the lowest positions both financially and preferably and that also both in private and public sector as well as in science. In Hungary women constitute 37 % of doctorates but only 13,7 % of professorates.

According to (Szabó et. al., 2013) only 4 % of full members, 15 % of corresponding members and 16 % of doctors of the Hungarian Academy of Sciences were women in 2009 and these numbers haven't changed much since according to Pető (2018).

80 % of household work is done by women also when they have the higher paying, higher prestige job. Taking care of the children, caregiving of elderly and disabled people is mostly assigned to women as well. Wage gap between women and men was 14,4 % in 2006 and 16,3 % in 2007 and it is hard to find any women in the highest political positions (The National Strategy for the Promotion of Gender Equality, 2010).

Women and sustainability research in Hungary

Following the collected data by EIGE[31] from January 2017 and previously by the European Commission, DG Justice[32] about the percentage of women in different decision-making positions in sustainability related fields such as environment and climate change at national, European and international level, I have found, that among female senior administrators in National ministries dealing with environment and climate change in 2018 Hungary's score (22,2 %) is worse than the EU 28 average (41 %).

I also examined women's participation rate in 2019 at some Hungarian academic and other scientific institutions that have sustainability related research fields.

[31] The European Institute for Gender Equality (EIGE) Gender Statistics Database contains data on the numbers of women and men in key decision-making positions across a number of different life domains in order to provide reliable statistics that can be used to monitor the current situation and trends through time.

[32] https://eige.europa.eu/gender-statistics/dgs/browse/wmidm/wmidm_env

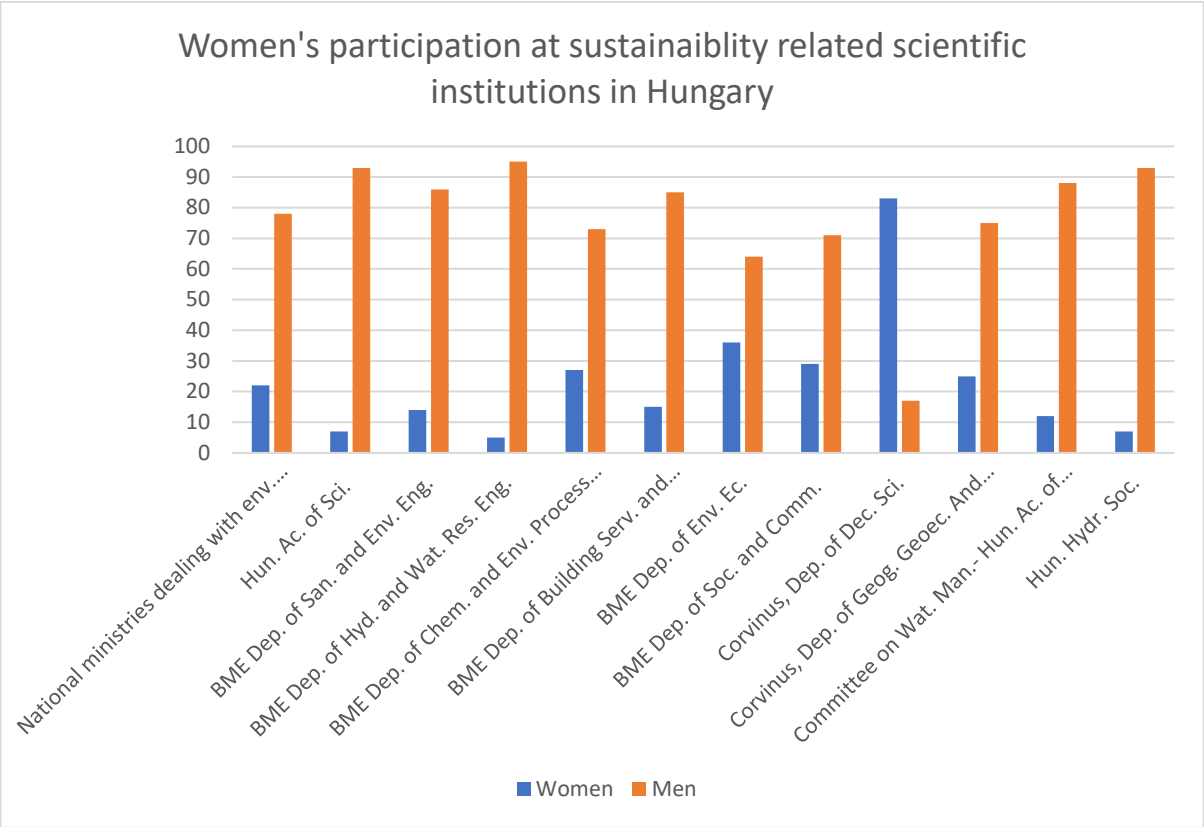

Figure 2: Women's participation rate in 2019 at Hungarian academic and other scientific institutions that have sustainability related research fields

At the Hungarian Academy of Sciences among the 756 members only 55 are women (7,27 %).[33]

At following University departments with sustainability related research and education fields, higher level academic staff (senior lecturers, visiting lecturers, associate professors, professors, professor emeritus) was counted as the gender gap tends to open up after PhD. Budapest University of Technology and Economics (BME) Faculty of Civil Engineering – Department of Sanitary and Environmental Engineering: 19 men, 3 women[34], BME Department of Hydraulic and Water Resources Engineering: 19 men, 1 woman[35]. BME Department of Building Services and Process engineering[36]: 22 men, 4 women, BME Department of Chemical and Environmental Process Engineering[37]: 16 men, 6 women. BME Faculty of Economic and Social Sciences, Department of Environmental Economics: 7 men, 4 women[38], BME Department of Sociology and Communication[39]: 12 men, 5 women. Corvinus University, Department of Decision Sciences[40]: 1 man, 5 women, Department of Geography, of Geoeconomy and Sustainable Development[41]: 12 men, 4 women.

At the Committee on Water Management - Section of Engineering -Hungarian Academy of Sciences among the president and members, there are 15 men and only 2 women. At the Hungarian Hydrological Society, the rate of men and women is following: presidency: president, vice-presidents, secretary (7 men); elected members of the presidency (17 men, 2 women) and other members (3 men) give together 27 men and only 2 women in decision making positions. Also more awards such as the Kvassay Jenő award (2 men, 1 women), the Schafarzik Ferenc award (5 men, 0 women) the Bogdánffy Ödön award (5

[33] https://mta.hu/mta_tagjai
[34] https://vkkt.bme.hu/vkkt/kollegak
[35] https://vit.bme.hu/vit/department-staff?language=en
[36] https://epget.bme.hu/oktatoi_oldal.php
[37] http://kkft.bme.hu/hu/
[38] http://eng.kornygazd.bme.hu/kategoria/munkatarsak/
[39] https://szoc.bme.hu/hu/home-hu-hu/munkat%C3%A1rsak.html
[40] https://www.uni-corvinus.hu/main-page/about-the-university/departments/department-of-decision-sciences/?lang=en
[41] https://www.uni-corvinus.hu/fooldal/egyetemunkrol/tanszekek/geo-tanszek/munkatarsak/

men, 2 women), the Pro Aqua award (15 men, 10 women) and the Vitális Sándor award (1 man, 2 women) were given to men then to women (with the sum of 28 men and 15 women.)[42] Global Water Partnership (GWP) Hungary has among its founders 2 men and 1 woman, at the board of trustees there are 3 men, and 1 woman and at its advisory board there are 5 men and 2 women.[43]

Comparing Figure 1 and Figure 3 it seems, that Hungary is beyond the international and EU level of gender equality in sustainability related decision-making positions and has a high gender inequality rate.

Possible reasons behind socioeconomic impediment of women

Women generally have less time for paid work, as they are expected to do unpaid reproductive labor. Although unpaid childcare is one of the largest economic sectors, not only is it unpaid work, but it also leaves less time for paid scientific work. Women also have to face neurosexism and strong norms based on gender beliefs, such as "a woman's job is to look after the home and the family". These judgements and expectations are further supported and also reinforced by government policies. These topics will be further discussed in this chapter.

Social reproduction for free?

Social reproduction can be defined as, "the broad material social practices and forces associated with sustaining production and social life in all its variations" (Katz, 2008, pp. 18). Social reproduction can mean child care, elderly care, teaching, household work, cooking, cleaning and also water collection. This work is largely unpaid although it is one of the biggest economic sectors, it is naturalized, feminized and racialized[44] (Ruder, Sanniti, 2019).

According to the Report of the UN Secretary-General (2016) women carry out at least two and a half times more unpaid household and care work than men do. Women therefore have less time for paid work whilst their unpaid work "sustains families, supports economies and often fills in for the lack of social services". The report claims that this should be recognized as real work and states that unpaid care and domestic work "is valued to be 10 and 39 per cent of the GDP and can contribute more to the economy than the manufacturing, commerce or transportation sectors".

Unpaid childcare – the biggest economic sector?

The Australian Bureau of Statistics (2006)[45] recorded that the figure for the individual, replacement cost of unpaid labor was 43.5 % of GDP. The housekeeper replacement cost was 41.6 % and the opportunity cost method recorded an equivalent of 57.1 %t of GDP. Economic Nobel prize nominee Waring citates a 2017 Price Waterhouse Cooper research[46] in one of her presentations showing that the largest economic sector in Australia is unpaid childcare, and the second-largest sector is all the rest of the unpaid work. These sectors are bigger then banking, insurance and financial intermediation services. According to Waring (2018) activities with strong gender dimensions were, and still are excluded from UNSNA rules. These are: cleaning, repair of household durables, preparation and serving of meals, care, training and instructions of children, care of sick and inform people, and the transportation of member of the households and their goods. Activities done by men such as moving lawns and cleaning cars can be postponed, but meals and care cannot according to Waring. In the UNSNA documents Waring discovered a system which claimed that primary production and the consumption of their own produce by non-primary producers is of little or no importance. Non-primary producers were described as "inactive" and "unoccupied". According to Waring this means all women's unpaid work in agriculture, orchards, fisheries, vegetable gardens, and preserving, drying and processing this produce.

[42] http://www.hidrologia.hu/mht/index.php?option=com_wrapper&Itemid=39
[43] www.gwpmo.hu
[44] Global Care Chain
[45] https://womensagenda.com.au/latest/women-undertake-72-of-all-unpaid-work-in-australia-the-consequences-are-egregious/
[46] https://www.pwc.com.au/australia-in-transition/publications/understanding-the-unpaid-economy-mar17.pdf

A research on the Australian Time Use Survey of New Mothers[47] showed that having an infant added 24 hours a week to a woman's unpaid workload. Breastfeeding took 17-20 hours per week. The survey also showed that breastfeeding is worth AU$2.1 billion per year but it doesn't "exist" for GDP.

In 1776 Adam Smith wrote in his book (The Wealth of Nations) that "It is not from the benevolence of the butcher, the brewer or the baker that we expect our dinner, but from their regard to their own interest." As they don't do it for profits the driving force of economics must be self-interest. But what about women caring for their children? Is their driving force really only self-interest? Marçal's critique (2016) of the Smith's driving force is based upon Smith forgetting about his mother. He never married, but lived with his mother, having all the carework done by her mother, for free, supposedly because of the single fact that she loved him. Mothers and grandmothers don't do care work out of self-interest. They do it because of the true love they have for their children and grandchildren. Marçal (2016) claims that we need a new economic system, where we make women's work visible, the work that keeps societies and economies together.

Neurosexism

Neurosexism is the acting out of the myth, that men and women have different brains. Undoubtedly there are some biological differences. Most men have bigger brains, but women have a higher proportion of grey matter in most parts of the cerebral cortex, which is consequently slightly thicker and more convoluted. But these differences don't justify talks about "male" and "female" brains in any context. A Nature recension[48] about the book "The Gendered Brain" by cognitive neuroscientist Gina Rippon states that "the hunt for male and female distinctions inside the skull is a lesson in bad research practice". Rippon shows that studies that are revealing differences between "the two brains" are more likely to get published. Rippon also discoverd miscounts, statistical mistakes, misinterpretation of results and missing control groups in these studies.

Based on the existing beliefs about the female brain, a rhetorical question remains: who is more likely to be promoted, if men and women are to apply for the same scientific positions?

Extra reasons behind the impediment of women in Hungary

Strong social norms on women's "place"

There are many theories trying to explain the low representation of women in science. One of these is the life course perspective (Xie, Shauman, 2003; Castaño, Webster, 2011) which states that the ideal period of career establishment usually overlaps with the ideal timing for family formation (Mason, Wolfinger, Goulden, 2013, Paksi, Nagy, Király, 2016). But what is the explanation for the even more male-dominated STEM fields or the extra challenges for Black women or Roma women?

In Hungary, responses to statements like - *A man's role is to earn money, and a woman's job is to look after the home and the family* - still show strong, existing traditional gender roles "whereby the man is the wage earner and the woman takes care of the home" (Nagy, 2012).

Hungarian society is very family-oriented (Pongrácz, Molnár, 2011). According to Paksi, Nagy, Király (2016) the majority of Hungarian people consider family life more important than work, and the majority of women consider having children a vital part of their life (Spéder 2009; Pongrácz,Molnár, 2011). According to Blaskó (2005) the very strong social agreement exists in Hungary that mothers should stay at home until the child turns three - could also have hampered the reconciliation of work and childbirth for women. However in many cases it's not just the belief system that is pushing women. Our social system doesn't support fathers staying at home. Also, in most cases, although women would like to stay home, they must go back to their mostly low-paid jobs in order to feed their family.

Backlash against women's emancipation, re-familization (Nagy, 2009); and also, gender segregation of the labor market and traditional gender attitudes (Blaskó, 2005) limit the opportunities for women. But structural changes of the 1990s have also

[47] https://womensagenda.com.au/latest/women-undertake-72-of-all-unpaid-work-in-australia-the-consequences-are-egregious/
[48] https://www.nature.com/articles/d41586-019-00677-x?fbclid=IwAR3s2KM-yemZkJy6wCGxAqsRuTUU75c-yH49aOoDXQe19KY0IR3Te3arfbA

limited demand for women in research and development particularly in engineering (Palasik, Papp, 2007) that had led to an under-representation of women in the fields of engineering. In the post state-socialist era of Hungary, women experience contradicting social norms in relation to the ideal timing of motherhood and also a strong social expectation of the long-term maternity leave (Paksi, Nagy, Király, 2016). These together are heavy burdens for female researchers.

Political reinforcement of gender stereotypes

In 1998 a centrist-conservative party replaced the socialist party in Hungary. According to Fábián (2009) this rather nationalist party could defeat the socialist party partly by gaining support from middle-class and professional women. The party promised maternity benefits and family allowance and really did reinstate financial support schemes for families. However, neither stakeholders of ethnicity groups nor women's groups were involved in the process of these policy changes.

The Council of Europe Commissioner for Human Rights also stated in her 2019 report on Hungary: "the focus of the newly adopted family protection action plan lies on women as child bearers, which carries the risk of reinforcing gender stereotypes and instrumentalizing women".[49] If we take a look at Hungary's scores at international rankings of gender equality, or at the political and academic participation rate of women, as well as at the rate of women in business leadership roles then the Commissioner's term "strikingly low" may be the right term to use for Hungarian women's relevance in Hungarian decision-making today.

Gregor and Kovats (2018) found out that Hungarian women not even question their classical gender biased roles as they don't have time for that. Gender myths are deeply rooted in Hungarian society. It is very difficult (in some cases even dangerous) to challenge them. Women in Hungary do much more unpaid work, then men do (Gregor, Kovats, 2018), although besides giving birth and breastfeeding there are no other tasks a men would not be able to handle. According to Gregor, and Kovats (2018) professionally only those women have a chance to prevail, who don't have care work, or who have a support chain of relatives, or who can afford to pay babysitters or other care takers (mostly from economically more vulnerable women).

It does not help that for men the current patriarchal belief system is very convenient: the social norm allows them not to do unpaid work, therefore they have more time for building their careers, to have hobbies, to rest.

Family policy

The Hungarian conservative government spends a lot on family policy but these spendings support the higher income families. The Orbán government is highlighting the importance of the restoration of 'traditional family values' and is fighting "against gender equality and homosexual relationships" (Szikra, 2014). They have introduced a generous tax-credit system, providing increased financial support for higher income families. They have expanded the income of these better-off families and have shrinked the protection of poor families. "Families with one or two children have gained 7 percent of the average salary per child per month in 2012, while larger families can keep 23 percent of the average salary per child." The remarkable financial resources through tax credits have been provided despite the crisis and the general cutback in social spending (Szikra, 2014).

However according to Szikra (2014) providing increasing resources to better-off families did not lead to the growth of birth rates (as expected) but right to the contrary, the total number of childbirths has been significantly lower than it was under the socialist government (HCSO, 2013). According to Szívós and Tóth (2013) the new system of higher income family supports together with the decreased unemployment benefits, has "contributed largely to the polarization of society and an increase in poverty".

Some practices to consider

[49] https://www.coe.int/en/web/commissioner/-/hungary-should-address-interconnected-human-rights-issues-in-refugee-protection-civil-society-space-independence-of-the-judiciary-and-gender-equality

In this chapter theoretical and practical ways will be shown that can help to achieve a more just and sustainable world. These are just a few examples, that could be applied in order to get closer to gender equality and sustainability but beyond these, many other concepts might also exist.

Gender mainstreaming and gender sensitive budgeting

According to the ILO's World Employment Social Outlook, Trends (2016) "if women played an identical role in labor markets to that of men, as much as US$28 trillion, or 26 %, could be added to the global annual GDP by 2025." But to use this potential we need "good-quality paid work, gender-sensitive policies and regulations, such as adequate parental leave and flexible hours."

A broader concept to help this process would be gender mainstreaming. "Gender mainstreaming is the (re)organization, improvement, development and evaluation of policy processes, so that a gender equality perspective is incorporated in all policies at all levels and all stages, by the actors normally involved in policy making" (Council of Europe 1998).

Gender responsive budgeting (GRB) is a tool, that addresses gender gaps in economic policies and aims to incorporate unpaid care work into economic policy analysis. Budgets need to reflect on gender inequalities, for instance on the ways female and male work force spend their time. GRB can be used as a gender- responsive or gender sensitive tool and therefore is applicable for gender mainstreaming.

In 1995 at the UN World Conference on Women in Beijing 189 countries committed themselves to implement GRB. The UN Convention on the Elimination of All Forms of Discrimination against Women (CEDAW)[50] obliges governments to avoid discrimination against women by means of budgetary provisions. Furthermore in 1995 EU member states also committed themselves to the principle of gender mainstreaming[51]. In 1999, the European Commission adopted GRB as an important instrument for gender mainstreaming. In 2003 it started to develop an action strategy for the introduction of GRB (Schratzenstaller, 2008). GRB consists of two steps according to Schratzenstaller (2008). The first step is the analysis of gender-disaggregated effects of public revenues and expenditures. The second step is that based on the results it aims to modify budget structures and processes in order to foster gender equality.

Although GRB seems promising, some scientists have their doubts about it. I think, that the main problem is, that it won't change the belief systems that sustain gender inequalities but on the contrary it might even mask the real problem.

Research Programs

Discrimination is not just socially harmful, non-ethical and non-humanist. It is also economically harmful to those who perpetrate it and a non-discrimatory market would always be more efficient according to Milton Friedman's student Gary Becker (1957). Becker also stated that this was also true for the state of women and that the employment of women was economically beneficial. Between the 70'- 90's big companies saw that likewise. McKinsey started to put women on board and Ford spent millions of dollars on grants for research done by women at top universities. Ford also helped to launch high quality feminist journals, found research centers and initiated conferences (Watkins, 2018). Up to now we have much less feminist courses and journals in Europe, than there are in the USA and that is certainly a field that needs change.

One of the European good examples is the REinforcing Women In REsearch (REWIRE) COFUND Program[52] which is funded by the European Commission with the goal "to establish a support scheme for excellent postdoctoral female researchers to foster their scientific development, to nurture their expertise and to make a profound impact on their future careers. The Program aims to address statistics published in the European Commission's "She Figures 2015" which clearly demonstrate that women are under-represented in academic careers."

[50] adopted in 1979 by the UN General Assembly
[51] codified in 1997 in the Treaty of Amsterdam
[52] https://rewire.univie.ac.at/

According to Eige[53] there are some good initiatives in Hungary as well, such as the projects of the Association of Hungarian Women of Science[54] and some others[55] as well. Hungary also has a National Research-development and Innovation Strategy[56] (2013-2020) aiming "to create equal opportunities for women in the Research & Development & Innovation professional field, for instance, when managers are appointed". And Hungary has a National Strategy for the Promotion of Gender Equality[57] in which the Guidelines and Objectives 2010-2021 (1004/2010 I.21) has a two-bullet point section on women in science. "Gender issues as a subject of research should be a priority in all the research, development and innovation projects financed by EU resources and gender attitude and methodology should be included in applied research methods. When application schemes are invited and assessed, special attention should be given to the gender aspect". "Eliminate the obstacles hindering women's promotion in their scientific career and their participation in research grant applications." The percentage of women in leadership positions should reach at least 40 % by 2021 according to the strategy. A 2 years action plan has been adopted for the implementation. It stated that "the equal participation of women in science should be promoted by research on gender equality and by putting these issues in common discourses (awards, public events)".

However, the new government has been neglecting[58] the gender equality strategy and the plan as well. Furthermore, despite the smaller initiatives the numbers haven't got much better neither.

Quota systems

For example the Austrian University Act contains a number of laws pertaining to gender equality in universities. It covers all Austrian public universities and defines gender equality as a guiding principle but also as a task. The universities and the Ministry for Higher Education have to include measures to increase the number of women in leadership positions, as well as targeted support for female junior academics. Universities have to have plans for the advancement of women, and create administrative units for coordinating activities towards gender equality, women's advancement and gender research. They have to have a Working Group for Equal Treatment tasked with combating discrimination based on gender, as well as on ethnicity, religion, age or sexual orientation. In 2015 the women quota was raised to 50% for collegial bodies.[59]

Rethinking economics

We may consider the rethinking and redesigning the growth driven and male dominated mainstream economic system. The 2020 new pandemic corona virus shows us how fragile our economic and health care systems are: how much we undervalue our interconnectedness, how the poor had become poorer in the last years and now will probably become even poorer in the new economic crises caused by the virus and by our arrogant systems.

This arrogant, patriarchal capitalist economic system might be the main reason behind the domination over women and nature.[60] "North and South, East and West, the flexible, do-it-yourself, cooperative economy of women is daily subsumed by private and public spheres alike; just as the degraded 'resource base' of nature silently absorbs the longer-term costs of what is called 'development'" (Salleh, 1998).

[53] https://eige.europa.eu/gender-mainstreaming/toolkits/gear/legislative-policy-backgrounds/hungary
[54] http://nokatud.hu/rolunk/
[55] "The Hungarian Academy of Sciences introduced in 2009 that an age limit for its grants and fellowships which defined that female researchers who have a child under 10 years old and male researchers who have been on parental leave can receive an extension of two years by child to complete their research. Three universities in Hungary use sex-disaggregated data available from their HR Departments to assess the gender equality situation. The Central European University created a policy on gender equity at academic events and summer schools in 2012. The Girls' Day, organized by the Association of Hungarian Women in Science took place in Hungary for the first time in 2012. In this program, companies have open days for high school girls who can get a glimpse into the work of universities and companies in the field of technology and natural sciences. NaTE also gives an award called „Kiválóság Díj" (Excellence Award), since 2013. The Prize has a special section for a female Romani researcher. Seadrop Prize (Tengercsepp Díj) is given at the Faculty of Natural Sciences at the Eszterházy Károly College (in Eger) since 2010 to female scientists."
[56] https://stip.oecd.org/stip/policy-initiatives/2017%2Fdata%2FpolicyInitiatives%2F5513
[57] https://ec.europa.eu/migrant-integration/index.cfm?action=media.download&uuid=2A00B5EB-00E8-5ABD-610BA6798F7A21FE
[58] https://nokjoga.hu/segitoknek-donteshozoknak/jogalkotasra-vonatkozo-javaslataink
[59] https://eige.europa.eu/gender-mainstreaming/toolkits/gear/legislative-policy-backgrounds/austria
[60] However, this domination is not the evidence of women's closeness to nature (essentialism) but of their struggle for resources, as women simply have limited opportunities.

The nature of this domination is the very idea that “the economic men” can be independent, he can be free of caring, he can do it all on his own. This very naivety leads to serious consequences and this starts to show in the consequences of the pandemic, in the consequences of crossing planetary boundaries, in the consequences of climate change. “The economic men” might have to start taking responsibility.

Exploitation of environmental resources is analog to the exploitation of reproductive services provided by women. This analogy is easy to detect but for society to realize it and to stop it, seems to be more difficult.

4. Conclusions

The paper focused on the status of women and looked at sustainability science to show how many women have decision-making positions in helping to establish a more sustainable economic system.

The status of women is still horrifying and findings suggest that women are only involved in an insignificant number in the discussion on sustainability.

Comparing Figure 1 and Figure 3 we see, that Hungary is far beyond the international and EU level of gender equality in sustainability related decision-making positions. The Hungarian National Strategy for the Promotion of Gender Equality had been ignored by the new conservative government. The existing few Hungarian initiatives for promoting women in science alone seem not to be able to bring any serious structural change. According to Eige in Hungary “until October 2015, no gender equality plans have been set up in public research institutions”. There is still a serious horizontal and vertical segregation in science: women have the lowest positions financially, also both in private and public sector as well as in science. In Hungary women constitute 37 % of doctorates but only 13,7 % of professoriates and in 2020 at the Hungarian Academy of Sciences among the 756 members only 55 are women (7,27 %).

The Hungarian system of higher income family supports did not lead to the growth of birth rates as expected, but together with the decreased unemployment benefits they have contributed largely to the polarization of society and an increase in poverty. Also, as the Council of Europe Commissioner for Human Rights pointed out, the risk of reinforcing gender stereotypes and instrumentalizing women has risen in Hungary.

There is a clear need in Hungary to rethink gender equality and family policy, and also to ratify the Istanbul Convention.

According to UN statements without involving women, sustainable development goals can’t be achieved. This also means that a more sustainable environmental-economic-social system remains just an idea that won’t become reality unless patriarchal values cease to dominate. The question remains: how can we ensure gender equality and provide sustainable development, when the economic system keeps exploiting natural resources, as well as women.

UN Secretary-General António Guterres had summarized the situation by saying: “achieving gender equality and empowering women and girls is the unfinished business of our time, and the greatest human rights challenge in our world.”

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Would You Ride with Me?

Discrimination in Shared Mobility Platforms. Results of a Pilot Study

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Abstract
The number of sharing economy platforms are rapidly growing worldwide, especially peer-to-peer (P2P) online marketplaces operating in the travel and tourism industry. We focus our attention on a Hungarian ridesharing platform in order to understand the working mechanisms of discriminative selection by service providers against service users of various minorities, as the literature in this area, especially in Hungary, is limited. In our ongoing experimental research, we are collaborating with the most widely-used ridesharing platform in Hungary, carrying out an intervention-type research in 2020 to test whether multiple experimental stimuli have any effect on drivers' behaviour towards various minorities. In this paper, the basis of a conference presentation, we are going to discuss (i) the research design (ii) the collaboration between the platform and our research team, as well as (iii) the empirical results of our pilot study.

Keywords: shared mobility, discrimination, controlled field experiment, Hungary

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1. Introduction

Creating social links and building trust have crucial roles in the collaborative consumption platforms. Trust has received much attention in different disciplines of social science focusing on the role of trust in a new era of undergoing radical transformation by emerging digital technologies changing every facet of our everyday lives. Rachel Botsman defines trust as "a confident relationship with the unknown" in her influential book entitled *Who Can You Trust* (2017). In that book the author differentiates between various types of trust, and includes a glossary on trust terms in order to specify and distinguish among distributed, institutional, and local trust, as well as to define trust deficit, trust signals, and trust shift (for further detail see Botsman, 2017).

Trust has a massive sociological literature with many possible categorisations. According to Sztompka (1999), trust can be seen as a gradually extending circle. Sztompka considers trust as a necessary response in the face of unknown future circumstances and outcomes. Online sharing economies, which have a certain level of anonymity and leave room for deceit, create such unknown circumstances. Trust is identified on three levels; (1) the *individual* level, or as a personality trait, (2) at the *level of interactions*, as in the quality of a specific relationship, and (3) at a *cultural* level. These types of trust (personal, interpersonal and social) are embedded in a cultural context which can be interpreted as an obligation or rule of trusting. Putnam (2000) uses a different approach as he distinguishes two types of trust: *thin* and *thick* trust. While the latter is associated with local communities, embedded in frequent social relations, thin trust is also based on expectations of reciprocity but are capable of "extending the radius of trust beyond the roster of people whom we can know personally" (Putnam 2000:159).

Some sharing platforms, especially the ones that are labelled with the term “peer-to-peer”, such as ridesharing platforms, are providers of risky, “high-stakes” offline experiences, thus making trust between users a crucial resource. Digital (or online) trust is a required and essential resource for sharing platforms. In online interactions, trust has to be approached differently, as the level of trustworthiness is not known (Chen and Fadlalla, 2009. 87.). Because of this anonymity, there is hardly any trust when there is no available information about someone you will share an offline experience with (Cui et al., 2017). Privacy concerns are a highly relevant subject in the discussion about trust and the personal information of consumers (Chen and Fadlalla, 2009, 85). Thus, collaborative consumption platforms create a unique form of social capital that relies on positive and negative exchanges (Codagnone et al., 2016). The “visual-based trust” in online transactions (Ert et al., 2016), demographic information in order to gain trust (Cui et al., 2017), and prior experiences of others (rating system for ridesharing platforms) need to be taken into account in order to analyse the characteristics of the collaborative consumption platforms.

As various collaborative consumption platforms grow very fast worldwide, the model they provide develops in a hectic manner. The blurring of distinctions between public and private, as well as the information asymmetry, both raise concerns. The blurring of distinctions entails mainly regulation concerns, whereas the information asymmetry might also lead to moral hazards, according to Cohen and Sundararajan (2015). Moral hazards include risks such as receiving less careful service (e.g. less careful driver), lower levels of effort made by the service provider (e.g. dirty car seats) compared to services provided by the regular economy (e.g. ridesharing vs. regular train services).

Ridesharing platforms can be understood as social markets involving one-off, face-to-face interactions in informal settings. In many cases service providers have to share their narrow personal spaces (practically their cars) with foreigners. Analysing these kinds of social markets enables us to explore more diverse everyday interactions, where various minorities may face unequal treatment (Tjaden et al., 2017). As opposed to classic business models (i.e. public transport companies in the field of transportation), in the case of shared mobility platforms the individual service providers (the drivers) themselves are in charge of deciding whether to accept a request from a potential passenger. There is more and more research evidence that passengers of various racial and ethic minorities are significantly more frequently rejected by the service providers (Edelman and Luca, 2014; Edelman et al., 2016; Ge et al., 2016; Simonovits et al., 2018). On the other hand, drivers belonging to various ethnic and national minorities are also discriminated against, paying a discriminatory price premium of about 32% of the average market price in Germany (Tjaden et al., 2017).

In Hungary, discrimination based on ethnicity is likely to occur everyday. Since 2006 several field experiments have been carried out in Hungary, mostly to explore the mechanisms of discrimination in the labour market against various vulnerable social groups, i.e. the Roma, overweight people, and people with disabilities (Pálosi et al., 2007; Sik and Simonovits, 2008). Most recently, we conducted a small scale experimental study in 2017 testing racial and ethnic discrimination on one of the most popular ridesharing platforms (BlaBlaCar) also operating in Hungary. The findings of the field experiment were in line with the previous research results: racial and ethnic background both serve as a basis for discrimination on online platforms, especially in the case of male passengers (Simonovits et al., 2018).

Experimental context: The Hungarian platform our research team co-operates with was established in 2007 by two university students whose primary goal was to create a sustainable and environment friendly transportation solution for medium and long distance travellers in Hungary. As of January, 2020 they have five full time employees and 700 thousand—mostly Hungarian—users. In the past 10 years they administered all together 3.2 million rides, out of which 200 thousand (6.25% of

the total rides)1 potential passengers were rejected by the drivers, who gave various reasons for their decisions such as “the passenger doesn’t seem to be likable”, or “the passenger is not available”, or “the driver is no longer travelling.”

With our research we are aiming to find out how the above mentioned 6.2% refusal rate changes by groups of passengers belonging to different minority groups after a subset of drivers were exposed to stimuli designed to reduce discriminatory behaviour. Our stimuli will take the form of animated spots that were designed in a collaborative effort of the researchers, leaders of the ridesharing platform and specialists contracted from an advertising agency[2]. Specifically, we designed a pair of spots with the goal of reducing prejudice against the Roma minority and disabled people. The spots were intended to trigger a feeling of compassion with these groups as well as maintaining tolerance as a key value of the partner organization.

Research goals: As in Hungary, the Roma is the largest ethnic minority (making up approx. 6-8 % of the total population), and discrimination against them is widespread (FRA 2018). Our primary goal is to test drivers’ reactions to requests coming from passengers of Roma origin. Beyond Roma ethnicity, we also intend to test the effect of potential riders’ physical (dis)ability on drivers’ behaviour.

Based on previous research evidence (Gneezy et al., 2012), we assume that different types of stereotypes and selection mechanisms work with regard to *ethnicity* on the one hand, and *physical disability* on the other. Gneezy and his colleagues suggest that physical disabilities which are perceived to be outside of the control of the individual, —such as blindness or having to use a wheelchair—are more likely to elicit pity and help from others. Our question is how these types of experimental stimuli work and interact with each other.

Furthermore, we also aim to explore which type of discriminatory models (statistical vs. taste-based) can be better applied to the working mechanisms of shared mobility platforms), partly based on the research design worked out by Cui and her colleagues in 2017 in the US context. The 2*2 experimental design offered by Cui et al. (2017) will serve as a basis for establishing causality between the type of information available for the potential rider (highly positive review vs. average review) and the potentially discriminatory behaviour of the potential driver (who is a private service provider). In other words, with the randomized experimental setup we will be able to answer our core research question: Is there a direct link between gathered information and discrimination by the users (supporting the idea of statistical discrimination)? Or the other way around: Does discrimination still persist, even if there are positive reviews provided on the riders (supporting the idea of taste-based discrimination)?

The structure of the paper is as follows: The section on our methods is the most extended part of the paper, consisting of various subsections of the pilot studies, hypotheses, and the implementation plan, while the section on Results and Conclusions are relatively short, as our research has been suspended due to the 2020 COVID-19 crisis affecting Europe.

2. Methods

[1] Source: online correspondence with Attila Prácser, co-founder and managing director of oszkar.com (Spring 2019).

[2] Amongst others we are grateful for the commitment and continuous help of Prácser Attila, founder of Oszkár.com, Péter Lerner, graphic design BA student at MOME university, and for the staff of the market Research Agency for administering the tests and helping us in the development of the research design as well. Last but not least for the volunteers let us use their photos to create the basic pool for Roma and Non-Roma faces of the experiment.

Two types of pilot studies were implemented in autumn 2019. On the one hand, we carried out online survey experiments (in two rounds) to enable us to select distinctively Roma and non-Roma photos for the online experiment. On the other hand, we conducted two waves of pilot field experiments, based on small sample sizes, to test our initial hypotheses (with altered stimuli), and to try out the experimental situations in the online field.

The development of the research design has been a joint project by our research group, graphic and visual designers, and the platform itself. First we will discuss the method of the online survey experiment (2.1), followed by a discussion of the pilot field experiment method (2.2), and then formulate our research hypotheses (2.3). Finally, we will show our plan of how to implement the field research (2.4).

2.1. Online survey experiments

As ethnic origin, one of the key stimuli of our experiment, was cued by the testers' profile photos and specific Roma and non-Roma names, we needed to pre-test the photos. The basic pool of photos was collected from volunteers of diverse groups of university students, representatives and staff members of Roma NGOs, and from the network of our research group. Additionally, an ad was also posted in various Facebook groups to search for volunteers in summer 2019. As a result of our multiple recruitment efforts we managed to collect dozens of photos, but mostly non-Roma ones. After many iterations we decided to follow the following strategy: our points of departure were photos of non-Roma individuals which were edited, altered, and adjusted to our research purpose in close cooperation with a graphic designer and our research team. As we treated the subjects of the basic photos anonymously—in line with the standards and requirements of the Ethical Permission gained from Eötvös Loránd University, Budapest, Faculty of Education and Psychology in 2019 (No: 2019/35 ELTE PPK)—we do not show these photos in the current paper.

The online surveys were carried out in two rounds to enable us to select distinctively Roma and non-Roma photos for the online experiment. The first round was launched in September 2019 (N=160) and the second round was launched in November 2019 (N=250). The sampling process was based on a convenience sampling, using various channels, e.g. Facebook groups, university students, and our research team's personal and professional networks.

The structure of these surveys was as follows: subjects were shown a series of 8 or 9 photos, and after seeing each of them they were asked to rate the person appearing on the photos in terms of age, ethnicity, social class, education, country of origin, and living in urban vs. rural environment. Then, a series of demographic questions were asked of each of the respondents. Importantly, each respondent was assigned either the Roma or the non-Roma version of the same photo, so that we could compare how our manipulations shaped perceptions on each of the characteristics mentioned above.

Beyond the online survey, our research team evaluated the selected photos with qualitative research techniques as well, i.e. we asked feedback on the photos from Psychology and Political Science MA students in our classes, and discussed the photos in our extended research group meetings with our colleagues and graphic experts. As the result of lessons learned from previous field experiments (Simonovits et al., 2018.) and group discussion with our students, we further standardised the photos in terms of paying strong attention to re-making the background of the photos to be as similar as possible. In other words, we tried to realise similar and natural settings (e.g. wall, garden etc.) as backgrounds for all photos to be used in the experiment.

To sum up, our aim was to develop distinctively Roma and non-Roma face pairs. This was achieved in an iterative process in which both the skin tone and facial features were altered to make the respective versions of the photos ostensibly Roma-

looking. Of course there is no exact way to achieve this, so our strategy relied on the intuition of the graphic designer and the research team – and thus, pilot surveys assessing our strategy seemed necessary.

2.2. Pilot field-experiments

The pilot field-experiments were implemented in two rounds on the ridesharing platform (N=90 and N=101, respectively), between which we discussed the preliminary findings, and re-adjusted the stimuli in terms of social status and review scores. (The number of cases and the main features of the profiles are summarised in Table 1.)

The experimental variables we tested in the pilot phases were the following:

- ethnic origin (Roma vs. non-Roma)
- physical disability (disabled vs. non-disabled)
- review scores (high vs. low)
- socio-economic status (medium vs. low status)

As far as control variables are concerned, gender was kept constant, since previous empirical findings from Hungary have shown that the primary target of discrimination on ridesharing platforms are males of minority ethnic origin (Simonovits et al., 2018.), and also because we did not want to include too many experimental variables in our design. Age was also kept as a control variable, as the primary target group and primary users of the analysed platform are younger generations according to the platform's founder.

We completed two pilot test series, with 90-100 cases of each.3 The main features of the experimental designs of the two pilot studies are summarized in Table 1.

Table 1: The main features of the profiles in the pilot experiments (August-December, 2019)

	Roma		non-Roma	
Main features	non-disabled (P1)	disabled (P2)	non-disabled (P3)	disabled (P4)
Pilot 1: August-September 2019 (N=90)				
N (number of tests)	21	24	21	24
Name (profile name)	Kevin GÁSPÁR Gazsi_94	Richárd KOLOMPÁR K.Richi92	Péter MOLNÁR Molnarpeti95	Máté VARGA vargamat_91
Age (in bio)	25	27	24	28
Profession (in bio)	receptionist	administrator at the post	porter	telephone dispatcher
Review score	4.8	4.8	4.8	4.8
Pilot 2: December 2019 (N=101)				

[3] Due to a misunderstanding between our research group and the market research company more tests were carried out by the Roma disabled profile than originally planned.

N (number of tests)	25	31	24	21
Name (profile name)	Kevin GÁSPÁR gazsikevin_94	Richárd KOLOMPÁR ricsi_kolompar92	Péter MOLNÁR Molnarpeti95	Máté VARGA vargamat_91
Age (in bio)	25	27	24	28
Profession (in bio)	stock clerk	factory machine operator	electrician	Semi-skilled worker
Review score	4.2	4.2	4.2	4.2

Age, hobbies (such as 'I like to travel and listen to music'), and professions indicating labour market status were all incorporated into the potential riders' bios. Whereas in Pilot 1 requests were written in proper Hungarian, in Pilot 2 requests included grammatical and stylistic mistakes and typos—aiming at further emphasizing differences in socio-economic status.

While ethnic origin was visualized by photos and confirmed by typical Roma and non-Roma names, testers with disabilities mentioned that they are wheelchair users, and will ask for extra space in the car, but not for extra help from the driver. The non-disabled group asked for extra room for extra luggage in order to keep the requested favour under control. (See examples for requests in the Appendix)

To select appropriate Roma and non-Roma names, we used multiple sources. In line with previous landmark experimental research (Bertrand and Mullainathan, 2004), our primary aim was to identify distinctive Roma and non-Roma names. Based on previous results of Hungarian surveys (e.g. HLCS, see Simonovits and Kézdi, 2016; Váradi, 2012) and experimental research completed in the Hungarian field (Sik and Simonovits, 2008), we carefully[4] selected distinctively Roma and non-Roma names (both family and first names)[5] for our testers (presented in Table 1.)

2.3 Hypotheses

Below we formulate our hypotheses, based on previous research results and our pilot experiments.

- H1: Ethnic discrimination: We predicted that requests from individuals with ostensibly Roma sounding names would be less likely to be accepted by the drivers, and the tone of communication will be less friendly.
- H2: Discrimination based on disability: We predicted that requests from individuals who signalled that they are in a wheelchair would be less likely to be accepted by the drivers, and the tone of communication will be less friendly.
- H3: Statistical discrimination: We assumed that the main reason for drivers discriminating against riders is statistical (as opposed to being tasted based), i.e. discrimination would be less likely if there are positive reviews on the riders.
- H4: Impact of general persuasive appeals: We predicted that service providers (drivers) exposed to persuasive appeals in the form of online ads emphasizing the importance of inclusion would reduce their discriminatory behaviour.

[4] E.g. we excluded names that might remind experimental subjects of a famous Hungarian person or celebrities
[5] As opposed to the relevant US research tradition (most of which took the work of Bertrand and Mullainathan 2004 as a starting point), we not only used first names to express Roma identity, but also family names, as many Roma people living in Hungary have distinctive Roma names.

- H5: Impact of targeted persuasive appeals: We predicted that service providers (drivers) exposed to persuasive appeals in the form of online ads emphasizing the importance of inclusion of a particular outgroup – i.e. Roma or disabled – would further reduce their discriminatory behaviour towards that outgroup.

2.4. Implementation of the research

As described above, ethnic origin will be visualized by photos (chosen via the above mentioned two waves of online survey in 2019, total N=410), and confirmed by typical Roma and non-Roma names. With high (4.8 out of 5) and medium review score (4.5 out of 5)[6] we aim to test whether it is statistical (due to information asymmetry) or taste-based discrimination (i.e. drivers' prejudices towards Roma passengers) that is most widespread in this field.

The field-experiment is going to be implemented in one wave, based on a within-subject design, a few weeks after the intervention is introduced to the drivers (cf. Fang et al., 2019). Originally, we planned to launch the intervention in March 2020 followed by the large scale tests from April 2020. Unfortunately, as a side effect of the COVID-19 crisis and quarantine interventions of the Hungarian government there are not enough driver-passenger interactions to start our research (as of 7 April, 2020 the total traffic administered by Oszkár dropped to 5% of their regular traffic, based on online correspondence with the platform's founder); hence we postponed the implementation phase to late summer or autumn 2020.

The intervention: this will be based on two different versions of a 20-second-long animated video spots covering the topic of inclusivity closely connected to the general values of the platform, splitting the sample into three subsamples: one third of drivers will receive the specific Roma content, one third of them the specific wheelchair content in terms of inclusivity and tolerance —which are core values at Oszkar.com. The drivers will be "forced" to watch these ads, as the content will be embedded into the platform in a way so as to not let the driver move forward to his or her account. The rest of the drivers, serving as a control group of our experiment, will not receive any content from us. As of April 2020, the spots are under development by an expert team of visual artists in close cooperation with the platform to ensure that both the content and the visuals are in line with the platform's communication style. We plan to send these spots to the drivers in late summer, as by that time the easing of the COVID-19 related interventions will hopefully enable us to re-launch the field-experiment. The most challenging element of the preparation of the animated spot was to find a proper (but not too stereotypical) Roma character. This problem, obviously, did not emerge in case of the disabled character, as we simply had to use a wheelchair. Beyond the specific characters, non PC jokes made by the drivers might also to be used in the spots, saying such as "cripples need not apply" and "your skin tone is not the result of a recent sunbath" using as excuses for not taking on the disabled and Roma characters, respectively. (For more details, see a preliminary version of the storyline in the Appendix.)

Outcome: The reaction of the drivers will be categorized as positive, negative, or no-response. We expect significant differences of outcome by profiles in terms of ethnicity and review score. Beyond quantitative measures, we are also going to apply qualitative content analysis in order to be able to analyse the tone of the communication.

[6] Based on statistics gathered by the platform the average scores of reviews are 4.74, and only 10% of the reviews are below 4.25, that is why we set medium scores as 4.5.

3. Results and Discussion

In line with the structure presented above, Section 3 is organised as follows. First we show the results of the online survey experiments (3.1.), followed by the evaluation of the results of the pilot field experiments (3.2).

3.1 Results of the online survey experiments

As described above, we deployed two survey experiments conducted on convenience samples to verify the validity of our manipulations to be used later on. In particular, we sought to test whether the manipulation of photos in order to cue ethnic identity was indeed successful. To that end, we fielded a pair of short surveys on Facebook and asked our respondents to rate a series of photographs on a variety of dimensions. We wanted to assess whether faces appearing on the "Roma versions" of the same photos were indeed perceived as more likely to be of Roma ethnicity.

In the first study, we found important heterogeneity in the effectiveness of our manipulations. Photos apparently have differed both in terms of baseline perceptions of "Romaness" as well as the impact of the editing on these perceptions. Based on these results, we made use of further edits on the photos and narrowed down our selection of the individuals appearing on the photos. In the second study, we repeated the same procedure with the update pair of photos. That second study provided a sufficient corroboration of our manipulation: for the final selection of pairs of photos, baseline perception of Roma ethnicity was low across the board. Moreover, the edited versions of the photos were perceived as likely to be depicting people of Roma origin.

Table 2 reports the main findings from this pilot study. In particular, we report the percentage of subjects who rated each version of each photo as "likely Roma" or "definitely Roma".

Table 2: The proportion of subjects who rated each version of each photo as "likely Roma" or "definitely Roma (December 2019), in percentage (N=250)

ID of the selected photos from the first round	P1	P2	P3	P4	P5	P6	P7	P8
Non-Roma	4	2	0	1	0	2	0	0
Roma	65	48	33	38	39	41	49	50

Note: Red colours label the photos selected for the large scale field experiment.

The results show that the manipulations were successful: people in the selected photos were indeed perceived as Roma by the majority of subjects in our convenience sample. Moreover, people in the un-edited versions of the photos were not perceived as such. It is important to note here that neither in the pilot study, nor in our final experiment will we be able to perfectly manipulate the way subjects perceive our testers. Thus, any differences we find between experimental groups is likely to understate the two causal effects of ethnic origins.

3.1. Results of the pilot field experiments

Two pilot studies were carried out to test the various experimental stimuli and the texts applied in the requests, as well as to explore the entire process of communication with the riders. In the first pilot—conducted in August 2019—bookings were made upon a positive response from the contacted drivers. In other words, in 60 out of the 90 cases the testers booked places in the cars in reality, to test the coherence between positive feedback and the real behaviour of the drivers. As none of the

bookings was deleted by the divers, we may assume that by only requesting the rides (instead of making real bookings, which would be too costly to cancel later) we could adequately measure drivers' behaviour towards the different testers.

In the first pilot study we found two thirds of the feedback to be positive overall, which might partly be due to the high review scores of the riders (set to the level of 4.8 out of the maximum 5) and operating with lower-middle labour market statuses such as: receptionist, porter, administrator at the postal service, and telephone dispatcher. Below we show the results of the first pilot study. (Table 3)

Table 3: The outcome of the test (the received message) in percent, first pilot study, August 2019 (N= 90)

PROFILE	positive	negative	no reply	undefined	Total
P1: Roma not in wheelchair (N=21)	71	10	5	14	100
P2: Roma in wheel chair (N=24)	67	8	8	17	100
P3: Non-Roma and not in wheelchair (control) (N=21)	76	14	5	5	100
P4: Non-Roma in wheel chair (N=24)	54	21	17	8	100
Total	**67**	**13**	**9**	**11**	**100**

The Pilot 1 results did not show what we had expected: the highest rate of positive feedback (76%) was found in case of control condition (P3), while the lowest rate of positive feedback (54%) was measured in case of the Non-Roma in wheelchair condition (P4). Quite surprisingly, both Roma profiles got relatively high proportions of positive responses; however, for both profiles the proportion of undefined cases was considerably high (14 and 17% for P1 and P2 respectively.)

Lessons learned from Pilot 1:

- After Pilot 1 we realised that the full name of the prospective riders did not appear in the "sender" field of their messages, but rather only their profile names; we therefore slightly changed the profile names in the second round.
- We realised that response rates we achieved were very high (two third of the responses were positive in Pilot 1), and therefore lowered the review score, as well as the social status of the testers.

In order to lower the level of positive feedback—and enable larger differences across testers— we changed two factors in the design of the Pilot 2 study. On the one hand we set the review scores to 4.2, which is considered to be relatively low on this platform, and we also lowered social status by putting grammar mistakes and typos[7] into the requests. As far as the professions are concerned, we used lower status jobs to further express low social status.

As a result of the abovementioned design changes, the overall positive feedback rate decreased to 59%. At this stage, bookings were not made upon a positive response from the driver. Only online correspondence was conducted with the divers. The results are summarized in Table 4.

Table 4: The outcome of the test (the received message), in percent second pilot study, December 2019 (N=101)

PROFILE	positive	negative	no reply	undefined	Total
P1: Roma not in wheelchair (N=25)	60	24	12	4	100

[7]As the requests were formulated in Hungarian, we did not translate the type of mistakes we made at this point, as it would have been too challenging to reproduce them in idiomatic English.

P2: Roma in wheel chair (N=31)	42	42	10	6	100
P3: Non-Roma and not in wheelchair (control) (N=24)	79	8	4	8	100
P4: Non-Roma in wheel chair (N=21)	62	19	5	14	100
Total	59	25	8	8	100

In line with our expectations, the highest rate of positive feedback (79%) was found in case of the control condition (P3), while the lowest rate of positive feedback (42%) was measured in case of the Roma in wheelchair condition (P2). Moreover, both experimental stimuli (being Roma and using a wheelchair) equally reduced the chance of getting a positive response from the drivers, i.e. both Roma not in a wheelchair (P1). Non-Roma in wheelchair (P4) got 60 and 62% of positive feedback.

Based on the findings of the two pilots, a joint decision of our research group and Oszkar.com was made to distinguish between primary and secondary experimental variables as follows:

We decided that the primary experimental variables will be the following:

- ethnic origin (Roma vs. non-Roma)
- review score (high vs. medium)

The secondary experimental variables, randomly assigned to the experimental profiles, will be the following:

- having extra bag/suitcase
- traveling in wheelchair

In order to test the interactions of the experimental variables on the one hand, and the impact of the intervention on the other, the following experimental design will be introduced (Table 5):

Table 5: Controlled experimental design with intervention (planned number of observations N=1800)

Intervention: with multiple contents (Exp1 and Exp2) and no content (C)			**Within-subject-test: Autumn 2020 (N=1800)**		
Exp1:	Exp2:	C:		High score (4.8)	Medium score (4.5)
R O M A	W H E E L C H A I R	C O N T R O L	Male		
			Roma	450 tests	450 tests
			Non-Roma	450 tests	450 tests

After the experiment is completed, we are also planning to conduct a short online survey (N=1000) in order to ask drivers about their decision making process, as well as about their views on topics related to online trust, reputation, and the role of reviews on the platform.

4. Conclusions

Finally, we summarise what we have learned from the almost one-year-long pilot phase of our experimental research. As stated above, our aim was to test how the design we developed works in the online field, more specifically, (i) how the main features of the profiles work in the field, and (ii) how the experimental variables interact with each other, and (iii) how we should "fine-tune" the characteristics of the profiles in order to prevent too high or low levels of positive feedback.

In our view, based on the results shown above, our pilot research was successful, not only in terms of practicalities and implementation, but also content-wise, as after fine-tuning the design—based on the results of the first pilot field research—the results of the second pilot phase underlined our initial hypotheses on discrimination against potential riders based on ethnicity and disability.

From a methodological point of view, we believe that it makes sense to put this much effort into the preparation phase of a field experiment, especially in case of an online field that has hardly been researched so far.

Furthermore, it is also unique—at least in the Hungarian context—that an experimental research design has been prepared and implemented in such close cooperation with the platform itself, with the head of the platform becoming even more committed to our research goals by the end of the preparation phase of the research. Moreover, our ongoing research can be evaluated as an action research, as we are going to interfere with the working mechanisms of the platform by sending the visual ads to the drivers, and hopefully shaping their views on tolerance towards and acceptance of minority riders.

Beyond its direct impact, our innovative study has policy relevance as well, as unequal access to collaborative platforms seems to be a growing concern among scholars (e.g. Cohen and Sundarajan, 2015), platform owners and policy makers. In the case of Airbnb, the anti-discrimination regulations were introduced by the platform in 2016 as a consequence of the research that raised some issues about discrimination on the platform (Edelman et al. 2016), as well as because of various complaints about discrimination. As a result, the company's "Open Doors" policy has been in effect since November 2016 (Murphy, 2016). In case of ridesharing platforms, no similar direct policies aiming to redress the service providers' discriminatory behaviour, have been created, to the best of our knowledge.[8]

[8]In the terms of reference of BlaBlaCar, however, there is a point saying "not to speak or behave in any way or post any content… inciting violence, discrimination or hatred" (BlaBlaCar, 2017). Uber also sanctions discrimination, claiming that "Uber and its affiliates therefore prohibit discrimination against users based on race, religion, national origin, disability, sexual orientation, sex, marital status, gender identity, age or any other characteristic protected under applicable law." (Uber Non-Discrimination Policy, 2020.)

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Appendix: Supplementary research materials

Examples for Requests:

P1 and P3: *„I have a question: I am traveling with a big suitcase. Will it fit into your trunk?"* (control profiles)

P2 and P4: *„I am disabled, using a wheelchair, it is foldable, and it's like a large suitcase in size when folded (about 15kg, 25x92x50cm). Is that okay for you?* (physically disabled, experimental profile)

Preliminary storyline and photos of the interventions (work in progress)

The basic idea of the story is that the attitude of Oszkár.com is positive towards minorities and the platform urges its drivers to be tolerant and accept riders of any kind of minorities. The intervention has two versions: one of the spots will focus on a Roma and the other one on a disabled character. The spot is based on the following contrast: While the regular driver does not take the hitchhiker with minority background (Roma girl or a girl in wheelchair) and drives away in the first scene (red car in Figure 1), the Oszkár driver happily takes the minority rider (Figure 2). When the blue car (with the Oszkár logo) drives away the main message appears: "*At Oszkár there is no room for prejudices, everyone else are welcome*." Below we show some of the scenes of the spots, these are preliminary versions, only to show the basic idea, the characters and the texts are "work in progress" phase. (Figure 3)

Figure 1: opening scene with the regular car

Figure 2: scene with the Oszkár car approaching

"At Oszkár there is no room for prejudices, everyone else are welcome"

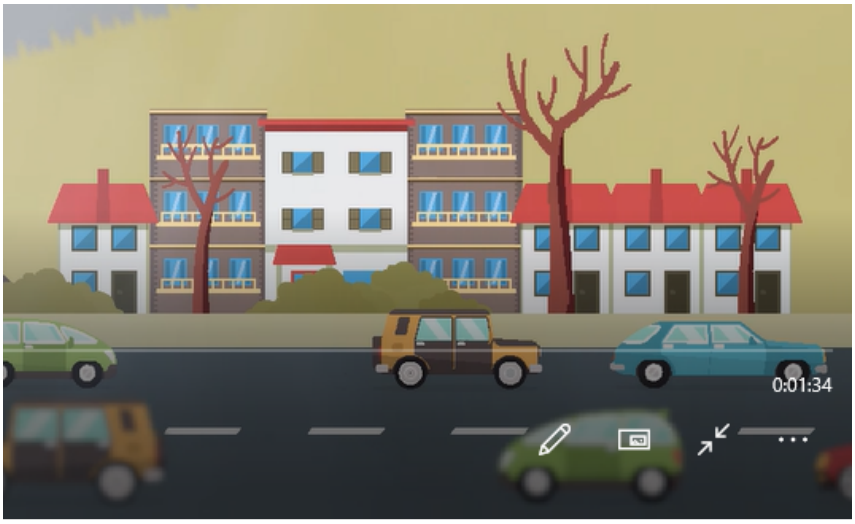

Figure 3: Final scene with the main message

Collaboration and Co-Creation for Sustainability, SDG Initiatives and Scale of Governance

An interactive platform for sustainability: the case of a simulated hospital in Colombia

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Abstract

The main goal of this research is to characterize the Simulated Hospital (SH) from the University of La Sabana in Colombia (South America) as an interactive platform for co-creation and collaborative innovation between different stakeholders that seek to be sustainable in the long term. The SH was created in 1998 as a "clinical simulation laboratory" which had only two classrooms, for medical and nursing students. In 2018, as part of the Strategic Plan of La Sabana that seeks to convert it into a "Third Generation University" (Wissema, 2009), SH became a space where all students in the area of health and other programs, live real hospital experiences, which are guided by innovative pedagogies and high technology (simulation robots and audiovisual equipment). The methods employed in this case study included ten visits to the SH to observe its operation; eight semi-structured interviews that included the SH' director, support staff for simulation scenarios, simulated patients (SP) and professors; revision of reports and internal documents from the SH; informal conversations with the SH's director and photographic records of the SH spaces. The findings were discussed and analyzed considering the collaborative innovation and co-creation literature. The results show that this SH is an interactive platform, where persons (e.g., staff and professors), processes (e.g., design of simulated experiences), interfaces (e.g., delivery and surgery rooms) and its artifacts (e.g., simulators), demonstrate an "agencial assemblage" that allows to each stakeholder can innovate in the creation and capture value for their sustainability.

Keywords: Interactive platforms, Co-creation, Collaborative innovation, Simulated Hospital, Sustainability

1 Introduction

Innovation has evolved over time. At first, it was just closed innovation. Under this perspective, companies apply their resources and organizational knowledge to the complete innovative process, from ideas generation to the commercialization of final products and services. Lee et al. (2012) had called this initial situation "Innovation 1.0". Likewise, these authors explain that the second step of innovation evolution, "Innovation 2.0", occurs when the changing pressure increases over companies, and they require innovative collaboration to develop a sustainable competitive advantage. When the change keeps growing, and the innovation continues, companies evolve toward an effective response: "Innovation 3.0" (Lee et al., 2012). This new stage is based on open innovation. In that vein, the collaboration with external agents has a prominent role since the necessary knowledge to innovate is distributed inside and outside the firms. Under the current business environment, Lee et al. (2012) present the "Innovation 4.0" as a new paradigm innovation based on the co-innovation or collaborative innovation. It is "a platform where new ideas or approaches from various internal and external sources are applied differently to create

new value or experience for all stakeholders, including consumers (Hippel, Ogawa, & De Jong, 2011). The core of co-innovation includes engagement, experience, and co-creation for the value that is difficult to imitate by competition. The co-innovation platform is built on principles of convergence of ideas, collaborative arrangement, and co-creation of experience with stakeholders" (2012, p. 824).

Similar to the innovation evolution, in the health sector, specifically in the organizations dedicated to the simulation, have occurred a process where the simulation laboratories have had the opportunity to evolve, thanks to the growing openness that innovation has had in recent years, which is characterized by being increasingly collaborative and encouraging co-creation among different stakeholders. Such is the importance of these organizations that currently there is worldwide many simulation centers. Based on data from the Society for Simulation in Healthcare-SSH, which is the world's largest organization dedicated to medical simulation, currently, there are registered 720 organizations worldwide, from which 337 are accredited (SSH-Society for Simulation in Healthcare, 2020). According to Amaya (2018), these centers can be classified according to its stage of development in simulated laboratories, simulation centers and simulated hospitals, being the latter the most advanced of them. The first, *simulation laboratories*, are units dedicated to developing the medical and nursing technical skills and abilities to students from medicine and nursing. Some examples of them are: The Cooper University Hospital Simulation Laboratory and the Yale School of Nursing Clinical Simulation Center and Assessment Labs in United States, the Nursing simulation laboratory in Jordan, the Healthcare Training Asia, and Skill Lab, both in India.

Regarding the *simulation centers*, they are places that allow professionals and students not only to develop and improve their skills and abilities, but also they promote the application and integration of knowledge and the analysis and evaluation of complete clinical situations that include the design of scenarios with medium and high-fidelity simulators. Some examples of these centers are: The Johns Hopkins Medicine Simulation Center in United States, The Clinical Skills and Simulation Centre in United Kingdom, the Sunnybrook Canadian Simulation Centre, the Center for Advanced Medical Simulation and Training in Swedish, the Kuala Lumpur Hospital's Simulation and the Skill Centre (Indicium) in Malaysia. Finally, the *simulated hospitals* are platforms where students, professors, staff, and simulated patient (SP) learn and develop skills and abilities using realistic locations as hospitalization rooms, emergencies, special care units for adults, children, and neonates, among other spaces. In addition, these places have defined a pedagogical model that ensures learning and ongoing monitoring of students' competencies, which coincides with the real scenarios for patient care. The Simulated Hospital in Miami Dade College (USA) and the Simulated Hospital from Universidad Europea (Spain) are examples of this kind of organizations.

In order to contribute to the literature of innovation, this study describes in a deep way the dynamic of the Simulated Hospital (SH) from the University of La Sabana in Colombia (South America), as an interactive platform for co-creation and collaborative innovation between different internal and external stakeholders that seek to be sustainable in the long term. According to this, we proposed the following research questions: Can this SH be considered an interactive platform and if so, what characteristics does it have?

The study is based on a single case study (Yin, 2014) of La Sabana's SH, which was created in 1998 as a "traditional clinical simulation laboratory" only for medical and nursing students. Then, in 2018, as part of the Strategic Plan of La Sabana that seeks to convert it into a "Third Generation University" (Wissema, 2009), the SH became a space where all students in the area of health and other programs, live real hospital experiences, which are guided by innovative pedagogies and high technology (simulation robots and audio visual equipment). The data was collected between March 2019 and February 2020 through ten visits to the SH to observe its operation, eight semi-structured interviews to the SH's director, support staff for simulation scenarios, SP, and professors. The interviews included questions related to the four components from interactive platform model (Ramaswamy & Ozcan, 2018). Additionally, we carried out several informal conversations with the SH's

director, reviewed unpublished internal documents and reports, and made photographic records of the different spaces of the SH.

The key contribution of this paper is to show how the Sabana's SH is more than an organization dedicated to the practice and enhancing of medical hard and soft skills, since it is not only a place where occurs repetitive practices. There, in middle of realistic interfaces from the hospital life, a dynamic interaction between internal and external stakeholders is presented, which use artifacts as simulators and medical devices through particular processes to generate a constant flow of closed and open innovation that creates and capture value from them and allows the sustainability of the complete system. For that reason, it is possible to affirm that the Sabana's SH belongs to the innovation 4.0 paradigm, and it is an example of the interactive platform model propose by Ramaswamy and Ozcan (2018). The paper proceeds by reviewing the interactive platform model, collaborative innovation, and innovation for sustainable development literature. Then, we explain the research methodology and present the findings of the study. Thereafter, we provide a discussion of the findings, and finally we offer some conclusions.

2 Literature review and conceptualization

This conceptual framework is composed of an explanation about the dynamic behind the innovative organizations, for that reason, firstly we describe what an interactive platform is and what are its features. Then, we present the differences between cooperative and collaborative innovative practices with the aim to characterize the co-creative interactions among interactive platform's stakeholders. Finally, we show the relationship between innovation and sustainability, where this latter is considered the main purpose of the innovative dynamic of an interactive platform.

2.1 An interactive platform and co-creation

According to Ramaswamy and Ozcan (2018), an *interactive platform* is an "agencial assemblage" made up of heterogeneous relationships between artifacts, persons, processes and interfaces (APPI components). *Artifacts* include digitized and physical things, including data in the form of numbers, text, images, audio, and video. *Persons* are the interested parties or stakeholders in their roles as clients, employees, suppliers, partners, among others. Depending on the different combinations (agencial assemblage) of these components, organizations can configure special interactive platforms and thus, get different results of value creation. *Processes* include more conventional and digitized business interaction processes. Finally, *Interfaces* include physical and digitized means by which one entity interacts with another entity.

Based on the above mentioned, an agencial assemblage has a double emphasis: "ensemble" and "process". It is an "ensemble" because defines an arrangement of parts that work together for a certain time, as well as a "process" by how those parts come together. Additionally, taken together, they are not closed systems. The parties can subsist regardless of the intrinsic relationships they have with each other. They are "open" to new components that join them with the potential to generate new collaborative interactions to co-creation. The parts are autonomous and "can separate from one whole and connect to another, entering into new interactions". Consequently, an agencial assemblage is also extrinsically relational.

Co-creation is the implementation of interactional creation through interactive system-environments (ordered by interactive platforms), entailing agencing engagements (transforming experiences in interactions) and structuring organizations (actor-networked relations in environments of interactions both in terms of "what they can create" and "what creates them", which stabilize heterogeneous relations among APPI components of platforms). Figure 1 provides a graphical representation of interactive platforms composed of their constituent APPI components, through which interactive creation occurs. Therefore, the value base is the dynamic of co-creation experiences for innovation between internal and external stakeholders, which have sustainability (eco-efficiency and eco-effectiveness) as the main purpose.

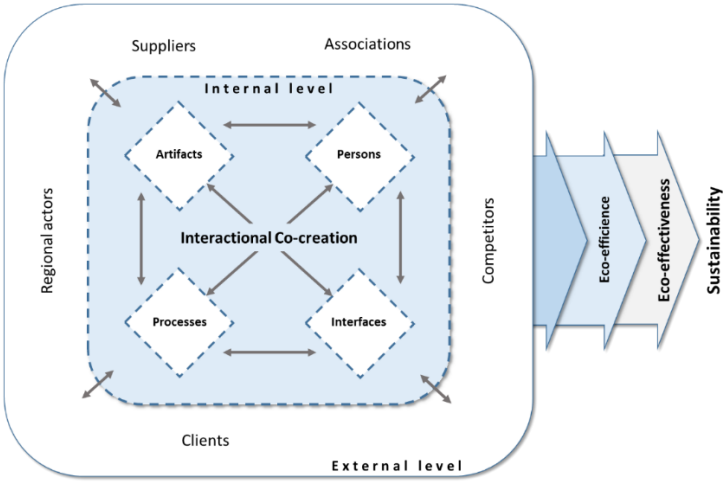

Figure 1. *Interactive Platforms for collaborative innovation*
Source: own elaboration based on Interactive Platforms and Co-creation (Ramaswamy & Ozcan, 2018)

2.2 Collaborative innovation for co-creation

Based on the work of Miles, Miles, and Snow (2005), Ketchen et al. (2007, p. 372) define *collaborative innovation* as "the creation of innovations across the firm (and perhaps industry) boundaries through the sharing of ideas, knowledge, expertise, and opportunities". It involves, according to Baldwin and Von Hippel (2011) collaborators that share the design and the results of the work, openly presenting their individual and collective efforts for anyone to use. Under this concept, *collaboration* is a concrete type of open innovation whose particularities reside in that agents: *i)* contribute with resources and different and complementary capabilities to the process of innovation; *ii)* they orient themselves towards a mutually desired objective (for example, to identify and solve a problem, improve a concrete process, create a new product or business, etc.); *iii)* the common interest prevails; *iv)* often implies unpredictable results; *v)* the grade of interdependence in interactivity among the collaborators is higher than in any other kind of innovation practice and, as a consequence, *vi)* the success depends on the trust and commitment to the values of honesty and equal treatment (Von Krogh, 1998). Therefore, considering an interaction inside-outside organization, collaborative innovation gathers some of the practices of open innovation. As observed in Figure 2, collaborative innovation, as a proposal, generates differences between practices associated with opening innovation. Thus, there are practices based on collaboration and others based on cooperation (Rodriguez-Ferradas, 2014). Some examples of open innovation based on collaborative practices are innovation networks, open code communities, and co-creation with users. The joint venture, crowdsourcing, innovation markets, and outsourcing of R&D, are examples of open innovation practices based on cooperation.

Collaboration is a philosophically different (and, arguably, more demanding) process than *cooperation*, where desired outcomes are relatively clear, the distribution of future returns can be negotiated in advance, and the cooperating parties act essentially in their self-interest. Collaboration often involves unpredictable outcomes and relies heavily on trust and a joint commitment to values of honesty and equitable treatment (Ketchen et al., 2007). In contrast to cooperation, collaborating parties take each other's interests into account as much as their own (Von Krogh, 1998).

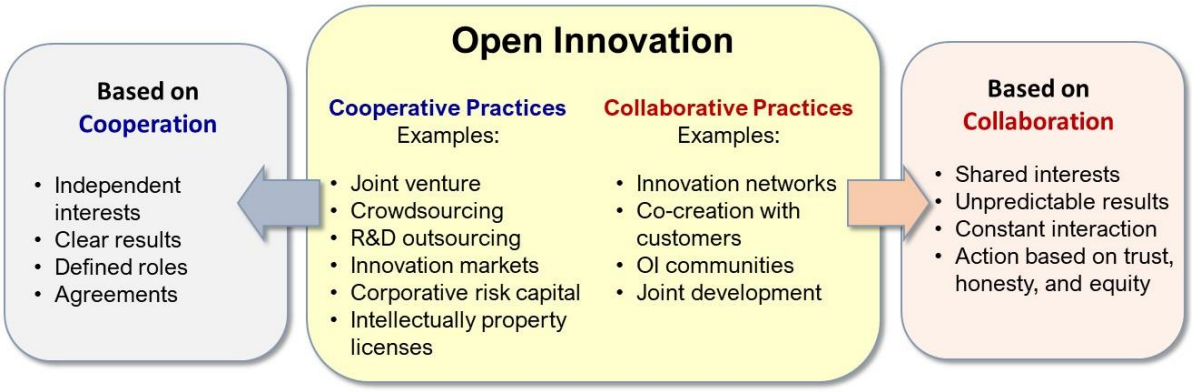

***Figure 2**. The relationship between open innovation and collaborative innovation.*
Source: own elaboration based on Rodriguez-Ferradas (2014)

Regarding *the management of collaborative innovation*, Swink (2006) states that companies have some benefits but also have to face some barriers. On the side of benefits, these companies can capture valuable knowledge, information, and resources thanks to the collaboration with other agents. Regarding the barriers, companies must solve problems linked to physical and temporal aspects, relational and cultural differences, organizational and hierarchical structures, and differences in knowledge, information, and data management.

2.3 Sustainability as the interactive platform's purpose

According to Seebode, Jeanrenaud, and Bessant (2012), the current problematic situation caused by the persistence of the techno-economic paradigm and their growth cycles, requires a change on a large scale, a change at the systems level. In line with this, Freeman and Perez (1988), and Perez (2002), a new and "long wave" of innovation is needed. Likewise, for sustainability's experts, this is a "sixth wave" that is linked to the growing social movements and communication networks that support them.

Under this lens, it is necessary to visualize organizations like systems composed by interactions for innovation and align these with the main purpose of sustainability. Therefore, organizations need to be considered like innovative and interactive platforms, whose dynamics create value for achieving sustainable development. Thus, Seebode et al. (2012) propose that innovation for sustainable development (ISD) challenges the organizations' dynamic capability to learn new approaches and solutions. Hence, ISD requires working with different knowledge components such as new technologies, new markets, new environmental or regulatory conditions, etc. Additionally, it means that organizations need to enhance their knowledge absorptive capacity (Zahra & George, 2002). In sum, they need capability (and enabling tools and methods) to acquire, assimilate and exploit new knowledge and to work at a systems level. However, the knowledge of organizations does not emerge from only one source and in a simple way. Conversely, as Henderson and Clark (1990) point out, to search new knowledge implies understand organizational configurations (the "component/architecture" challenge). For them, innovation rarely appears isolated, but rather it emerges as a bundle of knowledge which is brought together into a configuration. In that sense, successful ISD requires the use of knowledge under an "architecture of innovation" (Henderson & Clark, 1990), which has been denominated in this research as "interactive platform".

Regarding the outcomes about the management of ISD and under a narrow view, these are associated with the "eco-efficiency" concept (Schmidheiny & Stigson, 2000) which involves finding new and more efficient ways of "doing more with less" and therefore, to change the organizational management focus towards the "3 Rs" (reduce, re-use, and recycle). In contrast, from a broad perspective, it involves actions of the all system around emergent and radically different solutions. According to Seebode et al. (2012), this system-level innovation has the capacity to generate positive social and environmental impacts rather than simply mitigate negative ones, representing a shift from eco-efficiency to "eco-effectiveness" (Mcdonough &

Braungart, 2002). This latter represents the focus on creating "shared value", which creates connections between social, environmental and economic progress (Porter & Kramer, 2011).

3 Methods

3.1 Context

The empirical work is based on a single case study (Yin, 2014) drawing on observation visits to the SH, revision of reports and internal documents from the SH, photographic records and semi-structured interviews. We selected the Sabana's SH as a case study because it belongs to (1) a category of organizations scarcely studied and even less as innovative systems; (2) it is a special place where a lot of internal and external stakeholders interact; (3) it is an innovative unit in the university, where there is an important investment in technology, and high develops about active learning; and finally, (4) it represents a particular organization that searches its sustainability through the collaborative innovation as a result of stakeholders co-creation. This provides a suitable setting for studying if the SH is an interactive platform and which are its characteristics.

The SH was created in 1998 as a "traditional clinical simulation laboratory," for medical and nursing students, which had only two classrooms. There, they performed separately in simulated scenarios, some practices that served as support and reinforcement of specific topics. Then, in 2011, new classrooms were opened, and the nursing, physical therapy, and medicine programs began to work in an integrated way. In 2014, they included the simulation throughout these programs to strengthen the training in specific competencies for these professionals. Later, in 2018, the SH was transformed in a space with characteristics of a "real hospital," where nursing, physical therapy, medicine, and psychology students began to work in an interdisciplinary way, which is novel and not common. Currently, the SH has about of 695 m^2, where around of 120 students can train simultaneously per hour. There, they can practice patient care, labors, surgeries, cardiac resuscitation, and neurorehabilitation, among other procedures, while professors monitor these activities. Worth noting that the SH is part of a strategy for the learning assurance that is include in the University Development Plan.

The SH is certified as an international training center by the American Heart Association (AHA) and it is part of the international training network lead by the same organization which works through research in the prevention, detection and treatment of cardiovascular diseases and strokes. At present, the SH it is working to be certified again by two international organizations, the Society for Simulation in Healthcare (SSH) and Fundamental Critical Care Support (FCCS). In addition, it offers their facilities for research and extension projects such as the courses of basic life support (BLS), advanced cardiovascular support (ACLS), first aid and advanced pediatric resuscitation (PALS) and Heart Saver (Salvacorazones), which are certified by the AHA.

3.2 Data collection and analysis

In order to determine if the SH can be considered as an interactive platform of co-creation, we used a combination of semi-structured interviews with photographic records of the spaces of the SH (e.g. simulated scenarios, surgery room, hospitalization and debriefing rooms), observation visits and secondary data analysis. Eight semi-structured interviews were conducted with the SH's director, support staff for simulation scenarios, SP, and professors. These interviews, which were conducted between March 2019 and February 2020, and lasted 60 min on average, included questions related to the four components of an interactive platform model (Ramaswamy & Ozcan, 2018). Additionally, several informal conversations with the SH's director were carried out. Secondary data such as guides, work-guides, hospital reports, and unpublished internal documents, provided a means of collecting data about the hospital and its processes. Each interview was audio-recorded and transcribed, then they were manually analyzed by the authors. After, the case is discussed and analyzed considering the collaborative innovation and co-creation literature. Particularly, we used the definitional framework of co-creation developed by Ramaswamy & Ozcan (2018), since from a multilevel perspective (Carayannis & González, 2003; Sears & Baba, 2011), it integrates concepts as

interactive platforms and their components (artifacts, persons, processes, and interfaces) (Lee et al., 2012; Ramaswamy & Ozcan, 2018) where stakeholders create and capture value (Lepak, Smith, & Taylor, 2007) to achieve sustainability (Porter & Kramer, 2011) and increase their competitiveness (Carayannis & González, 2003)**.** Finally, the authors discussed the findings to ensure that conclusions are accurate.

4 Results

In this section, we analyze the results in light of the four components from interactive platform proposed by Ramaswamy & Ozcan (2018). Thus, we first identify the internal and external stakeholders (persons) that interact in the SH. Then, we describe the diverse processes that take place in the SH. Next, we analyze the interfaces where interact the different agents and after that we identify the artifacts that allow the SH to function properly. Finally, we present the eco-efficiency and eco-effectiveness evidence as component of sustainability, which is the main purpose of the SH as interactive platform of innovation.

4.1 Persons/Stakeholders

The SH impacts agents at different levels through a dynamic of co-creation and collaboration. It interacts with the following stakeholders (see Table 1).

Table 1. *The SH's Stakeholders*

Level	Category	Stakeholder	Description
Internal level	Value's Creator	SH Staff	• The Director and operation staff that include a logistic manager and three 3 technicians. • Occasionally 2 SENA apprentices per year, who are students from the industrial apprenticeship program of Colombia's National Apprenticeship Service.
		PAT Students	• Undergraduate students from different schools of La Sabana: business, administration, psychology, communication, nursing, engineers, and physical therapy, among others. • They are students for the Program Let´s learn to work (PAT, for its acronym in Spanish) and can be administrative or simulated patients. • In average 25 per semester
		Professors	• Professors: full time and part time • From the schools of Medicine, Nursing, Psychology and Physical Therapy • They develop about 34 classes per semester • There is one professor for every eight students
	Users	Undergrade and graduate students (University of La Sabana)	• Students from the schools of Medicine, Nursing, Psychology and Physical Therapy • In average there are 980 students per semester
		External users	• They are students from others national universities and members of the community (non-professionals, professionals, and non-health professionals). They can be members of the Sabana's health brigades, members of health's associations and people from the region. • In average 170 persons per semester are served.
	Board of directors	Medicine, Nursing, Psychology, and Physical Therapy programs	• Deans and programs' directors from Medicine, Nursing, Psychology, and Physical Therapy programs.
	Value's Creator Allies	Other Sabana Units (Psychology, Engineering, and Economics and Administrative Sciences, among others)	• They are different agents from Clinic Universidad de La Sabana, Schools of Psychology, Engineering, Economics and Administrative Sciences (EICEA), Direction of Learning Assurance, Family Institute and ASPAEN Association.

Level	Category	Stakeholder	Description
External level	Value's Creator	Clinical Tutors	• They are professors that work at hospitals but collaborate with the evaluation process. They participate in the assessment using the Objective structural clinical examination. • In average there are 120 tutors per semester • They contribute with ideas to improve the guides and simulated scenarios.
	Suppliers	Suppliers of products, biomedical equipment & Simulators	• They are three large wholesale distributors or with exclusive representation from recognized brands of biomedical equipment and simulators.
		Maintenance suppliers	• They are two large wholesale distributors or with exclusive representation from recognized brands of biomedical equipment and simulators. • Small regional companies.
		Clients for their personnel training	• In the case of the Clinic Universidad de la Sabana and other hospital institutions, the trainings are in accordance with their continuing education plan. • For companies, training is on emergency brigades and basic resuscitation.
		Donor suppliers	• Clinic Universidad de La Sabana • La Sabana's Fundraising Unit
	External stakeholders	Region's Agents	• Hospitals and clinics for student practices • The city halls of the Province of Sabana Centro • Small regional companies
		Professional Associations	• They are professional associations of Medicine, Nursing, Psychology and Physical Therapy.
		University Schools of the country	• Include different Colombian's schools, sister universities, and networks to improve processes and research.
		Organizations on Simulation	• In Colombia, INSIMED Foundation and the Colombian Association of Simulation in Health Science and the University of Boyacá • At international level, the University of Puebla in Mexico, and the American Heart Association (AHA)

Source: *own elaboration*

In the SH there are stakeholders at the internal and external levels of the university. Internally, there is a group of them dedicated to value creation such as the staff, the professors who interact daily with each other and the users (undergraduate and postgraduate students of the university, and external people who attend various courses and certifications) and the PAT students. Around them, there are the deans and directors of programs of Medicine, Nursing, Psychology, and Physical Therapy, as well as professors from other schools who carry out research and special projects in alliance with the SH team. Externally, the SH interacts with external medical professors (tutors), regional agents such as small providers, clinics, hospitals, and local governments. In a broader scope, the SH interacts with certifiers of medical procedures and patient care, equipment and service providers, donors of biomedical equipment, professional associations, and universities. Likewise, it interacts with associations, organizations and units dedicated to simulation research and management at national and international level (mainly in Portugal, Mexico, and Chile). Figure 3 shows the diversity of internal and external stakeholders. With a star we indicate what stakeholders develop collaborative innovation activities for value co-creation in the SH.

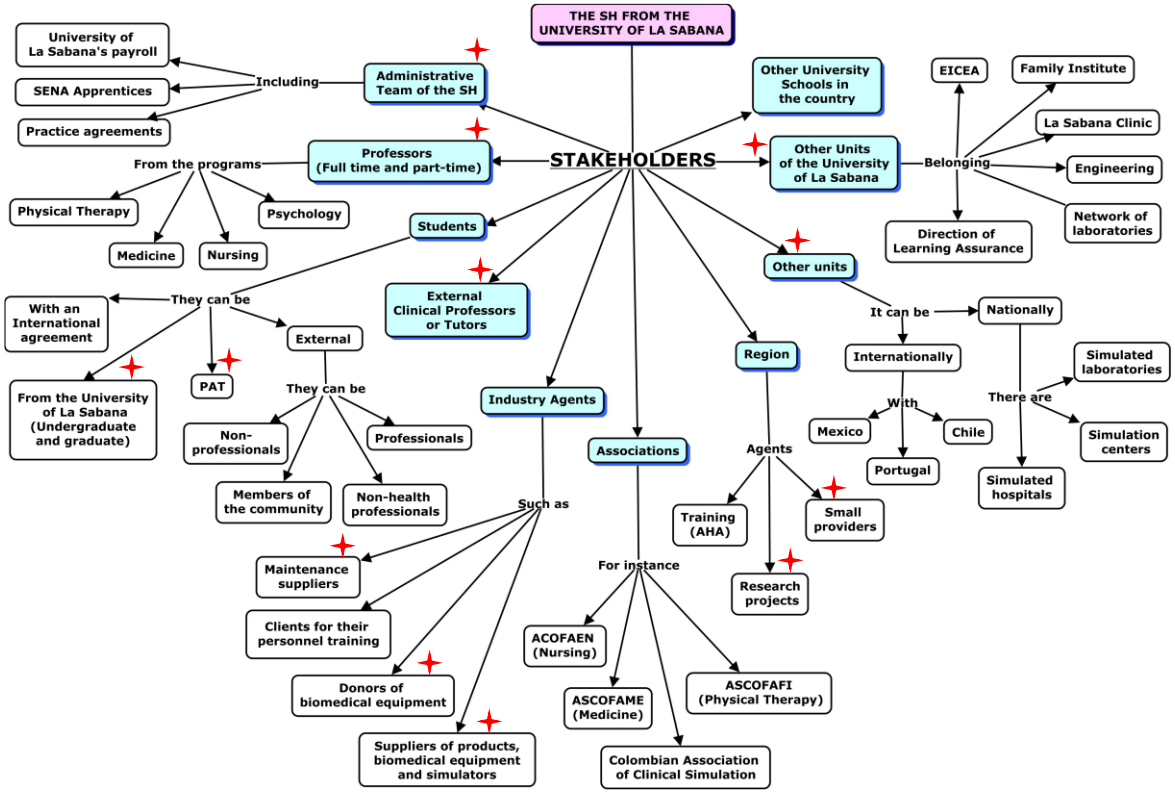

Figure 3. *Stakeholders of the SH from the University of La Sabana*
Source: own elaboration

As we can see, there is a great diversity of actors at all levels, which interact in diverse collaborative innovation processes to co-created value to achieve the sustainability of the entire platform or system.

4.2 Processes

In the SH academic and administrative processes are developed daily, which in terms of innovation can be collaborative, cooperative, or mixed. The administrative processes are related to the activities that allow to the SH functions properly and maintains good relationships with internal and external agents. Internally, these processes are led by the SH's director with the support of her logistics coordinator, technicians and SENA apprentices. Within these activities, the scheduling of classes and classrooms, provisioning, maintenance and the offer of simulation practices and skills development stand out. The SH staff and other stakeholders of the university participate in these activities, work collaboratively and generally seek incremental innovations to overcome the challenges that arise every day. Externally, the SH's director leads innovation actions, which is mainly presented cooperatively with her suppliers and donors, local governments, as well as agents who are offered courses and certifications. In contrast, there are collaborative relationships with clinics and hospitals, professional associations, simulation centers, and sister schools.

Regarding the academic processes, the SH's director, jointly with deans and the directors of medicine, nursing, psychology, and physical therapy programs, are in charge of managing and innovating in the curriculum of their respective programs, in order to adjust the competencies and skills that students must develop according to their career. Based on this, they define the work guides, the scripts for the simulated students, the assessments, etc. In this case, the process is cooperative, since the learning objectives, content, competencies, and skills, among others, are clearly defined. Additionally, the SH develops teaching activities for the learning of students from various undergraduate and graduate level programs, where there is flexibility and interdisciplinarity. Research and social projection activities are also developed through cooperative

relationships with Sabana's units and schools such as medicine, nursing, psychology, physical therapy, business, engineering, and the family institute. These kinds of activities are also carried out with external agents such as simulation associations and sister universities.

4.3 Interfaces

The interfaces can be internal or external. In the case of the SH, the *internal interfaces* are the realistic scenarios (e.g. surgery o labor rooms) in which the professor is an observer (see Figure 4). In these spaces, students interact with professors and hospital support staff to attend "simulators" (electronic manikins) and/or SP, which enables them to learn in an interdisciplinary environment, where error is part of the learning process. Likewise, they live experiences such as managing emotions and stress, caring for patients with different socioeconomic levels, cognitive ability and personal realities, or the scarcity of medical equipment and instruments. In these interfaces, the students must face unknown situations where they can be alone with a SP or they can be part of an interdisciplinary team of professionals, where they must handle situations of low, medium, or high complexity. The debriefing rooms are special places because there the SP, students and professors discuss the results of the exercise to reflect about the student learning and to generate new ideas that help to improve the sceneries, scripts and the handling of medical situations. It should be noted that the SH offers interfaces where students have the possibility to practice specific procedures (e.g. intubation) with the support of technicians and thus to develop specific skills required.

Figure 4. *Artifacts of the SH from the University of La Sabana*
Source: own elaboration

Daily, the SH develop around 10 practices (around 1700 practice hours per semester) that take from two to five hours. From these, 70% are simulated practices and 30% are skills and abilities practices. In these activities, participate per hour between 90 and 120 students from the schools of medicine, nursing and physical therapy, and psychology. However, other academic programs, such as gastronomy and business administration, develop some practices to learn about generalities of the digestive

system or to study the emergence of creative ideas and innovative practices, respectively. Finally, it is important to mention that due to the Covid-19, the SH has already started working with virtual simulation as a new interface. This specialized software presents virtual patients that serve for clinical rationing and decision-making of students through an interactive platform. Through this, they develop the entire process of patient care in different environments and life cycles (adults and children).

Regarding *external interfaces*, the SH interacts in diverse sceneries different from the university such as meetings, agreements, academic events, projects, and conferences, among others. For that reason, they do not participate in its daily operation. They are suppliers of biomedical materials and equipment, maintenance companies, equipment donors, professors, and researchers from other national and international universities. Sometimes, there are special interfaces as kinder-garden, secondary schools and professional´s associations, when SH carried out research and training activities. With other simulation centers, the interface is through informal agreements of collaboration, for example, to develop research projects or share ideas about scenarios, which help them to improve their processes and scripts.

For the university, the SH is considered as an innovative and integrator space for different activities from various actors, which must be efficient and self- sustainable due to the high investment that it represents. In that sense, the SH has a constant pressure to capture benefits. For this reason, it must look for stakeholders to achieve new contacts and therefore benefits.

In general terms, it is possible to determine differences between an SH, a laboratory and simulation center. Thus, the SH has the characteristics, the environment, and the spatial distribution of a real hospital. Its spaces are multifunctional and adequate for multidisciplinary and interdisciplinary practices. Therefore, they are flexible to support the requirements of the demanding schedule.

4.4 Artifacts

The SH has the furniture, equipment, software, hardware, and medical and surgical instruments necessary to recreate diverse medical situations. Thus, it has five scenarios of advanced simulation equipped with Gesell chambers, two sceneries that simulate hospitalization and emergencies, simulators (mechanics and electronic manikins), laboratories with its instruments, guides, and scripts to recreate medical situations. This allow the SH to offer a “personalized service” where each teacher can ask for special emphasis and requirements. Table 2 describes in detail the SH’s artifacts.

In a certain interface and through the processes, the artifacts are articulated to participate in the value creation for each stakeholder. These artifacts can be divided in soft and hard. The first, are the characterization and the performance of the SP that gives life to each simulated practice. Worth mentioning that one of the most important aspects of soft artifacts is the relevant role that person has in the process, which is a characteristic feature of the university’s human style. Under this approach another soft artifact is the own style of learning methodology. Examples of the hard artifacts are the scripts, which synthesized the performances above mentioned. Likewise, the physical simulators (mannequins), virtual simulator, therapy equipment and instruments, and video devices, among others, are hard artifacts.

Table 2. *SH Artifacts Description*

Artifacts	Description
Laboratories	• Exercise physiology • Gait analysis • Physical therapy technology with a special classroom • Neurorehabilitation • Electrophysiology
Specialized software	• Program for planning and assigning rooms • Program for the development of management indicators • Program for filming the scenarios and debriefing • Software for simulators of medium and high-fidelity
Hardware	• 50 PC for administrative processes
Simulators	• More than 120 simulators of high, medium, and low fidelity • The higher fidelity, the more emulates human reality
Medical and surgical instruments	• Furniture and biomedical equipment for the provision of emergency, hospitalization, surgery, labor, and special care units. • Furniture and biomedical equipment for the laboratories of neurorehabilitation, electrophysiology, physiotherapy and, technology and movement analysis.
Disposable and consumable items	• Gloves, face shield, and medical devices.
Learning guides (students)	• Around 130 guides for medicine by specialty, nursing by emphasis, physical therapy by therapeutic interventions, and psychological situations.
Scripts for simulated patients	• About 130 scripts with information on characterization, signs, symptoms, and dialogues. They include medical history with supports.
Planning formats (for teachers)	• Skills and abilities required • Simulation practices: detail of the time, place, instruments, and equipment required
Documents related to the simulators and biomedical equipment	• Sheets, manuals and quick operation instructions, maintenance schedule formats, and technical sheets of the equipment.
Videos	• Records of learning experiences. • Periodically, they are selected and some of them are kept to train students or to present in academic events, and the rest are erased.
Active simulation training methodology	• Training style from scripts and with characteristics in terms of procedures, values, constructive criticism, etc.

Source: ***own elaboration***

All these artifacts allow creating value to innovate in the services that the SH provides. They mainly come from two sources: *i)* external technologies adopted or assimilated, and *ii)* own co-creation between staff, SP, students, professors, and others. Both sources indicate the practices of open and closed innovation. The combination of these two sources generates opportunities to exploit own innovations that could be subject to intellectual property. This imply that the SH has the potential to reach the efficient expected for the university board of directors, which again means a pressure to become a sustainable unit.

4.5 Sustainability

The sustainability is a relevant issue for the SH given that its operation depends on it. For this reason, in the search to be eco-efficient, it always take advantage of available resources and looking for innovative ways to "do more with less" (Schmidheiny & Stigson, 2000). In line with this, the SH apply the "3R" principles (reduce, re-use, and recycle) to its operation. Regarding reducing, the SH optimizing spaces and carries out actions such as repair own or donated equipment at low cost or design artifacts with diverse functionalities (e.g. a stretcher which can be used to transport patients or for procedures), which enables the SH to save money. Concerning reusing, the SH uses several times simulators and many of the materials employed in the simulations. Finally, relate to recycling, the SH receives biomedical equipment that is no longer adequate for use in real medical procedures and repairs it. Likewise, the SH makes an appropriate disposition of the simulators that no longer have any possibility of use or repair and the materials that must be discarded.

In terms of the eco-effectiveness, the SH has a positive impact in economic, social, and environmental terms. Economically, it has reduced costs applying the 3R principles while meeting the high standards of education required by the university. For

example, the university has no longer to pay to other hospitals/clinics for their students to carry out their professional practices there. In addition, the SH drives the development of a new sector of the economy (simulation), creating employment and the development of new high-tech products and services. In social terms, the SH support small regional ventures by giving them the possibility to elaborate or repair parts of some biomedical equipment, which in turn enable the creation of new jobs, particularly for young people, who represent a population with high unemployment rates and in many cases with very low income. Likewise, it has trained people from people from the region, especially technicians, caregivers of chronically ill persons, and children and young people in school gardens and secondary schools. This new methodology of active education allows not only an evolution in teaching methodologies but also foster the culture of creativity and innovation, technology, teamwork and interdisciplinarity. Finally, in environmental terms, the simulation generates savings in the disposable and consumable goods that would be used in real settings such as a hospital. Likewise, the SH generates few mechanical and electronic waste and they are managed appropriately and repair equipment reducing the virgin material used. In addition, given that students can carry out their practices in the SH, they reduce the number of trips to other simulation centers, which in turn reduce their carbon footprint.

5 Discussion

As described earlier, we find that the SH is indeed an "Interactive Platform", where people (e.g., SH staff, professors, students), processes (e.g., design, preparation and assembly of scenarios for simulated practices, and skills and abilities practices), interfaces (e.g., scripts for simulations, classes, courses and certifications, clinics, operating rooms, hospitalization and emergencies, physical therapy and neuro-rehabilitation laboratories, debriefing rooms) and its artifacts (e.g., simulators and medical equipment), demonstrated a "permanent interaction between internal and external agents", allowing them to co-create value, be competitive and sustainable. This is consistent with the multilevel perspective of innovation, which integrates the internal actions of the organization with those of its ecosystem (Carayannis & González, 2003; Sears & Baba, 2011), and where stakeholders create and capture value (Lepak et al., 2007) to increase their competitiveness (Carayannis & González, 2003), and to achieve sustainability (Porter & Kramer, 2011).

Our findings suggest, on the one hand, that the interactive platforms proposed by Ramaswamy and Ozcan (2018) offers an alternative vision to understand the dynamics of co-creation in an organization. However, when these co-creation processes are understood as innovation processes in which different actors participate, it is necessary to add literature that allows a deeper understanding, hence the work of Ketchen et al. (2007) about collaborative innovation in this research. Also, the vision of a platform where interactivity dynamics exist presents, in a tacit way, the leading role of some stakeholders who interact to innovate as a means to create and capture value (Lepak et al., 2007). Additionally, the stakeholder vision broadens the interactive platform adding to the internal level, an external level where key agents for collaborative innovation processes also co-exist (Lepak et al., 2007).

On the other hand, the model would be incomplete if a general purpose of the platform or system is not added, which considers short, medium, and long-term solutions, as well as internal and external levels. The answer lies in incorporating the perspective of Seebode et al. (2012), under which, internal and immediate results are measured with the magnifying glass of "eco-efficiency", while long-term and external results are measured with "eco-effectiveness". The achievement of both therefore demonstrates a tangible way of achieving sustainability.

In the SH, sustainability is evidenced by increasing eco-efficiency and eco-effectiveness, which impact not only its results but also its way of innovating. Thus, the demands for efficient use of resources have been transformed into actions of reduce, reuse, and recycle, which have led the SH to practice frugal innovation. This practice favors innovation that allows doing more with less (Schmidheiny & Stigson, 2000), using few locally sourced resources and at the lowest possible cost to generate simple and high-value solutions for users or clients (Hossain, 2017; Pisoni, Michelini, & Martignoni, 2018). Likewise, these

efforts have managed to generate sustainable services at low cost, which is contrary to the evidence that shows higher costs in sustainable products (e.g. Barbiroli, 2011; Goldbach, Back, & Seuring, 2003; Ingenbleek, 2015).

From a practical point of view, the proposed model allowed presenting in detail each of the components of the SH as an interactive platform for innovation and sustainability. Thus, people describe internal and external stakeholders, who interact cooperatively or collaboratively to innovate. In the SH, these interfaces are not only spaces, but also stages of the administrative and academic processes, which, from a certain point of view, are more complex than those of a real hospital, because the hospital reality is recreated. All the above is accompanied by artifacts that specify and materialize procedures, actions, and decisions on the platform of the system. Overall, the analysis of the SH as an interactive platform characterized by the presence of internal and external stakeholders, who innovate to co-create and achieve sustainability, is presenting a model according to the 4.0 generation of innovation (Lee et al., 2012) which is beyond closed and open innovation.

6 Conclusions

In conclusion, it can be affirmed that all SH correspond to the highest level of development of this type of organizations and this is due not only to their technological development and teamwork capabilities, but also to the dynamics of an interactive platform that allows it to function as an ecosystem made up of a diversity of collaborative interactions internally and externally, which are aligned to achieve purposes of co-creation of value, increase competitiveness and achieve sustainability.

The key contribution of this paper was discovered that the Sabana's SH is more than an organization dedicated to the practice and enhancing of medical hard and soft skills, definitively it is not only a place where occurs repetitive practices. There, in middle of realistic interfaces from the hospital life, a dynamic interaction between internal and external stakeholders is presented, which use artifacts as simulators and medical devices through particular processes to generate a constant flow of closed and open innovation that creates and capture value from them and allows the sustainability of the complete system. For that reason, it is possible to affirm that the Sabana's SH belongs to the innovation 4.0 stage, and it is an example of an interactive platform where is highlighted the collaborative innovation between internal and external stakeholders that drive to the sustainability.

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Eradicating Poverty through Energy Innovation

Co-producing people centered energy transitions through *praxis* at the grassroots.

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Abstract

A clean energy transition must address the role and contribution of energy on poverty and injustices. Failing to do so would be a humanitarian disaster and a missed opportunity, when it comes to investing in reduction of global inequality through energy innovations and for progress across the full range of UN Sustainable Development Goals (SDGs). Thus, a key focus of energy innovation needs to be the disruption and reversal of the current energy-poverty nexus to create generative energy solutions at the grassroots level. These would not only provide access to clean energy but also enhance local economic growth, income, and livelihoods, as well as create social value, reduce corruption, strengthen food and water security, and improve lives and livelihoods for women and other marginalized groups. Eradicating Poverty through Energy Innovation (EPEI) is an initiative by the Grassroots Energy Innovation Laboratory at Arizona State University to directly link energy innovation to poverty alleviation. EPEI seeks to add a second outcome criteria for energy transitions: to design and achieve an energy future for the planet that is not only low carbon but also improves human well-being and thriving among marginalized and systematically deprived individuals, households and communities. This paper summarizes EPEI efforts to enable researchers, practitioners, and communities to work together to co-produce grassroots knowledge, tools, and strategies that expand the ambition and capacity of the energy sector to become an instrument for comprehensively alleviating global poverty, inequality, and injustice.

Keywords: practitioner-academia partnerships, energy-poverty nexus, grassroots energy innovation, community energy, knowledge co-production

1. Introduction

Energy systems and poverty are deeply intertwined; while conventional wisdom associates access to energy to increased comfort and opportunities for livelihood, it can also create financial, ecological, and human cost that systematically burdens marginalized groups of people around the world, worsening poverty, injustice, and inequality (Drehobl and Ross, 2016; Shyu, 2014; Moore, 2013; Sovacool, 2011; Donoghue, 2004; Lovei and McKechnie, 2000; WCD, 2000). The developmental effects of energy are outcomes of the underlying machinations of interactions among various aspects of society's forms of organization, governing institutions, economic realities, technological innovations and infrastructures, ecological attributes, and communities. Such a complex, intersecting and multi-dimensional relationship is what complex systems science characterizes as a nexus (Biggs et al., 2015). The 'Energy-Poverty nexus' thus needs to be, at a minimum, disentangled and, ideally reversed, so that energy systems instead reduce poverty, injustice, and inequality. Transitioning to clean energy sources presents a unique opportunity to address systemic poverty conditions on a global scale. In fact, to not use this transition to recognize and challenge current structural injustices would be a humanitarian disaster and an enormous waste of capital. A key element of the clean energy transitions agenda therefore needs to focus on the disruption of the energy-poverty nexus through place-based, innovative solutions at the grassroots level, enabling local economic growth and resilience to climate change, while also bolstering availability and access to essential services like drinking water and sanitation, in addition to

electricity for lighting, cooking or charging phones (Miller et al., 2018). The Sustainable Development Goals (SDGs) promoted by the United Nations (UN) provide one means of understanding how systemic poverty conditions can be addressed through the creation of clean, renewable energy systems that are accessible, sustainable and resilient, while also attending to local conditions and needs. We focus on grassroots energy endeavours as a means of addressing the energy-poverty nexus. Energy transitions in the past have brought fundamental changes in the organization of human communities, social and economic relationships and institutions, forms of production and consumption, and global distributions of power and wealth (Jones, 2014; Mitchell, 2011; Smil, 2003). The current transition has a large potential to improve well-being in societies suffering from energy poverty (Sagar, 2005), which is inseparable from achieving disruptive impact on conditions of injustice, inequity, and lack of opportunity (Liu et al., 2015; Samad et al., 2010). Clean cook stoves to micro-grids have been positioned as technological interventions for addressing the massive energy access challenge on local scales (Modi et al., 2005) and to lift millions out of energy poverty in the process (Adil et al., 2016; Tracey and Anne,2008; UNDP, 2006). However, the outcomes from these programs or projects are varied and demonstrate the limitations of the overt focus on energy access numbers (e.g. percentage of homes electrified or units of electricity consumed) in reducing energy poverty and driving human development (Nordhaus et al., 2016; Pachauri et al., 2012). There is a need to attend to associated dimensions of human and community development (Practical Action, 2016) and design energy systems that address technology, economic, political and socio-cultural factors simultaneously (Sovacool et al., 2012) and not rely on technological innovations alone to change or challenge structural conditions of poverty. Hence, a key concern here is the critical knowledge gaps regarding the social and economic practices and arrangements necessary for users to translate access to energy into economically productive and socially valuable outcomes and, ultimately, into social *and* economic development (Miller et al., 2015a).

Putting people at the centre of energy transitions, building capacity at the grassroots for systemic design and implementation through research-practitioner partnerships, is key to enhancing the capability of communities to better translate energy systems to sustainable development outcomes. In order to substantially address such issues at the intersections of social and technological systems, the Grassroots Energy Innovation (GEI) laboratory at Arizona State University (ASU) launched the Eradicating Poverty through Energy Innovation (EPEI) initiative, with the goal of significantly expanding the ambition of the energy sector and to repurpose it towards the eradication of poverty. It seeks to place poverty eradication firmly at the center of the energy transitions agenda, instead of purely technological, investments, or quantified targets such as zero carbon emission paradigms with poor linkages to human well-being and thriving of marginalized and systematically deprived individuals, households and communities. At the same time, the EPEI also pursues lowering barriers and burdens to the pursuit of well-being, posed by socio-economic and technological structures as well as the energy system. We describe this shift to human-centered paradigmatic thinking in energy transition as “the social value of energy.” The central research question that forms the backbone of EPEI is ‘How can the energy sector improve the social value of energy?’. Stemming from the fact that energy systems are integrally tied into social, economic, political, and environmental systems and landscapes - the social value of energy framing recognizes how transformational energy development and expansion can be situated within and on these systems and landscapes at different levels, as they relate to the systems of value held by diverse stakeholder communities. The social value of energy therefore includes the aggregate value that is created by energy systems, but also accounts for how value is distributed (or not) across individuals and groups, and why. It also accounts for social benefits to different stakeholders as well as burdens and risks across different temporal (past, present and future), geographic (from local to global impacts), and social scales (from the individual to the community).

By making communities and their needs a central priority for energy systems innovations, EPEI focuses on three major aspirations with the potential to contribute to the eradication of poverty:

1. **Support local and global stakeholders to navigate the complexities of energy transitions** - Decarbonizing energy systems while creating universal access that enables sustainable, social, and economic well-being will be one of the most complex systems transformations humans have ever undertaken. Core to that complexity is the understanding how energy is entangled with cultural, political, economic, behavioural and societal values, which will undergo shifts alongside the

technological transition. Rigorous research rooted in a constant dialog with local communities and stakeholders at multiple levels and recalibration of practice is thus required to navigate such heterogenous transitions.

2. **Helping communities improve the human outcomes of energy investments -** The goal of designing new energy systems should be to improve human outcomes and help create thriving and sustainable human communities. New and reformed metrics to evaluate projects, plans, and outcomes need to be created by and for local communities that recognize them as participants in creating and achieving goals for more just and equitable energy futures and ensure that human well-being conditions are advanced, not deteriorated.

3**. Assist communities in the design and pursuit of just and sustainable futures through energy innovation** – Recognizing that creating new energy systems is about energy innovations that are generative in the long-term processes of change, energy systems need to complement community futures and trajectories towards ending poverty, injustice and reduce inequalities . Technology, management practices, governance structures, policy and education are some of the areas where innovation is necessary to enable energy innovations that squarely address poverty eradication.

In this paper, we describe the actions and outcomes of the EPEI initiative in addressing gaps that exist in contextual and conditional translation of energy to human development outcomes, by a multi-pronged approach consisting of: (a) a core group of interdisciplinary researchers, (b) a deliberative platform for researchers and practitioners to co-produce actionable knowledge, and (c) a range of academia-industry collaboratives and applied research projects that test and refine knowledge based interventions design and strategy. The following sections first describe the methodological and theoretical influences, and then discuss the results in each of the three tracks of the EPEI initiative.

2. Methods

Energy analysis and design are not merely technical exercises but are ambitious exercises in imagining, planning, and creating new social worlds (Miller et al. 2015a; Miller and Richter 2014). However, the current paradigms that guide energy transitions planning tend to focus narrowly on technology design at the expense of other systemic attributes. A review of 35 Energy Planning Models (EPM's) for national energy policies highlight the surprising insensitivity of such models to the socio-economic, socio-cultural, and organizational dimensions of the contexts to which they were being applied (Debnath and Mourshed, 2018). Even where there is identification of a source of variability, it is categorized in broad social variable buckets (e.g. corruption) for the purposes of easy quantification. This is not surprising since most mathematical models for planning energy transitions are technological reorientations or optimizations, based on pre-set outcomes quantified in terms of GDP and CO2 targets (Gaciuta et al., 2018; Bhattacharyya and Timilsina, 2010). At the community scale of energy planning, a gap exists between assumptions behind theories of socio-economic and ecological change from energy systems and the practice of implementation, owing largely to top-down approaches (Rakshit et al., 2017; Seyfang et al., 2013). Lack of evidence on how real people at the community-level use energy and what situational constraints differentiate remote, marginalized, resource-deprived communities is a common missing piece (Slee, 2015).

EPEI takes an alternative methodological approach that emphasizes the human-centeredness of energy systems. These systems are designed and operated by and for human actors and communities who inhabit specific social, economic, political, and environmental contexts. This section briefly describes the three core ideas that underlie the methodologies of the EPEI initiative.

1) **Social Value of Energy** (Miller et al., 2018, 2015b): The relationship between energy use and changes in economic prosperity or social well-being does not follow a fixed or universal pattern. However, it is generally understood to be a positive relationship. The degree and types of benefits thus need to be explored, understood and established. The social value of energy offers a heuristic to investigate and articulate benefits or value propositions that an individual, household, business, community, or society derives from energy they are able to create and/or use. It incorporates both economic and non-economic

benefit or value, the latter including such considerations as health, education and overall well-being, that are difficult to quantify in econometric terms but are undeniably important. The social value of energy also accounts for costs, burdens, risks, and other negative outcomes or externalities associated with the generation, transmission, or consumption of energy. It can be expressed in simplified terms as the sum of the diverse economic and non-economic benefits of energy systems, minus their costs, burdens, and risks, minus any additional externalities that arise from their implementation and operation. Thus, the social value of energy provides a direct measure of the causal link and direction of influence between the availability of energy (and/or access to it) and the potential for improving measures for community well-being on any of several SDGs, including poverty, health, education, food security, and/or sustainability.

2) Co-Production of Place-Based Knowledge and Action: Energy systems and economic development are inseparably intertwined with a range of social and ecological justice issues. These are inherently local issues that are contextual and constructed by the people and communities inhabiting those places. Therefore, appropriate tools to engage legitimate local stakeholders are needed, in order to co-produce knowledge and action that can be validated and used in ways that empower and transfer agency to local actors (Borda, 1986; Freire 1982) and influence social practices around energy use (Shove et al., 2012). Co-production of knowledge and action leverages inclusive participation of academic and non-academic communities aimed at creating sustainable development pathways (Pohl et al., 2010). Given the layers and place-specific nature of the larger poverty challenge, managing how different and sometimes contested or contradictory knowledge systems interact in the process of making decisions needs to be clarified and articulated (Edelenbos, 2011; St Clair, 2006). Co-production of knowledge should help produce systematic and multi-level knowledge that combines perspectives and information processing biases of the breadth of actors, also known as 'mode 3 knowledge systems' (Carayannis et al., 2016). In the process of innovating in shared spaces and for a multitude of stakeholders, legitimacy and trust-based relationships are better established. Such processes are crucial to disrupting the control and eventual imposition of solutions-based ideals, and result in improved participatory control or a 'reversal' of management (Chambers, 2014).

3) Engaged Design for Transition: In order to better integrate social and ethical considerations into energy systems, design should be grounded in a set of co-produced human and social values with an explicit goal to enhance the socio-economic and ecological well-being of communities. The inherent complexity of the task of integration requires engaging with a range of critical questions involving design trade-offs, coping with uncertainties, and the limitations of current analytical approaches (Nieusma, 2004). Products, services or enterprises seeking to address marginalization through design requires changes in design practices, and more importantly in the governing mentalities that underlie those practices (Manzini, 2014). Values-based design therefore draws from multiple design approaches that focus on arrangements that enable people to engage in meaningful and fulfilling activities – like developing one's skill, contributing to a greater goal, creating and nurturing relationship with people one cares about, or improving health (e.g. appropriate design, design for well-being) (Steen, 2016; Knobel and Bowker, 2011; Nieusma and Riley, 2010; Sengers et al., 2005). Such integration and centricity of values, however, cannot be assumed, imposed or pre-ordained according to the inherent power asymmetries in multi-stakeholder situations. Therefore, the practice aspects of innovation that engages end users in meaningful ways or user-centered design are necessary complements to the procedural grounding provided by values-based design (Baskerville and Pries-Heje, 2010). User-centered design offers tools and practices for active involvement of users to improve the understanding of user and task requirements, and the iteration of design and evaluation (Mao et al., 2005). This is key for the design outcome to be usable and useful for the intended end users. It would account for lifestyle factors, social practices, and cultural uniqueness of any given context by employing information and feedback processes that capture acceptability, preferences, aesthetics and several other socio-cultural attributes of the potential design (Still and Kate, 2017; Lowdermilk, 2013). Therefore, designing for energy transition should be an engaged practice which includes goal setting and value orientation of the design exercise, through the utilization of tools and processes that effectively disrupt representational asymmetries to make design more inclusive and participatory.

These three major theoretical influences are reflected in the methods and approach to collaborations and research undertakings by the EPEI initiative, which are reflective of the concept of praxis (Freire, 2015), in which we integrate theory with method in the applied research projects described in the next section. Given EPEI's aim to overcome boundaries of disciplines and practice, adaptability is a critical quality for research and practice of energy and poverty to interact constructively. Therefore, instead of being prescriptive, the methodological approach draws form the existing pool of knowledge and adapts them for exchanges between the communities of research and practice.

3. Results and Discussion

Eradicating Poverty through Energy Innovation (EPEI) was articulated as an initiative with the ambition to reboot the imagination on the relationship between energy and poverty, such that energy solutions deliver high levels of social and economic value for energy users and thus help create generative relationships that simultaneously grow clean energy solutions and end poverty, inequality, and injustice (*for more on the EPEI, see* Huth, 2018). Achieving this ambition would require addressing the fundamental knowledge gaps described in previous sections. The production of multi-level, locally grounded and actionable knowledge is a central focus of the initiative. Additionally, such knowledge would be incomplete and of limited practical use if inclusive, reflexive, and participatory processes do not underpin the initiative. In the two years since the first EPEI workshop and multiple applied research studies in nine countries, there have been several insights produced for the theory, practice, and communication strategies for pursuing sustainable development in marginalized communities through value enhancing energy systems. Analysing the outcomes and insights generated, a set of interlinked agenda can be articulated for the advancement of research, knowledge exchange and reflexive action for a just and socially valuable energy transition The EPEI initiative, in response to the identified areas of advancement, has grown into three distinct but interlinked platforms, namely – the Grassroots Energy Innovation (GEI) laboratory, the EPEI workshop, and the EPEI global community of practice. These platforms are informed by the theoretical and methodological frameworks described in the previous section and form the praxis of EPEI. In this section, we describe the need and potential of each of the three dimensions of the agenda and discuss how the EPEI platforms are pursuing them.

- **'People and Systems of Poverty' centered energy research agenda** – The design and usability of energy systems plays a crucial role in delivering social and economic outcomes. Energy systems are rarely neutral and can enable ways out of poverty or make it worse. The ability to enable pathways out of poverty is not determined by the engineering efficiency of the infrastructure, rather by the collective effectiveness of the socio-technical arrangements (e.g. technology, governance, financial transactions, participatory decision making, institutional support) in empowering the energy users to translate energy to well-being outcomes. In other words, the progressive creation, sustenance and acceleration of social value of energy is critical to socio-economic development through energy innovation. The pursuit of such innovation is heavily dependent on research approaches that systematically deconstruct the technological system of energy production, distribution and use, in its situational reality framed by ecological, political, economic, cultural and behavioural dimensions. In other words, research on energy systems should put *people and their situations of deprivations* at the centre of the inquiry. Understanding and articulating the situational construct of poverty (and other forms of deprivations), should therefore become the basis for investigations on the design, management and governance of localized energy transitions for sustainable future.

The EPEI initiative pursues this agenda through its ***Grassroots Energy Innovation (GEI) laboratory*** at ASU, which is the research unit that carries out fundamental investigations on defining and measuring social value of energy and developing the concept further. A group of faculty, graduate researchers and undergraduate students from multiple disciplinary backgrounds collaborate on a wide variety of research linked to the objectives of the lab. The theoretical research focuses on intersections of poverty, energy engineering, social enterprises, knowledge systems, development studies and social justice. This is supplemented by longitudinal and engaged research with and in communities to generate primary data. Methodological

approaches and toolkits have been developed and tested over time. The lab regularly hosts exchange scholars from various parts of the world and partners with research units in their parent universities for collaborative projects. A research agenda with a global scope and local focus requires researchers from a variety of disciplines, geography, demographic and cultural linkages to participate. Hence, the GEI lab has built collaborations with other research groups, such as with the Socio-Technical Energy Futures group at Institute for Technology Assessment and Systems (ITAS) at Karlsruhe Institute of Technology (KIT), Germany. Such collaborations are crucial to the advancement of research and forms the basis for the next agenda on knowledge exchange.

- **'Knowledge exchange' agenda -** Relatable, jargon-free communication is an area that requires massive reorganization and rethinking in the global context of energy access research and practice. The dominance of particular types of knowledge and academic training of professionals or so-called experts, leads to gaps in exchange of ideas, frequent and eventual misunderstandings. The historical lock-ins of the energy system – energy user relationship limits the ambition and interest of communities in radical reimagination of an energy system in its technological isolation. Therefore, if energy innovation is to be repurposed for poverty eradication, then the representational asymmetries and dominance of energy sector and its experts must be disrupted. An alternative culture of sustainable futures-oriented deliberations needs to be established, unshackled by sector-specific jargons and knowledge system boundaries. In order to integrate and exchange diverse forms of knowledge, platforms that bring together academics, practitioners, public intellectuals and civil society members are crucial. The knowledge exchanges produced in such settings can therefore be grounded in proper context, undergo rigorous scrutiny and be filtered so that narrow generalizations and disjointed narratives do not subvert legitimate knowledge.

The ***Eradicating Poverty Through Energy Innovation workshops*** are examples of such knowledge exchange forums. Organized by the GEI lab, the EPEI workshops bring together organizations, agencies, and community representatives from all aspects of energy planning, especially in nations, regions, and communities that have systemically suffered from a lack of access to stable energy production. The EPEI workshop is a platform for energy access practitioners, community-based actors, and academics from all over the globe. It provides a forum for networking and knowledge sharing around grassroots energy initiatives happening around the globe, and bringing the social, cultural and marginalized perspective to the forefront of energy access discourses. The network of participants continues to facilitate collaborations, information exchanges and joint projects. This initiative is founded on the belief that constructing inclusive and equitable futures for everyone requires engaged research and practices that involves people in action situations on the ground; to construct energy systems that enable socio-economic-ecological well-being. While engaging stakeholders as equal partners builds rigorous, evidence driven, and place-based solution strategies, the process also fosters critical reflection and shared knowledge systems for informed action. The 2018 inaugural workshop in Tempe, Arizona (USA) laid the foundation for a deliberative platform that allowed attendees to explore different aspects of the social value of energy in diverse forms and places, in order to make explicit connections between pathways out of poverty and energy production and use. The 2019 EPEI workshop in Dehradun (India) continued the conversation, this time with an emphasis on Southeast and South Asia and bring a regional focus that sought to build interlinkages and to deliberate strategies for integrating Sustainable Development Goal (SDG) 7: Clean and Affordable Energy (as well as other SDGs). This second international conference workshop on "Energy Innovation Initiatives for Attaining Sustainable Development Goals" started with the objective of exploring ways of attaining sustainable development goals with energy as the enabler. Representing more than ten countries, the participants from government bodies, academics, policymakers, scientists, consultants and entrepreneurs shared their experiences and ideas on working with SDGs and local communities. These delegates deliberated for three days on the role of energy innovation in attaining SDGs, the barriers in energy innovations, various financing and ownership models, and informing and engaging with citizens on creating and implementing energy innovations. Ultimately, the discussions focused on persistent and common barriers to creating energy innovations such as: 1) identifying energy innovation opportunities at the local level by working with local communities and understanding

their specific needs; 2) articulating and implementing policies that are flexible and user-centric to suit different factors such as culture, demography, and local needs; 3) engagement, awareness and communication of energy development opportunities; 4) adaptability of innovations to encourage acceptance of innovations; 5) local education and training in energy development, management, and operations; and 6) financing and ownership of energy innovations. The workshop blended panel and round table discussions, brainstorming sessions, short talks, posters and innovation rapid discussion sprints to create an engaging and diverse format over the three days of the conference.

Also, in 2019, the EPEI research team worked with researchers from ITAS-KIT to conduct a three-day workshop in Fortaleza (Brazil) and multiple engagements in Manila (Philippines), with local stakeholders in the energy access and development sector. These engagements aimed to foster the development of partnerships and projects between the participants, looking for systematic approaches that link energy and the challenges and problems faced by rural communities for sustainable, inclusive and equitable development. The discussions brought together experts, governmental agencies, non-governmental organizations, research institutions, funding agencies and decision makers, Joint initiatives and proposals have resulted from these deliberations, that aim to develop local capacity and projects at the convergence of energy and rural development with a special emphasis on vulnerable groups.

Similar platforms, like the biennial Innovation Lab by the Affordable Energy for Humanity (AE4H) initiative (a joint effort of the Waterloo Institute of Sustainable Energy, Canada and Karlsruhe Institute of Technology, Germany), play an important role in furthering the knowledge exchange agenda, globally. A critical next step however, will be transforming this knowledge to action on the ground. This would mean taking it out of meetings and conferences to actual projects where learning by application can happen in rapid and adaptive ways. Thus, to close the loop for research and knowledge exchange the final element of the agenda is reflexive action.

- **'Reflexive action' agenda** – Participation of a variety of grassroots actors is essential to the identification, communication and inclusion of diverse knowledge systems, which eventually leads to improved research and practice of energy innovation. Small businesses, non-profits and government agencies, educational and research entities, and most importantly, the communities are key stakeholders. Further, a major opportunity area is the inclusion of non-energy entities in the stakeholder mix, especially those invested in other areas of community development relevant to poverty eradication e.g. livelihoods, food security, clean water, climate change adaptation and resilience, gender and social justice. They are capable of providing expert inputs on these issues, making the research, design and implementation of energy systems much more socio-culturally sensitive. On the other hand, since energy service is an enabler of outcomes in a variety of development sectors, programs and initiatives in those sectors can become better aligned. Facilitating such collaborations for design and implementation strategies, will require building networks or consortiums of academics and practitioners to formulate, apply and secure resources to implement transformational ideas. Collaborations like these would make research far more insightful and capable of rapidly producing insights based on localized and thick data, at the same time enabling multi-dimensionally informed decisions by stakeholders. This approach addresses a key human resource gap among grassroots actors.

The ***Global EPEI community of practice*** demonstrates such collaborations of shared interest in grassroots energy innovation for sustainable communities. Multiple applied research projects across the globe and capacity building initiatives have resulted from the collaborations developed through EPEI meetings and have led to bilateral exchanges as well as multi-stakeholder, applied research projects. Some of the most relevant projects are:

- The 'Implementing Off-Grid Renewable Energy to Create Social Value and Community Development' applied research project was conducted from 2018 to 2019 by a research team from ASU, and the Karlsruhe Institute of Technology, Germany, in partnership with local organizations from Nepal, Philippines, Uganda and Bolivia (two social enterprises, one business accelerator and one non-profit organization, respectively), and was supported by the Global Consortium for Sustainability Outcomes. This project presents s an example of EPEI's praxis that integrates

theory with practice. Twenty (20) community scale, off-grid renewable energy projects, selected from the pool of projects that have been executed by the local partners and using a variety of technologies and governance structures, were studied. Participating enterprises and communities collectively analysed value creation pathways as well as barriers and drivers. Insights derived from the study were then utilized to inform design parameters for new projects. A community solar mini grid in Nepal, two school electrification and community services projects in the Philippines, revised training and value creation analysis toolkits for small energy businesses in Uganda and a scale- up project in Bolivia resulted from this yearlong study. The project led to improvements in the business-as-usual practices in the energy access sector by: (a) taking on and achieving more ambitious sustainable development goals linked to energy access projects, (b) empowering communities and local actors to use energy systems more effectively to create social and economic value like linking energy innovation to food and water security, (c) having stronger social designs that synergize with their engineering and economic components to create resilient and anticipatory projects, and (d) reducing the financial burdens on project beneficiaries.

- 'Improving Social and Economic Impact of Energy Infrastructure Investments in Sierra Leone: through Enhancement of Social Value Creation, Capacity-Building, and Decision Support', is a partnership with research, government and international development entities to create evidence supported pathways for energy transitions in Sierra Leone. Starting in April 2019, the two-year project is collecting multi-level and granular data on energy utilization, and value creation opportunities among the geographically, socio-economically and culturally diverse regions. In parallel, a capacity development effort is underway with the aim to create skills to conduct analysis and decision making among the institutional stakeholders. The project is funded under the Applied Research Programme on Energy for Economic Growth (EEG) by the UK Government, through UK Aid. The goals of the project are to: 1) Intensify sustainable development outcomes of energy projects and investments in Sierra Leone, by creating evidence for high impact translation pathways; 2) Create a community level focus on social and economic value creation, thereby developing a portfolio of best practices in design, operations and utilization of energy systems to draw from; and 3) Build a community of practice among relevant stakeholders in the energy space in Sierra Leone, facilitating strategic exchange and coordinated action based on scientific evidence and practices.
- '**Solar energy for food sovereignty of riverbank families**' is the most recent applied-research project approved in partnership with ITAS-KIT and local partner from Brazil, namely *Associação dos Trabalhadores Agroextrativistas da Ilha das Cinzas* (ATAIC), Embrapa Amapá and Laboratory of Renewable Energies of the Federal University of Amapá. This project is scheduled to begin in July 2020, has a funding period of 2.5 years and intends to significantly improve quality of life and income generation of all 50 families living at the island Ilha das Cinzas, located at the Brazilian Amazon in the State of Pará. The island is isolated from the continental area and fluvial transport is the only way to reach the community, which has no grid connection and limited access to other essential services, like clean water and basic sanitation. Under this project, solar facilities will be installed to supply basic human needs and promote food sovereignty and production. In addition, community members, especially women and youth, will gain capacity to install, operate and maintain solar facilities. One key element is that the whole project will be managed by the community members with the support of local partners and the ASU & KIT research team. The project is funded by the Honnold Foundation.

Other long-term collaborations include:

- Collaboration with four communities in Puerto Rico to enable them in developing community owned solar electrification projects, aimed at natural disaster resilience and poverty alleviation. A team of researchers from the GEI lab are conducting socio-technological studies to determine the best suited scenarios of finance, technological design, and governance arrangements that enable community leaders to make decisions.

- Exchange scholars and joint research projects with Pakistan's National University of Science and Technology (NUST) and University of Engineering and Technology (UET), under the US-Pakistan Centre for Advances Studies in Energy.
- Outreach to high school districts in Arizona through the Quantum Energy and Sustainable Solar Technology (QESST) laboratory at ASU, to create educational material and project-based learning on solar energy technologies.
- Transferring social value of energy mapping tools to non-profit entities engaged in relief in Rohingya refugee camps in Bangladesh.

Similar collaborations in other parts of the world have demonstrated their effectiveness in addressing local challenges with energy transitions. The GEI lab holds frequent interactions with the Community Appropriate Sustainable Energy Security (CASES) partnership- a international research initiative involving 15 northern and Indigenous communities and public and private sector project partners from Canada, Alaska, Sweden, and Norway. It is structured to exchange knowledge and skills among partners to transform the energy system in participating communities.

4. Conclusions

The GEI lab, the workshops, and the global footprint of collaborative projects under the EPEI umbrella seeks to create more sustainable and resilient energy access for communities, starting from the grassroots, in order to develop responsive and adaptive energy systems. It follows the identification of an intersecting and complementary set of agendas to pursue energy solutions that can deliver high levels of social and economic value for energy users. It creates generative relationships between clean energy solutions and reduction of poverty, inequality, and injustice based on locally relevant and co-produced knowledge. A 'people and systems of poverty' centered energy research community, that is supported by constructive and transdisciplinary 'knowledge exchange' platforms will lead towards a culture of 'reflexive action'. Engaging a diversity of regions, actors, and methods, it underscores the necessity of understanding how energy can meaningfully address the challenge of poverty, and how the pursuit of SDG 7 can entail the integration of the different SDGs. EPEI demonstrates that there is no one-size-fits-all approach to energy access. Each community project must include local stakeholders and practitioners, from the initial stages of collaboration and consultation, to final stages of planning, development, and implementation, as well as future management and maintenance. Understanding and moderating the role of energy in society such that energy transitions eliminate systemic poverty, will not be advanced by universalist, natural laws-based approaches. Instead, we argue for a grounded, co-evolving and relational construct of the energy-poverty nexus, requiring continuous exploration by and with the very communities that need access to clean, resilient, and sustainable energy systems. The EPEI initiative is entrenched in place-based and people-centric co-production of knowledge for heterogeneous transitions and together with its constituent platforms, understands energy as socio-technical systems that shape, refract, and drive energy production and distribution. Energy technologies do not function in isolation; they are integrated with diverse forms of social organization and work, including finance, labour, management, markets, and infrastructure. These arrangements are essential to the distribution, operation, maintenance and expansion of systems to meet future needs and to the effective delivery of energy services. To create and implement effective socio-technical systems requires user-created and -centered approaches that are understanding and reflective of the co-production of local values and ecosystems.

The experiences so far also establishes the fact that exploration of social value and the design of programs and projects for SDG7 will be a long-term activity, driven by the goals of continual enhancements in the quality of life and well-being of people facilitated by energy innovation. Hence, the EPEI initiative continues to grow its network of partners to discovers and communicate new knowledge, forge new collaborations with researchers, practitioners and communities, and develop knowledge frameworks to support the design, planning and implementation of multiple energy transitions, particularly in communities around the world.

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Simulating stakeholders' participation: how is the climate awareness development process affected by city stakeholders?

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Abstract

As centres of population, cities are dealing with the challenge of climate change. Climate resilience has been developed to both mitigate and adapt to the predicted and unpredicted events caused by climate change. However, several factors such as local data and knowledge, level of resources, level of funding, level of awareness or socio-demographic characteristics determine the effectivity of the climate resilience plans. In this paper, we get focused on the awareness level of cities that is defined as having experience and knowledge about climate change as a hazard as well as increasing the attention by having willingness of taking action and participate in a committed and collaborative way to adapt and face the challenges of climate change. Hence, when defining the climate awareness development process, stakeholders level of participation is key. In this research, we present a framework that defines an effective roadmap to develop climate awareness and a simulation model that enables to simulate different scenarios. In detail, the paper simulates and further discusses four different scenarios with different stakeholders' participation. As a result, the importance and the role of each stakeholder composing a city during the climate awareness development process are discussed.

Keywords: Climate change, city stakeholders, awareness, collaboration, system dynamics

1. Introduction

Nowadays, most of the world's population lives in cities, and it is forecasted that 60% of them will live in urban areas by 2030 (United Nations 2016). A city is defined as a complex system of systems in which the interaction between the infrastructure, the ecological system, the socio-cultural system, the economy and the governance are assembled (Zhang and Li 2018). As complex systems, cities have been adapting to the challenges their surrounding have posed them throughout history. However, climate change (CC) sets a new global challenge due to its dynamism and uncertainty which in turn cause direct effects on the proper functioning of cities both in the long and short term (Moglia et al. 2018).

Recognizing their responsibility in increasing the effects of CC and in decreasing the vulnerabilities related to them, cities have attempted not only to reduce their impact on the environment but also to build resilience to be able to face the irreversible effects of CC and transform themselves into more sustainable urban areas (Moglia et al. 2018; Reckien et al. 2018). However, as complex systems, building climate resilience and becoming a sustainable city presents several challenges. For instance, the European Union in 2013 listed a set of barriers that would face cities in their way to become sustainable such as the lack of local data and knowledge, lack of resources, lack of funding, lack of awareness or socio-demographic characteristics. In other words, social, economical and ecological factors that define cities as complex systems need to be taken into account to shift these cities into resilient and become them sustainable.

In this paper, we focus on the social factor and the need to develop collaboration between the city stakeholders towards city sustainability. We followed Gimenez et al. (2017) in defining city stakeholders as "any individual, group or organization within a city who can affect or can be affected by the resilience-building process". We also classified stakeholders into different clusters, namely public entities (e.g. local governments, governmental associations), private companies (e.g. the private sector, academia or professional associations) and community groups (e.g. NGOs, civil society organizations, donors), as they are relevant to any discussion of awareness-development and resilience-building.

In this context, recent literature highlights developing awareness of not only public entities but also private companies and community groups as a key ingredient to achieve collaboration and consequently increase the effectivity of the climate-resilient building plans (Luís et al. 2018; Poponi et al. 2019). Awareness can enhance stakeholder's communication, proactivity and engagement, which leads to increase city resilience operationalisation and decreases the effects of CC (Luís et al. 2018).

However, even though the importance of developing awareness has been highlighted, a clear definition of how to develop stakeholders' awareness of CC is lacking (Mcdonald et al. 2019). In this vein, this study aims at addressing the lack of

procedures to develop awareness and analysing the effect of the participation of all city stakeholders when building climate resilience and becoming a sustainable city. This paper summarizes the results of a framework that defines an ideal awareness-development process published in Iturriza et al. (2020a) and demonstrates through a System Dynamics model the expected effect and relevance of the participation of the three types of stakeholders.

The article is structured as follows: Section 2 explains the need to develop stakeholders' climate awareness. The used method to analyse the effect of stakeholders' participation is described in Section 3. In Section 4, the results of the study are presented. Following, Section 5 describes the validation and discussion of the main results. Finally, Section 6 concludes with the main ideas of the study.

2. The need for city stakeholders' climate awareness

The literature presents different climate awareness definitions. In general, the frameworks that aim to build climate resilience at a city scale, define awareness based on the following attributes: experience, knowledge, attention and collaboration. In order to become aware of CC, it is important to perceive that CC is a relevant problem for the sustainability of our planet and consequently for our wellbeing. If we do not have a CC related experience and start perceiving CC as a problem, we are not going to take action towards its mitigation and adaptation (UNISDR 2009; Maraña et al. 2015; Neo et al. 2017; Prescott et al. 2019). Hence, experiencing and consequently being knowledgeable of the risks and the impacts caused by CC is a key factor in understanding how the problem of CC is essential to our wellbeing and how critical it is to deal with it (UNISDR 2009; Lieske et al. 2014; Larson et al. 2017; Neo et al. 2017; González-Hernandez et al. 2019; Prescott et al. 2019). Furthermore, climate awareness is materialized also as the level of attention we pay to CC. Defining attention as the willingness to act and participate in implementing the measures required to face the challenges posed by CC in an active and committed way (UNISDR 2009; Liu et al. 2010; Lieske et al. 2014; Sima 2016; Larson et al. 2017; Neo et al. 2017; Yin et al. 2018; Berndtsson 2019; González-Hernandez et al. 2019; Prescott et al. 2019). Finally, acting collaboratively helps improving and maintaining the level of awareness over time since collaboratively facing the problem enriches the communication among the stakeholders which consequently leads to a higher level of experience, knowledge and attention to face CC (Sima 2016; Yin et al. 2018; Prescott et al. 2019).

Recent studies highlight the positive effect of increasing awareness as it enhances stakeholders' proactivity, improves city resilience operationalization and the transformation into a sustainable city (Pietrapertosa et al. 2018; Liu et al. 2016; Al-awadhi et al. 2019; Olazabal et al. 2019). The president of 100 Resilient Cities, Michael Berkowitz (2016), in his plenary speech at the Habitat III Conference, highlighted the necessity of the stakeholders to act jointly to increase city resilience and said: "The story of resilience is one of collaboration—it takes all levels of government, the private sector, and civil society, working cooperatively toward a common purpose: reducing catastrophic risk and, at the same time, improving the daily lives of residents". Before him, Kapucu (2012), similarly said: "collaboration and partnerships which have been identified as two of the most important aspects of managing disasters, are also the most challenging ones".

In this context, it is important to bear in mind that each city stakeholder have self-interest and hence for public entities, private companies and community groups to collaborate, and proactively participate they all need to realise the benefits of doing so. The challenge is now to know how to develop climate awareness not only to align stakeholders' interests and objectives regarding climate resilience in their city but also to spread the idea that if the relevant stakeholders do not get involved and work jointly everything gets inefficient. In this article, we present a System Dynamics model to simulate different stakeholders' participation scenarios with the aim of understanding and analysing the effect and the relevance of all stakeholders' participation when developing climate awareness at city scale.

3. Methods

The System Dynamics method (SD) has been used to model the theory developed in Iturriza et al. (2020a) concerning climate awareness-development. The aim when using this method was to encapsulate the developed theory and study both the effect and corroborate the relevance of all city stakeholders' participation when developing climate awareness.

System Dynamics is a concept and a methodology to build quantitative models proposed by Jay W. Forrester of the Massachusetts Institute of Technology (Forrester 1961). SD is based on a top-down methodology, which makes it possible to analyse and manage complex adaptive systems involving interdependencies among elements of the system (Forrester 1961; Sterman 2000). SD is grounded in information feedback control theory and deals mainly with nonlinear dynamics, internal feedback loops, and time delays which influence the behaviour of the whole system (Forrester 1961; Roberts 1981). The key concept of SD is that all the objects in a system interact through causal relationships (Forrester 1961; Roberts 1981). Consequently, SD models allow decision-makers and managers to test alternative assumptions, decisions, and policies (Hsieh and Chou 2018). SD makes it possible to provide decision-makers and managers with a complete view of the modelled system by adopting a holistic perspective that could include social, environmental and economic aspects of that system (Sterman 2000). Furthermore, SD facilitates educating decision-makers and managers about the underlying system structure that influences the behaviour of the system (Sterman 2000).

For the case of our study, SD methodology provides several benefits. On one hand, SD allows effective modelling of socio-technical systems, consisting of human, organizational and technological parts. This is possible because the SD methodology allows models to deal with "soft" variables that cannot be quantified otherwise, but that are often important factors that influence the behaviour of other variables in the system (Forrester 1980). On the other hand, SD is used when the individual properties are not decisive and high-level aggregation is desired or required for management purposes (Sarriegi et al. 2008).

The SD models have a wide-range application and can be found in the literature with different applications and objectives (Iturriza et al. 2018). SD has been used in different disciplines of research such as engineering, scientific humanitarian sciences, economics, manufacturing and management, planning and logistics, healthcare, urban planning, etc.

To conclude, SD modelling methodology provides the following benefits to our study: (1) modelling the problems and interactions occurring between elements of the system and incorporates feedback loops that affect the system and (2) simulating short and long-term actions' effects and showing the intended and unintended consequences of these policies.

4. Results

In this section, we first summarize the climate awareness-development process. We follow this by presenting and discussing the effect and relevance of all stakeholders' participation in this process through the analysis carried out using our SD model.

4.1 Climate awareness development framework

The framework used in this research defines an ideal process to develop city stakeholders' climate awareness. Iturriza et al. (2020a) present more information about the conducted research in defining this awareness-development process framework and the created discussion. This section summarizes the main results to understand the theory encapsulated in the SD model and the consequent analysis of stakeholders' participation.

According to our followed awareness-development process framework, a stakeholder needs to go through four sequential steps when developing awareness toward CC. Starting with the lower level of awareness, "Step 1: Passive", and ending with the highest level, "Step 4: Synergies". In each of these steps, the values of the attributes that define climate awareness are described and hence, how awareness is developed through this step. In section 2 we defined the attributes for awareness in the context of climate resilience: experience, knowledge, attention and collaboration.

Furthermore, depending on the step, the roles of city stakeholders differ and their relevance varies. Table 1 summarizes the four steps and the participation of each type of stakeholders.

Table 1. *Four-step climate awareness-development framework (PU: public entity; PR: private company; CG: community group)*

		AWARENESS-DEVELOPMENT PROCESS			
		STEP1-PASSIVE	STEP2-STATIC	STEP3-PROACTIVE	STEP4-SYNERGIES
		Do we perceive the challenge of climate change?	Do we want to make a change?	What can we do to improve this situation?	Who else can be part of the group?
Description		CC events make stakeholders experience the effects of CC and start to perceive CC as a hazard and realize that action is needed.	Stakeholders accept the hazards related to CC and start to develop knowledge to better face it. Yet still proactive participation is low and incentives are needed.	Stakeholders understand CC and are willing to act as they focus their attention on dealing with CC. Stakeholders both understand and participate in a committed way to deal with CC. Yet each stakeholder acts separately	Stakeholders are proactive and act collaboratively against short and long term effects. Existing barriers disappear, silo-thinking is eliminated, and problems are faced holistically.
Participation	PU	Participation	High participation	High participation	High participation
	PR	No participation	No participation	Participation	High participation
	CG	High participation	High participation	High participation	High participation

STEP 1: PASSIVE

In the first step, the involved stakeholders still doubt the existence of the CC challenge such as temperature rise and extreme weather events. In general, during this step, there is passive behaviour when it comes to CC. In order to advance, the first requirement is to live a CC related experience and perceive that there is a need to change. The main question in this step would be to ask "do we perceive the challenge of CC?" Experiencing CC hazards is essential in this step, Suffering a CC event, increases stakeholders' experience and makes them realise that what has been done is not enough to face CC. Stakeholders start becoming aware of the existence of the problem and the need to act (Rogers 1975).

In order to advance to the second step, community groups are the ones leading through this step. In this sense, the role of community groups is to start the awareness process. Community groups carry out actions to affect both public entities and private companies, such as demanding their policies to change and demanding them also to be transparent regarding their emissions and counteracting decisions, to ensure that they have adopted and enabled good sustainable practices. Public entities participation is also relevant during the first step. Public entities are responsible for the dissemination of CC-related information and knowledge in a less technical and more accessible way through studies, workshops, participatory sessions and incentives, to start generating a sense of co-responsibility and behaviour change to increase awareness and consequently cities' resilience against the threat of CC.

STEP 2: ACTIVE

In the second step, stakeholders perceive and start acquiring knowledge and thus understand the vulnerabilities and hazards related to CC, yet stakeholders do not behave proactively. As a result, incentives that foster behaviour transformation should be designed. The main question in this second step would be “do we want to make a change?”. Having gained experience in CC in Step 1 enables having accessible information about CC that makes stakeholders understand and be aware of the risks concerning the challenge.

To advance to the third step, the active participation of community groups and public entities is still required to keep stakeholders engaged through more accessible and less technical language. However, one of the stakeholder types should lead the process of behaviour transformation and incentives through this step. In order to reach the third step, our research concludes that compared to the first step, higher participation led by public entities is necessary. In this sense, public entities are understood as the leaders of the needed change. To facilitate the increase of awareness and building of resilience to face CC, actions that set mandatory and non-mandatory incentives as well as new tools, such as a handbook of strategic procedures, should be put into practice. These type of participation has a direct effect on private companies, which will be boosted by companies to transform and start adopting new values for new business models.

STEP 3: PROACTIVE

In the third step, the already gained experience and acquired knowledge lead to an increase in attention, which in turn makes stakeholders more focused on and proactive to act and deal with CC. Yet, this proactive participation is only developed at an individual level. Each stakeholder acts separately, without considering possible synergies that could result from collaboration with others. Commitment is key to lead and act in a proactive way (Poponi et al. 2019). The main question in this step would be "what can we do to improve this situation?" The stakeholders are in a situation of alertness because of interest regarding CC, they have generated attention about it and consequently, recognise the vulnerabilities and hazards around them and act accordingly in facing them in a committed way. Even if incentives are applied, in this step actions are carried out altruistically because each stakeholder perceives personal benefits and good in doing so (Tàbara et al. 2010).

As in the previous steps, the participation of both community groups and public entities is still relevant and needs to be kept over time. However, in order to advance to the fourth step, private companies need to increase their participation and pursue sustainable production and consumption of resources. They should not only seek profit but also generate environmental and social benefit such as social vulnerability reduction. For example, investing in sustainable technology makes companies reduce their emissions, which reduces pollution and increases social welfare.

STEP 4: SYNERGIES

In the fourth and last step, the experience, knowledge and attention achieved in the previous steps are shared and collaboration between stakeholders is created in a multilevel way. Stakeholders not only have the experience to deal with CC and know about CC effects, but they also are focused and have their attention on what needs to be done and to act in a committed collaborative way against long term effects. In this step, stakeholders seek both personal convenience and a universal good that might not directly result in personal benefits. Therefore, the behaviour in this last step means being in a process of constant change and improvement as existing barriers disappear, silo-thinking is eliminated and stakeholders start to face problems in a collaborative way (Kaluarachchi 2013). Based on the experience gained during the whole process, new daily habits are introduced, new collaboration networks are created, and new needs appear. The main question in this fourth step would be “who else can be part of the group?”.

Consequently, in this last step, the effectiveness of plans increases as stakeholders are committed and acting jointly (Toubin et al. 2014). The newly created collaboration networks facilitate communication not only inside the city but also among other cities (Kaluarachchi 2013).This, in turn, makes it easier to introduce plans and make them more effective. Accordingly, for the last step to be maintained over time, all the stakeholders need to be engaged and carry out sensitisation, transparency and knowledge exchange activities.

4.2 Simulations

The four steps described in the previous section can be more deeply understood by analysing the SD model that encapsulates the developed theory. The following sub-sections describe first how the model captures both the structure and the behaviour of the framework presented in Iturriza et al. (2020a) and then the analysis of the conducted simulations concerning stakeholders’ participation is further discussed.

4.2.1. Structure

Figure 1 shows the conceptual structure of the model by summarizing the key variables and relationships composing the model. Whereas Figure 2 shows the SD model built for this study. Only the example of public entities is shown in Figure 2 as the model replicates the variables and relationships for private companies and community groups. SD models are visually represented in a Stock-and-Flow diagram. Stock-and-Flow diagrams can represent a system in a way that the variables included in the model, and the relationships among them can be translated into mathematical formulas. In a Stock-and-Flow diagram, stocks represent the accumulation of material or state variables and are portrayed as rectangles. On the other hand, flows are represented as valves that control the inflow or outflow to and from the respective stocks. Other variables involved are called auxiliary variables. This kind of variables is necessary to close causal relationships inside the system. Moreover, the arrows that connect variables in Stock-and-Flow diagrams represent the causal relationships so that if variable A is affected by B, an arrow will connect both and the mathematical formula defining A will include the value of B. Our SD model depicts the steps of the defined framework, the attributes and also the policies that each city stakeholders should implement to represent its participation. Each stakeholder can implement three policies that have been defined following a co-creation process described in Iturriza et al. (2020b). Public entities are named under the acronym PU, private companies PR and community groups CG. Table 2 summarizes these policies. The policies are related to each other and the implementation of one policy might affect the effectiveness of the implementation of the other policies. Indeed, the order in which the policies are implemented is crucial in developing climate awareness

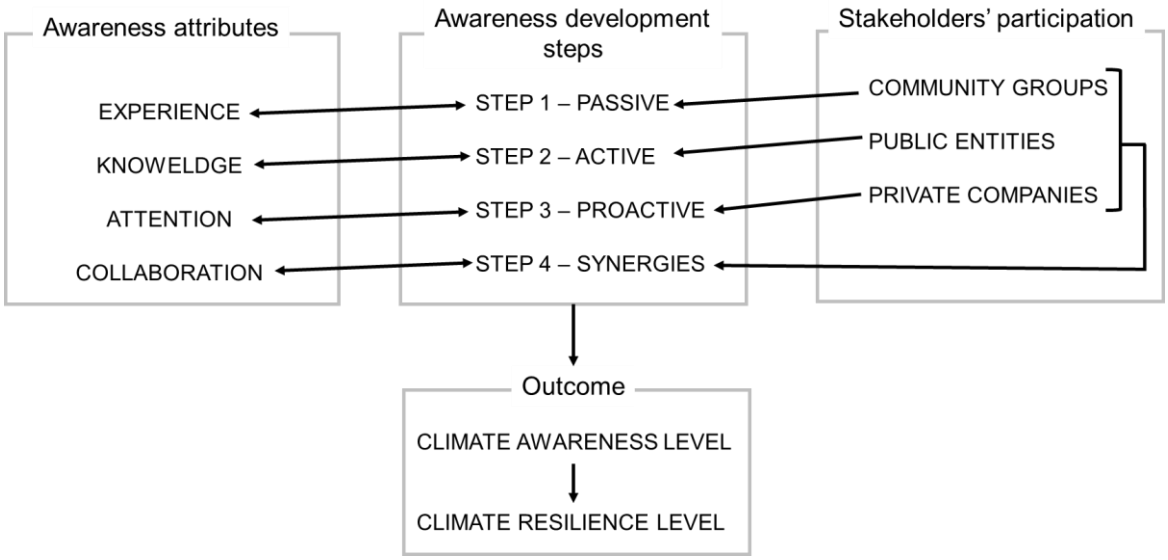

Figure 1 Summary of the main variables and relationships of the SD model

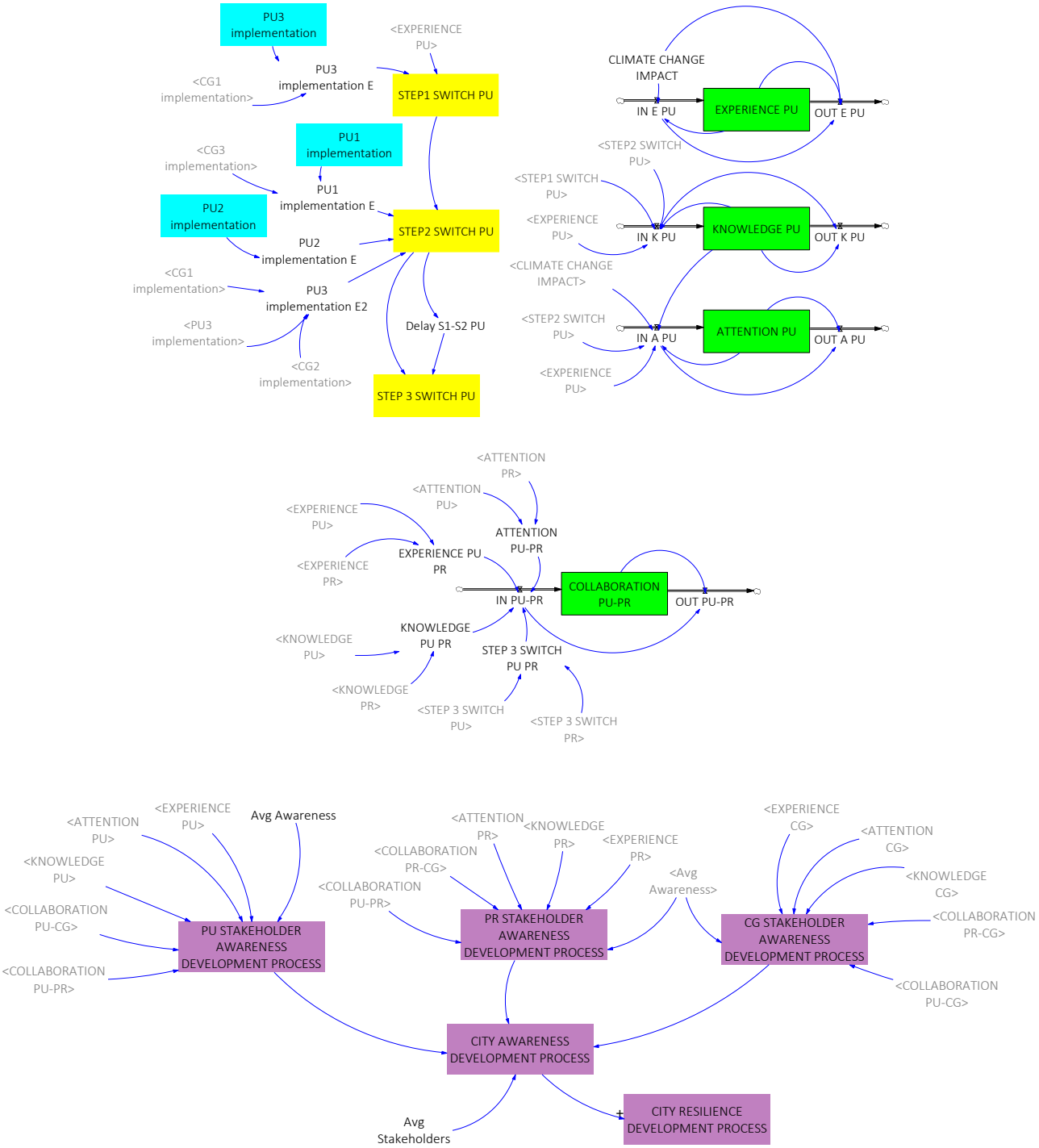

Figure 2 SD model encapsulating the climate awareness framework (only the example of public entities is shown)

Our SD model considers the theory described in section 4.1 and simulates different scenarios depending on the participation of the stakeholders. Also, as each stakeholder might be at different step of the climate awareness development process, the model simulates the awareness attributes for public entities, private companies and community groups separately (see Figure 2). This way, the model can simulate for example cities in which public entities have developed higher awareness levels than the other stakeholders.

The participation of the stakeholders is represented in the model through the implementation of the policies defined in Table 2. Depending on the implementation order of the policies (policies are shown in blue in Figure 2), the group of auxiliary variables named “STEP SWITCH” with a number in the middle (switches are shown in yellow in Figure 2) are activated. Activating a “STEP SWITCH” means that the stakeholder participation to advance from one step to the next has been achieved. Based on that, the inflow of each attribute (attributes are modelled as green Stocks as shown in Figure 2) increases and consequently the value of the attribute increases over time.

Following the theory presented in section 4.1, when a CC related event is suffered, experience is gained and awareness starts to be developed. In order for the city to advance from Step 1 to Step 2 of the awareness-development process, the participation of community groups and public entities is required. When the key policies are implemented, "STEP 1 SWITCH" is activated which moves the Stakeholder to Step 2. In Step 2, the available quantity and quality of knowledge concerning CC have increased and hence the knowledge increases as well. To move to Step 3, community groups' participation needs to be maintained and public entities' participation should increase. This way "STEP 2 SWITCH" is activated and Step 3 is reached. Consequently, attention is generated and stakeholders start to act proactively against CC. The participation of community groups, public entities, and also private companies is vital at this point to activate the last switch and move to the fourth and last step of the awareness-development process. At this step, the highest climate awareness is reached and maintained over time due to the created collaboration networks. Finally, the purple auxiliary variables (shown in Figure 2) represent the reached climate awareness level and the consequent city resilience effect. The climate awareness level depends directly on the average of the reached values of the attributes: experience, knowledge, attention and collaboration.

Table 2 Policies to be implemented by the stakeholders as defined in Iturriza et al. (2020b)

	POLICY	DEFINITION
PUBLIC ENTITIES (PU)	PU1: development of norms and sustainable procurements	Adoption of existing and new norms, standards and sustainable procurements that incentive private and community groups to develop CC awareness and increase city resilience.
	PU2: provide toolkit to develop plans against CC	Developing tools such as an online best practice repository or a handbook of strategic procedures, to facilitate the process of building and implementing a resilience plan to face CC.
	PU3: sensitization actions	Carrying out sensitization actions such as incentives to recycle, studies about CC, workshops concerning sustainability habits or creative participatory sessions with any of the three stakeholder group.
PRIVATE COMPANIES (PR)	PR1: corporate responsibility actions	Carrying out transparency actions such as publishing the companies’ emissions, sharing consumption data, communicating information about taken sustainable actions, financial movements or sharing the problems and barriers found in the process of developing sustainable habits.
	PR2: adoption of new values for new business models	Adoption of new business values such as the adoption of an inclusive and sustainable economy, low carbon emission practices or sustainable habits like recycling and pursue sustainable production and consumption of resources.
	PR3: development of new technologies for new business models	Developing technologies to transform private companies into new business models that not only seek profit but also generate social benefit such as social vulnerability reduction.

	POLICY	DEFINITION
COMMUNITY GROUPS (CG)	CG1: organize events and workshops	Organizing events and workshops to discuss the main concerns and problems derived from CC such as lower social welfare due to the effects of CC or vulnerabilities due to new climate scenarios.
	CG2: organize campaigns	The policy consists of organizing campaigns through social networks, media or physical events to create a positive impact on the three stakeholders' awareness.
	CG3: demand a change	This policy consists of demanding public entities and private companies' a change in the way they are facing the challenge of CC.

4.2.2 Scenarios

Our SD model allows conducting different simulations and representing different contexts that might be happening in the city. In this section, we use the model to simulate the following four scenarios:

- **Scenario 1**: The participation of **community groups and private companies** is attained gradually and consecutively. Yet, public entities do not participate proactively.
- **Scenario 2**: The participation of **public entities and private companies** is attained gradually and consecutively. Yet, community groups do not participate proactively.
- **Scenario 3**: The participation of **public entities and community groups** is attained gradually and consecutively. Yet, private companies do not participate proactively.
- **Scenario 4**: The ideal case in which the participation of **city stakeholders** is attained gradually and consecutively.

As awareness development depends on the experienced CC related events, in the model we have introduced a series of CC related event impacts (represented in Figure 3) in which six consecutive impacts are suffered. The first two impacts have the same magnitude, while the others decrease in magnitude. Each of these impacts could be denoting, for example, a certain amount of damage due to unexpected wild floods or extreme cyclones. This series of the four CC related events are maintained the same in the four scenarios for the analysis and comparison of the results of the different scenarios to be straightforward. It should be noted that aside from having two high impacts and two low impacts, their absolute numerical values as shown in Figure 3 are arbitrary, yet the simulated time correspond to weeks.

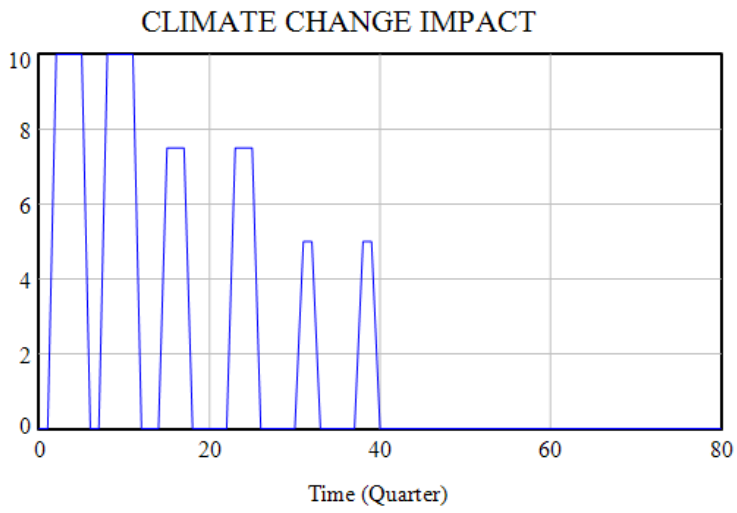

Figure 3 CC related impact introduced in the model for the four scenarios

SCENARIO 1

In the first scenario, the series of the CC related impacts shown in Figure 3 are introduced to the SD model. Only the policies lead by community groups and private companies are implemented. This way, the SD model simulates the scenario of a city that has suffered four consecutive CC impacts and only community groups and private companies react to both mitigate and adapt to CC, but not public entities.

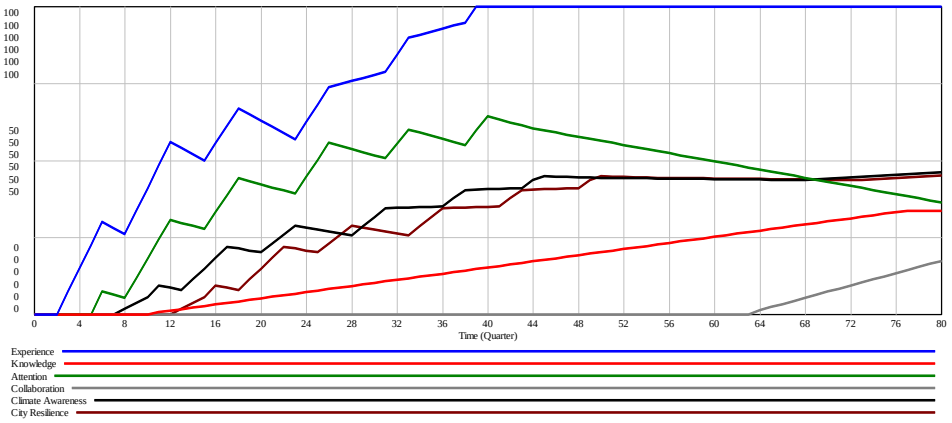

Figure 4 Results for Scenario 1

Figure 4 shows the behaviour of the model variables concerning awareness attributes: experience, knowledge, attention and collaboration. The figure, besides, shows the resulting stakeholders' awareness, and city resilience over the simulation period from simulating the model using the settings of Scenario 1. The experience reaches its maximum value of 100% due to its dependency on the suffered CC impacts. The other attributes, knowledge, attention and collaboration, however, are not developed to their 100% value. The attention illustrates six peaks related to the six suffered CC impacts, as stakeholders increase their committed participation abruptly when a CC related event happens. Nonetheless, as public entities are not implementing policies in this scenario, the accumulated attention due to the lived CC experience starts to decrease as time elapses given that no new impacts are suffered. The knowledge increases to a low value as private companies are participating but do not have either pressure or guidance from public entities to what should be done. Finally, collaboration is not significantly developed as to do so public entities need to act against CC.

Hence, public entities are responsible to boost and maintain the committed participation of both community groups and private companies (Wamsler and Raggers, 2018). At least in the first steps of the process to develop climate awareness, public entities are the ones to create and transfer the knowledge among stakeholders and facilitate to increase CC understanding. Hence, not having their participation in the first steps hampers the development of both knowledge and attention about CC as well as collaboration. The awareness and consequently city resilience do not reach their maximum values, as lacking public entities policies' implementation in the initial steps of the process decreases effectiveness of the other stakeholders' policies' implementation. Indeed, the reached awareness values are the consequence of the experienced CC related impacts that create a sudden increase in variables like experience and attention. Yet, these values are not maintained at the same level over time if new impacts are not suffered and hence, awareness and consequently resilience decrease too.

SCENARIO 2

In the second scenario, only the policies led by public entities and private companies are implemented and the CC related impacts shown in Figure 3 are introduced to the SD model as well.

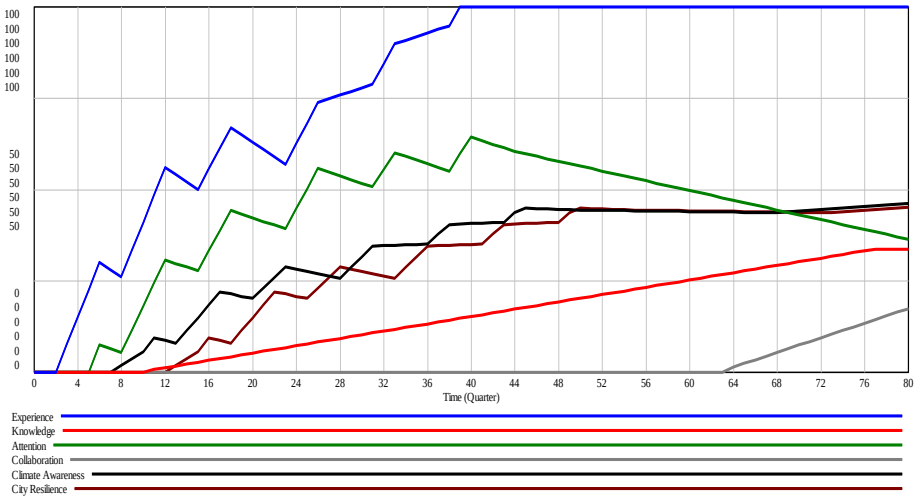

Figure 5 Results for Scenario 2

Figure 5 shows the results of Scenario 2. The behaviour of model variables is similar to the one in Scenario 1. On the one hand, since the experience attribute is not dependent on the stakeholders' participation but on the suffered CC impacts, and the CC impacts introduced in the model are the same for both scenarios, the behaviour lines are similar. On the other hand, both attention and knowledge of the stakeholders present the same behaviour in the first and second scenario because the implementation of community groups' policies is equally relevant in the initial steps of the awareness development process. Collaboration is residually developed as community groups are not dealing with CC as well.

Nonetheless, when it comes to developing climate awareness the role of community groups differs from the one explained for public entities in the previous scenario. Community groups are usually the city stakeholders that demand change. They boost the effort of not only public entities but also private companies and other community groups to increase their attention and participation to CC. In addition, concerning climate knowledge, community groups are responsible to process, transfer and adapt the developed information (Koch et al. 2017).

Similar to Scenario 1, it could be concluded that if community groups do not implement policies in the first steps, efforts to develop both knowledge and attention concerning CC, as well as collaboration among stakeholders, will be hampered. In this scenario, awareness and consequently city resilience-building process do not reach their maximum values, as lacking community groups policies' implementation in the process decreases the effectiveness of the other stakeholders' participation. Indeed, the reached awareness values are the consequence of the suffered CC related impacts that create a sudden increase in variables like experience and attention. Yet, these values are not maintained over time if new impacts are not suffered and hence awareness and consequently resilience decrease as well.

SCENARIO 3

In the third scenario, the CC related impact introduced in the previous scenarios is maintained and only the policies led by public entities and community groups are implemented. Hence, in this scenario, public entities and community groups react to both mitigate and adapt to CC, while private companies do not.

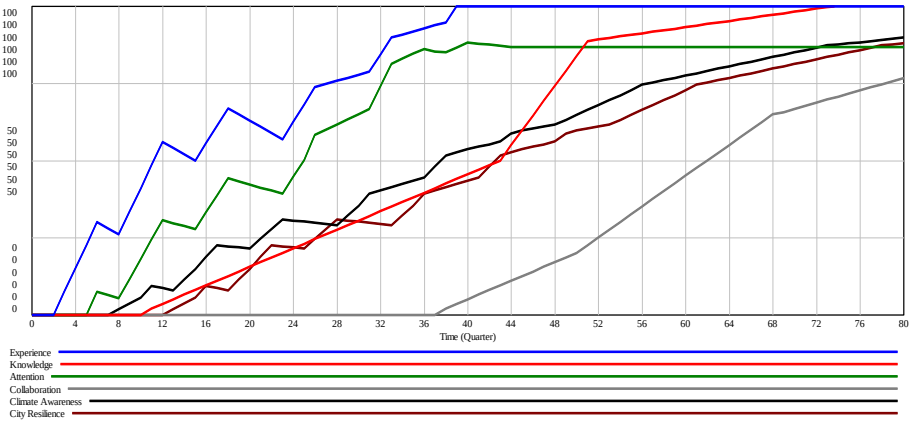

Figure 6 Results for Scenario 3

Figure 6 shows the results of Scenario 3. The experience reaches its maximum value as its increase depends on the experienced CC impacts. However, the attention presents a different behaviour to the previous scenarios. It increases also due to the experienced CC impacts, yet even if new impacts are not suffered, the reached attention level is maintained over time. The reason for this is that both the participation of public entities and community groups in the initial steps maintains the committed participation over time. In this vein, the fact that knowledge reached its 100% has a lot to do. As being knowledgeable of the challenge of CC and the need to act keeps the attention over time. Moreover, it is highlighted that knowledge reaches its 100% value with a constant increase and with a delay compared to the other variables. In this sense, understanding development should be faster to properly mitigate and adapt to CC, indeed having experience about how to deal with CC and generating attention to be focused on the issue is not enough. In this context, private companies are the stakeholders in charge of providing the goods and services to society. From that point of view, they are responsible for developing knowledge and transferring the understanding as they have the expertise (Bolouta and Pitelis 2014). Indeed, the lack of private companies participation affects the increment speed of understanding that is slower than desired. This fact leads attention and collaboration not to reach 100%. Finally, the collaboration shows higher values than in the previous scenarios as in this third step having high experience and attention values make stakeholders interact and start creating synergies. However, as private companies do not participate and thus the knowledge is not fully developed, the created collaboration networks are not as relevant and effective.

Hence, awareness and consequently city resilience-building process do not reach their maximum values, as lacking private companies' policies' implementation in the process decreases the effectiveness of the other stakeholders' participation.

SCENARIO 4

In the fourth and last scenario, the CC related impacts introduced in the previous scenarios is maintained and all the policies led by all types of stakeholders are implemented. Accordingly, public entities, community groups and private companies react both to mitigate and adapt to CC.

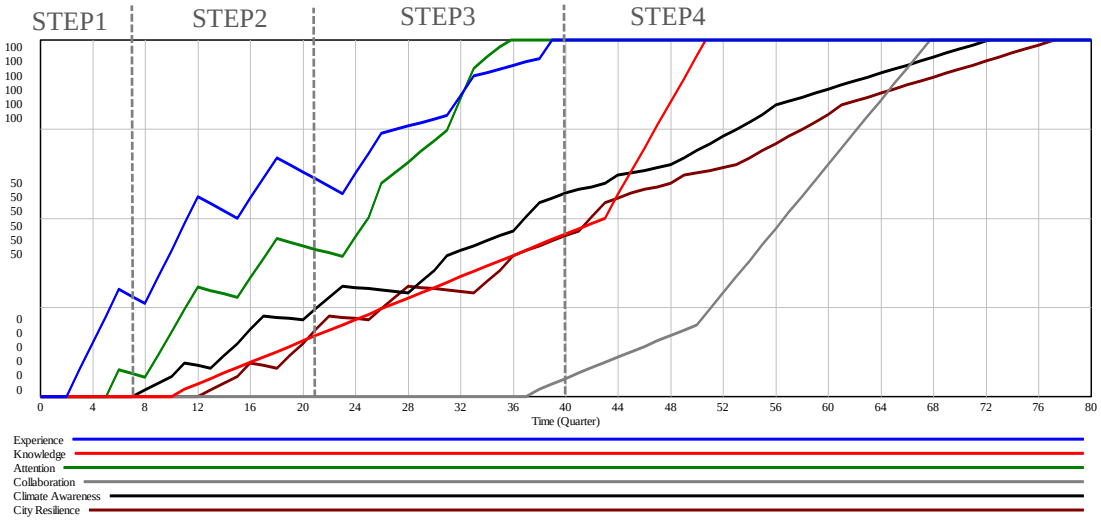

Figure 7 Results for Scenario 4

Figure 7 shows the results of Scenario 4. The experience reaches its maximum value as its increase depends on the experienced CC impacts. Both knowledge and attention of the stakeholders are developed to 100%. Attention shows a similar slope to experience at the beginning as this increase is related to the suffered CC impacts. Yet afterwards the increase is related to the participation of the three stakeholders type that are implementing the policies to deal with CC. Also, the implementation of private companies' policies speeds up the increase of knowledge. Compared to Scenario 3, the maximum knowledge level is achieved in a shorter period of time. Finally, collaboration is reached as a consequence of the participation of all stakeholders. From all the attributes, collaboration is developed the last as is dependant on the experience, knowledge and attention levels of all the stakeholders.

Scenario 4 highlights the relevance of the participation of all city stakeholders as stated in the theory presented in section 4.1. In fact, the four steps of the awareness development process are illustrated in Figure 7. The figure shows how public entities are proactive leaders when dealing with CC in the initial steps. They attempt to guide both community groups and private companies through the awareness development process. In fact, public entities are concerned with implementing mandatory actions, making knowledge accessible to facilitate understanding and boosting committed participation about CC. Community groups play a relevant role when developing CC awareness as well. In fact, community groups are considered an active resource in the society, one resource that can deal with CC and play a vital role in generating attention by demanding a change and participating in that change. Finally, the need for the participation of private companies is highlighted as well in this scenario. Private companies can be counted as actors who develop key knowledge to mitigate and adapt to CC. Their active participation is essential in developing knowledge in a timely and efficient manner in addition to maintaining the reached climate awareness and city resilience levels over time.

5. Validation and discussion

The curves shown in section 4.2.2 were further validated and discussed with 10 experts in the fields of urban planning, sustainability and CC through semi-structured interviews (see Table 3). The interviews aimed to ensure that our SD reproduced behaviours similar to real cases. To that end, all participants were asked the same five questions concerning how the four-step awareness developing process was explained through the over-time behaviour of each of the attributes and the relationships among them.

Table 3 Participants in the semi-structured interviews

	Expertise	City (country)
PUBLIC ENTITIES	Urban planner	Rome (Italy)
	Sustainability Officer	Bristol (UK)
	Environment department technician	San Sebastian (Spain)
PRIVATE COMPANIES	ICLEI, Sustainable resources, climate and resilience	Freiburg (Germany)
	German climate service centre, Climate impacts and economy	Hamburg (Germany)
	Sinnple, Social innovation and change	San Sebastian (Spain)
	Laia, Sustainability management	Beasain (Spain)
COMMUNITY GROUPS	Social dynamics	Kristiansand (Norway)
	Decision making	Glasgow (UK)
	Knowledge management	Albany (USA)

Overall, the experts agreed on the awareness definition presented and corroborated that the attributes and how they were obtained explain the climate awareness development process. In this sense, the social dynamics expert (see Table 3) argued that the framework is trustworthy, as the theory presented resembles the behaviours explained by Endsley (1988). Endsley's study defines awareness for the specific case of aircraft pilots, where the interaction of perception, understanding and projection could resemble the attributes defined in this research: experience, knowledge, attention and collaboration.

Moreover, practitioners also agreed that what is important about the graphs is not the absolute values but the shapes of the curves. The participant from the German climate change centre stated that the difference between participation and understanding in Step 2 of the framework is that the increase in participation was influenced by the impacts experienced. Similarly, the social dynamics expert pointed out that the experience gained from one impact to another might be cumulative, but it should also decrease as time makes city stakeholders forget past experiences. Indeed, this kind of expertise was introduced in the SD model so that the graphs in section 4.2.2 represent the described behaviour.

This research presents an SD model that encapsulates a theory of how to develop climate awareness at the city scale in an efficient and effective way. The model aims to depict through mathematical formulas the developed theory and facilitate the simulations that analyse the effect of the participation of the city stakeholders while developing climate awareness. The results of these formulas were further discussed with 10 experts to ensure they resemble real case behaviours.

Figure 8 illustrates the climate awareness development for four different scenarios that have been analysed in this article in section 4.2.2. Based on the results of these scenarios, we can conclude that in order for climate awareness to be developed effectively and efficiently, all stakeholders have to participate as their role is crucial during the process. As illustrated in Figure 8, Scenario 4 in which all stakeholders participate in developing climate awareness, the highest awareness level is reached. Whereas Scenario 1 and Scenario 2 are the simulations with lower awareness levels as the participation of both public entities and community groups are key to develop and maintain climate awareness over time. Finally, Scenario 3, in which private companies do not participate, shows a better scenario than in Scenario 1 and 2, yet the role of private companies is key to increase knowledge over time.

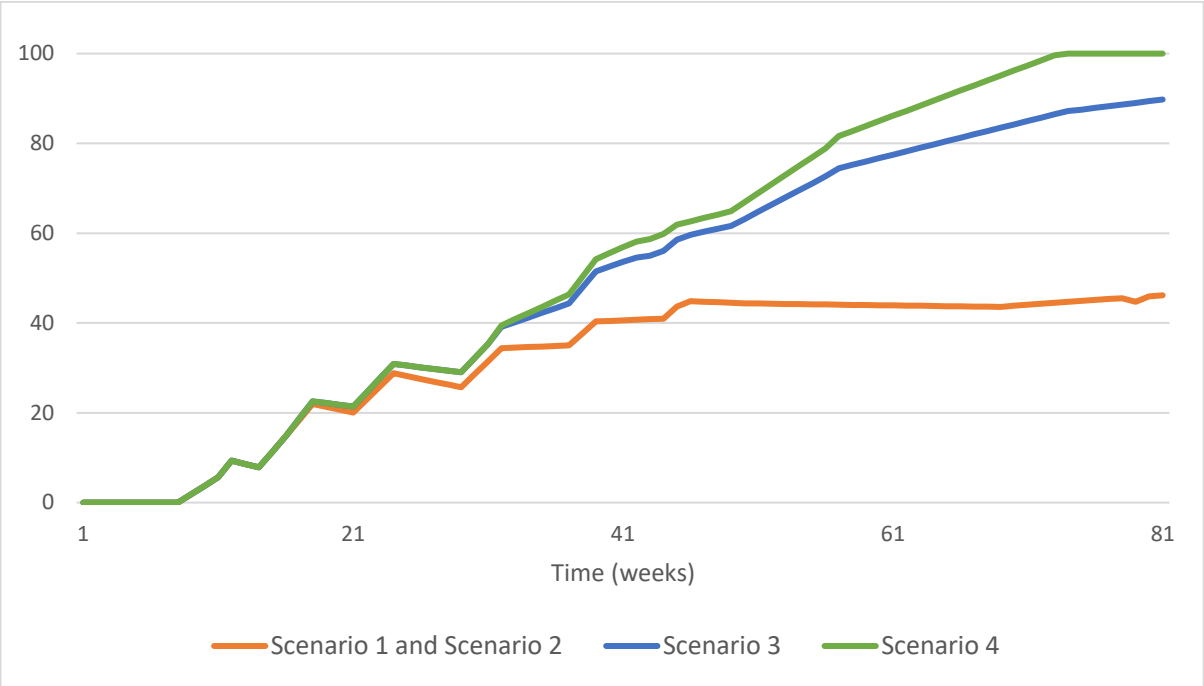

Figure 8 Climate awareness development comparison among scenarios

6. Conclusion

The results explained in this article highlight the importance of developing stakeholders' awareness to implement the already existing climate resilience plans at a city scale more efficiently. Awareness has the ability to enhance stakeholders' proactivity, improve city resilience operationalization and boost the transformation into sustainable cities. Nonetheless, there is a gap in the literature when it comes to how climate awareness should be developed. This article has summarized the framework that defines the climate awareness development process, and based on this framework we have presented and further discussed the effect and relevance of all stakeholders' participation in the process through an SD model.

The framework and accordingly our SD model has grouped the city stakeholders under: (1) public entities (e.g. local governments, governmental associations), (2) private companies (e.g. the private sector, academia or professional associations) and (3) community groups (e.g. NGOs, civil society organizations, donors). After carrying out four different simulation scenarios using our SD model and analysing the obtained results, this study concludes that the participation of the three types of city stakeholder is essential for developing climate awareness at city scale as all the stakeholders play a relevant and crucial role in the process.

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"Future is Now: Science for Achieving Sustainable Development" – the Global Sustainable Development Report 2019

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Abstract
Before leaving office, former Secretary-General of the UN Ban Ki-moon appointed the Independent Group of Scientists (IDS) comprising 15 experts to draft the Global Sustainable Development Report (GSDR). The Report is a key component of the mechanism to follow up and review progress on the recently agreed 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs). It aims to strengthen the science-policy interface and provide a strong evidence-based instrument to support policymakers in promoting poverty eradication and sustainable development. The document is intended to provide guidance from a scientific perspective that supports the implementation of the Sustainable Development Goals and the 2030 Agenda in ways that integrate economic, environmental and social dimensions. It is available for a wide range of stakeholders, including business, civil society, and the public. In the Report, we argue that the value and transformative potential of the 2030 Agenda is more than the sum of its 17 SDGs and 169 indicators. It is not only a unique normative compass, but it also represents a vision of how natural resources could be best shared for the well-being of the 9 billion people who will soon populate this Earth. The assessment is based on a total of 65 global assessments comprising the United Nations flagship reports and international scientific assessments, as well as 112 scientific articles published since 2015 with explicit reference to the sustainable development goals. Not all pathways and transformations towards achieving any given goal or target in the Agenda are equivalent in terms of their implications for the others. The Report presents a global system model comprising six major transformations – human well-being and capabilities, sustainable and just economies, sustainable food systems and healthy nutrition, energy decarbonisation with universal access, urban and peri-urban development, and global commons. Selected transformations are critical if the sustainable development goals are to be met by 2030 in ways that will ensure sustainability for both current and future generations. At the same time, means and levers of transformations include governance, consumption and production (including financing), individual and collective action, and society and technology. At the heart of this Report is a fundamental belief that the purpose of the economic system is to improve the well-being for all within the limits of what the planet can sustain. When we think about the kinds of changes that will be required for the development towards sustainability, it is tempting to focus on the practical issues like financial regulation, taxation or reduction of carbon intensity. Unfortunately, much more needs to happen, and quite quickly, to bring about the required transformative changes. The thermodynamics makes it clear that humans must find ways to balance the economic subsystem with the Earth's evolutionary and morphological processes, or the planet will use its own mechanisms to restore the balance. This paper deals with the ways the elaborated system model could be used to search for policy-relevant solutions transforming the society towards sustainability on global, regional or country level. While the Report as a product focuses on producing knowledge for transformations to sustainable development, IDS views GSDR also as a process that can advance the collaborations between science, policy, and society.

Keywords: Global Sustainable Development Report, sustainable development goals, systems approach, transformations, science – policy interface

1. Introduction

Since the adoption of the 2030 Agenda and Sustainable Development Goals, countries all over the world have started the process of incorporating SDGs into national plans and strategies and, in some cases, linked them to national budgets. At the same time, the mobilisation of society and non-governmental organisations towards the implementation of sustainable development principles was rising.

However, despite the initial efforts, the world is not on track to achieving most of the 169 targets that comprise the Goals. The limited success in progress towards the Goals raises strong concerns and sounds the alarm for the international community. Alarming is the fact that recent trends along several dimensions with cross-cutting impacts along the entire 2030 Agenda are not even moving into right direction. Four in particular fall into that category: rising inequalities, climate change, biodiversity loss and increasing amounts of waste from human activity that are overwhelming the capacities to process them. Thus, advancing the sustainable development must involve an urgent and intentional transformation of socio-environmental–economic systems, differentiated across countries but also adding up to the desired regional and global outcomes to ensure human well-being, societal health, and limited environmental impact (GSDR, 2019).

Governance of transformations to sustainability represents a hugely complex challenge, requiring coherent activities across multiple sectors and scales. New technologies alone will not deliver transformations to sustainability. As Mazzucato and Perez (2014) note, for example, “renewables alone do not constitute a synergetic technology system that results in a long wave for the economy”. A green long wave 'golden age' would need to include “conservation, pollution control, reduction of material content per product; designing for durability; replacing products, possession and waste with services, rental and maintenance and recycling, respectively; promoting the flourishing of the creative economy; making cities more liveable and less polluting; revamping transport systems and the built environment; promoting collaborative and sharing economies; focusing on health (including preventive and personalised medicine); and promoting all forms of education, in and out of schools” (Mazzucato and Perez, 2014). Strict environmental regulation, introduction of sustainability and welfare indicators, scepticism about the GDP indicator as a relevant guide for public policy, acceptance of lower material consumption levels without severe losses of happiness, reduction of status competition in consumption, and more cooperation at the community level are the main multipurpose instruments. It is important to note that one of the mentioned issues can translate into problems associated with another and the timing of the application of different strategies is very important. The SDGs need to act as a system of interacting components that together move the world into a safe and just operating space. Studies show that the SDGs are much more than just a collection of targets, but rather a system of synergistic reinforcement. While no single SDG has the power to transform the world alone, the whole set of SDGs together does.

We are often locked into unsustainable patterns of production and consumption through a complex mixture of factors, some of them institutional, some of them economic, some of them to do with infrastructure or lack of infrastructure, and some of them social or psychological in nature. As far back as Adam Smith, economists have struggled with the paradox of value, where diamonds are socially useless, yet expensive and water – essential to our lives – is infinitely cheaper. If we rely on the unregulated market to price everything, then we will find ourselves in the ultimately self-defeating situation where we only value life-giving water once it has become scarce and polluted. The effects of this can be seen on the non-market economy, or the core economy. The core economy is made up of all the unpaid labour that is crucial to keeping society and communities functioning – the time that is put into caring for older people, volunteering for the community, exercising democratic rights to protest, and raising children. These tasks (disproportionately carried out by women) have also systematically devalued as the market economy encroaches on the time that can be committed to them. Where markets have emerged in these activities they are poorly rewarded, making up the notorious ‘5Cs’ – cleaning, cooking, care, clerical and cashiering (New Economics Foundation, 2010).

In the sustainable development approach, this socially defined concept of value is placed at the centre of decision-making and progress towards it is measured. In public policy, achievement of such value would be instituted as the central goal. Instead of living with the consequences of spiralling inequality and climate change whilst politicians are applauded for achieving economic growth, politicians would be held to account on the social and environmental as well as economic outcomes that they achieve. Policy decisions would be audited across the ‘triple bottom line’ using approaches such as Social Return on Investment (SROI).

However, it is not just in the public sector that this new socially defined concept of value would have an effect. Involving businesses makes this potentially transformative. A ‘great repricing’ that aligns prices with value would be instigated. This would require businesses to take full account of the costs of any (unintended) negative consequences. Through intelligent use of the tax system, the price paid by the final consumer would be aligned with the real value (New Economics Foundation, 2010).

Take the example of wooden furniture manufacturing. At the moment, a manufacturer is not penalised for sourcing wood unsustainably. They pay for the wood, make their chairs and put a price on them based on whatever their costs were and the margin they want to make. If we value forests and require anyone that buys unsustainable wood to pay for the environmental costs of deforestation, then the price of the unsustainable wood and/or the furniture made from it would go up relative to

sustainable wood sourced. Similarly, food grown locally is often more expensive than that shipped around the world, not least because the environmental costs of the transport involved are not reflected in the price. Repricing in line with what we value would fundamentally change incentives for consumers and hence for business – there would be a significant disincentive to activities that lead to social or environmental harm and an incentive to do good as this would lead to greater price competitiveness. Successful companies would be those that create the most social and environmental value. Those that are destructive of this value would not be able to compete, forcing them to change their ways or to go out of business (New Economics Foundation, 2010).

Researchers and practitioners already have explored and proposed imperatives and implementation mechanisms for fostering the sustainability of production-consumption-systems (Lorek and Spangenberg, 2014):

- Innovations in production processes significantly reducing the environmental impact per unit made;
- Producers are responsible for waste generation and for waste from the disposal of products at the end of their life. Production waste prevention and waste as a resource (industrial ecology) are the highest priorities of waste management;
- Consumers, researchers and authorities are involved in the design and redesign of products to meet functions with significantly less environmental impact;
- Producers provide services rather than sell products; this reduces the number and life-time of products made while still providing to consumers the functions they need (product-service systems);
- Production companies impose the same standards on their suppliers and partners internationally to improve environmental and social performance;
- Consumers buy labelled products, based on independent certification. Unethical practices in marketing and advertising are restricted and based on product information only;
- Behaviour change by education of consumers about impacts of individual products, classes of products, and consumption patterns. Any change to be significant must include a shift of institutional settings (rules, laws, habit preferences). Otherwise, it can only call upon people to behave ‘right’ within ‘wrong’ structures, resulting in a rather limited potential for change.

To reach a society were all – or at least most – of the elements listed above can be well established, some fundamental transformations in societies have to take place, for instance, (I) support from powerful actors, like WTO and big business organisations, influencing the structures which are dedicated to make sustainable consumption an issue of public debate, (II) for consumers, policy and business decision makers to introduce scenarios as a means to assess the social, economic and environmental impacts, risks and costs and their trade–offs, (III) increase the demanding responsibility of governments to implement, monitor and enforce sustainable consumption strategies and action plans, because delegating such responsibilities to social actors means for them ‘participation overkill’ rather than achieving real-world changes, (IV) appreciation of the potential of social innovation, which still remains insufficiently explored, the efforts of scaling up extremely limited and the political macro structures to foster this process undeveloped, (V) NGOs, through closer cooperation with academia, could play a catalyst’s and initiator’s role, because often grassroots networks stimulate and catalyse their members and supporters, inform, motivate and link them.

As the necessary reduction of environmental impacts calls for shrinking instead of growing markets, sustainable economies revalue the contribution of non-market activities for human well-being like sharing or voluntary work. Thus, the already existing enabling mechanisms for sustainable consumption have to be consequently developed to meet a strong sustainable consumption approach (Lorek and Spangenberg, 2014).

While economists are typically emphasising carbon pricing as a policy tool to tackle global warming, natural scientists and multidisciplinary environmental research groups argue for deeper political engagement and proactive economic transition governance (Barnosky et al., 2014). This difference in perspective is in part due to the relatively recent advancements in

environmental research, measuring a faster-than-expected decline in natural ecosystems and taking into account the whole range of human-induced pressures, not just climate emissions (Jarvensivu et al., 2018).

The biggest transformative potential of the 2030 Agenda does not lie in pursuing a single goal or target but rather in a systemic approach that manages their myriad interactions. Progress on any sustainable development will depend on a range of interactions with other Goals that either support the achievement through co-benefits or hinder it through trade-offs. Progress on all the Goals will only be achieved if important trade-offs are addressed and transformed, and if co-benefits are deliberately realised. In other words, managing the arrows is more important than managing the boxes/cycles of individual targets (IGS, 2019).

2. Model of transformations towards the sustainability management

Transformation principally differs from evolutionary or chaotic change, i.e. it is intentional change based on societal agreement and factual understanding, and achieves outcomes at scale by involving tough choices and trade-offs.

Any transformation system aimed at reducing unsustainability or increasing sustainability in the performance criterion must include all three sustainable development dimensions: economical, environmental and social, i.e.

I=F (E, R, S),

where:

I – performance criterion;

E - economic savings;

R - reduced amount of generated waste and/or resource/energy savings;

S - social benefits.

The object of management could be global or local. If the object refers to a production or any other process, or its part, the management or control task formulated as follows:

To find the control input vector U by which the state of processes X1 should be transformed to state X2 within the system boundaries B and constraints of input vector U and to maximise the performance criteria I---max. The state of the object is the set of data on process variables giving complete and unambiguous information about the object history necessary for the determination of its behaviour in the future under certain management or control actions. The transformation system comprises two closed loops: feedback and feedforward, where feedback presents the reactive approach and feedforward – preventive (Fig. 1.). In the picture:

X – vector of the process state,

Xr – vector of reference state of the process,

Xm – vector of measured/assessed state,

U – integrated control actions/tools,

D – vector of disturbances,

Dm – measured/assessed disturbances,

ΔX - vector of deviations

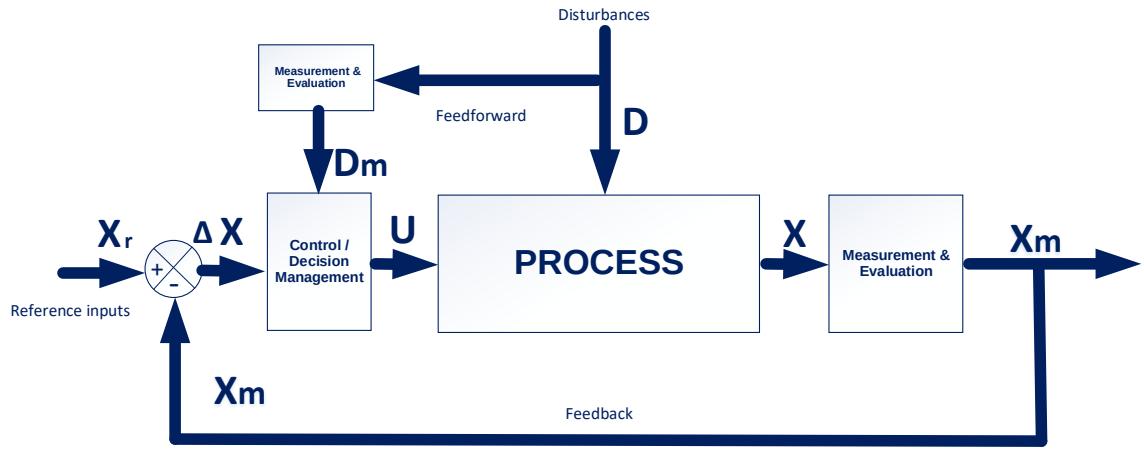

Figure 1. *The general structure of process transformation management.*

The Report results are based on a total of 65 global assessments comprising the United Nations flagship reports and international scientific assessments, as well as 112 scientific articles, published since 2015 with explicit reference to the SDGS. Taking a systemic perspective on the SDGs and their interactions in the Report, the elaborated model for the management of transformations towards sustainability is presented. The model comprises six entry points for successful transformations towards sustainable development, and four levers that are critical to maximising impacts in different parts of the world. The selected entry points are (IGS, 2019):

- Human well-being and capabilities;
- Sustainable and just economies;
- Food systems and nutrition patterns;
- Energy decarbonisation with universal access;
- Urban and peri-urban development;
- Global environmental commons.

Although some of these entry-points may seem to single out individual Goals, the Report focuses on the systems in which they are imbedded. Progress on all the goals will only be achieved if important trade-offs are addressed and transformed, and if co-benefits are deliberately realised. In other words, managing the arrows is more important than managing the boxes/circles of individual targets (see Fig. 2).

The Report also identifies four levers, which are coherently deployed through each entry point to bring about the necessary transformations (IGS, 2019):

- Governance;
- Economy and finance;
- Individual and collective action;
- Science and technology.

Each lever can contribute individually to systemic change; however, the Report argues that it is only through their context-dependent combinations that it is possible to bring about the transformations necessary for balancing across the dimensions of sustainable development and achieving the 2030 Agenda. The four levers are powerful agents of change that can impact the world for better or for the worse. Thus, they should be coherently deployed and combined to bring about transformational change. All actors should strive for coordinated efforts and prioritise policy coherence and consistency across sectors.

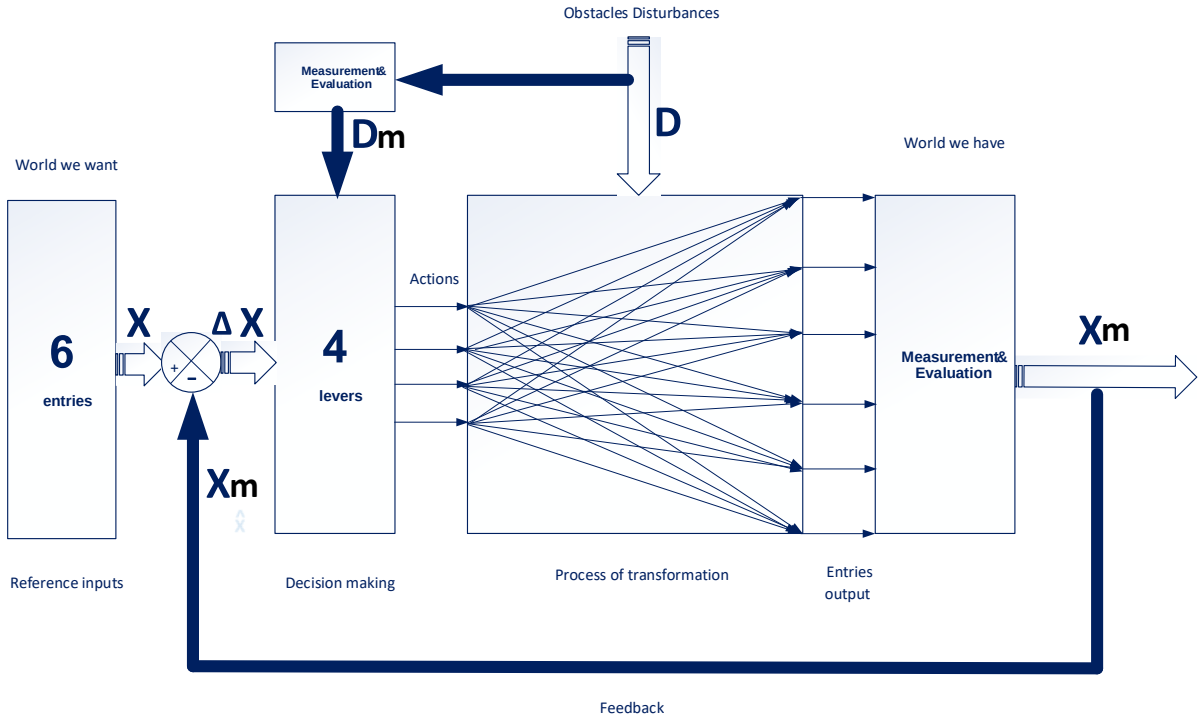

Figure 2. *The system for transformations towards sustainable development.*

The system for transformation management is presented in Fig. 2 where six entry points are named as state variables vector X and four levers – as vector U of integrated control variables. Co-benefits, trade-offs and tough choices are at the heart of sustainable development are clearly presented in the management system. To be effective and sustainable, management interventions in governance, economy, behaviour and technology should happen. There is an urgent need for close partnership among national government, academia, private business, civil society, citizen groups, and international organisations.

Different actors may have different views on how sustainable development can be best achieved; however, there are several points of agreement in global governance (IGS, 2019):

- Involving grassroots actors in process towards inclusive, multi-scale politics;
- Identifying and supporting new transformative alliances between traditional and new actors towards greater dynamism in transformative management;
- Improving the ability to manage hard choices, build coordination and consensus.

Some of the mentioned actions and other unexpected troubles in management system are treated as disturbances D and resolved by preventive measures using the feedforward loop.

The presented management system for transformations towards sustainable development helps the governments to drive implementation of the SDGs in many different ways. There is no one-size-fits-all solution; thus, problem formulation according the systems theory methods provides the approaches and solutions that are diverse, tailored, innovative, adaptive and supportive for decision makers. Effective use of the transformation management system only occur when governments incorporate targets and indicators into their national plans and budgets, formulate policies and programmes and create institutions that deal with uncertainties and risks, as well as systems for monitoring and evaluation (see Fig. 2.).

3. Discussion and conclusions

Standard models take no account of the use of finite resources and environmental constraints, and are blind to social outcomes in terms of equity and, of course, human well-being.

Macroeconomic models are open-ended by nature, with growth being the primary output of interest. Inputs feed in, interact with each other, achieve balance (or equilibrium) and outcomes result. We need to reverse this. That is, to start with the hard outcomes we need: environmental sustainability; equitable social and economic justice; and high levels of human well-being (Jackson, 2009). As Hall and Klitgaard (2011) have shown, today's dominant economic theories, approaches and models were built during the era of energetic and material abundance. The theories were only temporarily tried by the oil crises of the 1970s and the 1990s, with no remarkable theoretical or political changes. Thus, dominant economic theories as well as policy-related economic modelling rely on continued energetic and material growth. Co-benefits, trade-offs and tough choices are at the heart of sustainable development but not always been appreciated as such. The result typically was to prioritise immediate economic benefits over social and environmental costs that would materialise over longer terms.

To tackle the pressing challenges of a sustainable future, innovations need to introduce transformations at the core of the business model to tackle unsustainability at its source rather than as an add-on to counter-act negative outcomes of business. Although all business model innovations are welcomed, proactive innovation strategies appear to be most impactful (Bocken et al., 2014).

As sustainable economies do not match the mainstream thinking, business will hardly be the driver for such a development. This calls for better governmental leadership as well as stronger engagement of civil societies and their organisations. Strengthening social innovation and clear messages about the benefits of sustainable societies as well as risks of unsustainable ones are crucial elements on the way (Lorek and Spangenberg, 2014).

New forms of financing and financial governance are emerging in the complementary economy transition arena. Possible interventions could be as follows: tax on financial transactions to deter short-term speculations and to promote long-term investments; and crowdfunding using internet platforms to raise capital for promising initiatives and projects. Performance assurance bonds also represent an important instrument that could bridge mainstream and complementary markets, by helping social innovation organisations take over some functions of service delivery now handled directly by central and local government or their agencies. These instruments could also overcome sectoral and departmental divisions in government and its agencies, and enable public money to be pooled and directed toward cross-cutting initiatives and projects that address more than one area of need (Weaver and Marks, 2016).

Sustainability science is a precondition for sustainable development achievement. Boosting sustainability science and expanding access to scientific data and research globally benefit us all. Overall, insufficient mobilization and reorientation of science more broadly — including its approaches, organization and funding structures — threatens to derail the 2030 Agenda. Rather than standing by and allowing ourselves to come up short, the global community must enable scientific research to fulfil its transformational potential (Messerli et al., 2019).

The Global Sustainable Development Report identifies six entry points that offer the most promise for achieving the desired transformations at the necessary scale and speed. The levers are related to the means of implementation and each can contribute individually to systemic change; however, they are also different in that that they accommodate multiple, complimentary roles. The need for systemic transformations is critical, and action must be bold and decisive (IGS, 2019):

- For six entry points the Report presents integrated pathways to sustainable development, each country and region needs to understand the specific challenges and impediments and the needs and priorities they have. Growing first and cleaning up later is not an option any more in terms of country's own interest and the need for achieving transformations universally;

- Decoupling the benefits of economic activity from its cost at all levels is essential in itself, but there are numerous reasons why that is not happening: the use of GDP as the sole or predominant metric for guiding economic policy for human development; production valuation does not account all true environmental and social costs; economical development is based on continually increasing the consumption of waste generating goods and services; negative impact of globalisation on the environment and local development; investments and subsidies to fossil fuels and other industries that perpetuate deprivations, generate inequalities, deplete the global environmental commons and threaten irreversible damage;
- The proposed dynamic model of transformations helps stakeholders to recognise and leverage the interactions among the Goals in order to resolve the essential trade-offs hindering progress and to harness co-benefits among Goals. The success of the 2030 Agenda depends of the cooperation of governments, institutions, agencies, the private sector and civil society across various locations, borders and levels;
- It is a mistake to assume that human motivations are all selfish. Each society strikes a balance between altruism and selfishness and also between novelty and tradition. Furthermore, people are not like the passive automats of economics textbooks. They have goals, beliefs and aspirations and they actively construct the world around them through the ways in which they talk, behave and make meaning. Thus, government, schools, the media, religious and community institutions should promote cooperation, instead competition, reward people who sacrifice their own gain to serve others, i.e. support more altruistic and more conservative values;
- The perverse incentives for unsustainable (and unproductive) status competition (advertising, corruption) should be dismantled or corrected. New structures that enable the people to flourish, and particularly to participate fully in society in less materialistic way should be established;
- Major transformations in areas like energy systems, health, food and urbanisation make it necessary to rethink partnership between science, government, the private sector, civil society and more. An example is the One Health approach to improving health and well-being through prevention of risks and mitigation of diseases that originate at the interface between humans, animals and their natural environments, because new infections are usually driven to emerge by ecological, behaviour or socioeconomic changes. For this, WHO works closely with the Food and Agriculture Organization of the United Nations (FAO) and the World Organisation for Animal Health (OIE) to promote multi-sectoral responses to food safety hazards, risks from zoonoses, and other public health threats at the human-animal-ecosystem interface and provide guidance on how to reduce these risks. The recent case of the new coronavirus COVID-19 clearly shows that this approach should be immediately strengthened.
- Official development assistance remains vital to achieving the SDGs in many developing countries. Institutions that finance the development, including public development banks at the multilateral, national and regional levels, should play a significant role. Driven partly by legislation and public pressure, some private investors including foreign investments are taking sustainability into account when making investment decisions. Thus, the fundamental challenge is to manage the entire financial system with ambition, transparency and accuracy towards the financing of sustainable development.

Nevertheless, there is reason for hope. Scientific knowledge allows identifying critical pathways that break the pattern of ‘business as usual’ and there are numerous examples from across the world that show that it is possible. The proposed model of transformations towards the sustainable development should be pursued in the spirit of finding pathways that enable a good life for all, leaving no one behind, while safeguarding the environment for future generations and ensuring planetary justice.

Acknowledgement

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Public Participation and the Role of Stakeholders

The emergence of Environment and environmental professionals in Portuguese policy and politics

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Abstract
The emergence of modern environmental concerns dates to the nineteenth century, with diverse roots, including public health and the conservation and management of natural resources. In Portugal, the environmental movement began with "Liga para a Protecção da Natureza" (*League for the Protection of Nature*), in 1948, at first from a scientific and academic perspective. The National Commission for the Environment was created in 1971, to prepare Portugal's participation in the UN Stockholm Conference on the Human Environment (1972). Since then, the importance of technical knowledge in environmental policy has been increasing, both due to the growing seriousness of environmental challenges, and the need to integrate interdisciplinary knowledge and multiple social interests in order to build innovative and effective solutions. This paper aims to investigate how the Environment is approached in Portuguese policy and politics, especially the role of environmental professionals in political parties. The goal is to gain a better understanding of how the Parliament and political parties work on environmental policies, and to highlight the importance of the environmental professionals in the formulation of policies. The methodology used was based on interviews with representatives of political parties in Parliament and a sample of 34 key environmental policy actors in the political, technical, NGO and social media domains, cross-checked with literature review. It was possible to gain interesting insights. There is a gap between the manifestation of environmental concerns and their practice. Political parties say they value the presence of environmental professionals and technical knowledge is universally regarded as essential, but they employ very few as advisers. On the other hand, many respondents report that often scientific information is insufficient, or decisions are taken by the imposition of other interests, neglecting technical foundation. The respondents' points of view are guided mostly by their own experience, and not so much by their position or professional field. Although Portugal was innovative in the creation of the Framework Law for the Environment in 1987, much of national environmental legislation was derived from European policy. Today, Portugal faces major environmental challenges, the most cited by the respondents being climate change, consumerism and waste, efficient use of water, circular economy, territorial planning and environmental education.

Keywords: Environmental policy, environmental politics, environment professionals, political parties, Parliament

1. Introduction

In a representative democracy, citizens delegate the task of governing to their elected representatives, on the assumption that the public policies adopted by them reflect their priorities. This is called democratic responsiveness.

Party interaction can take two forms: competition between parties in search of political power or cooperation between them, which occurs, for example, when different party forces form a coalition. Thus, party systems play a central role in the governance model of representative democracy (Jalali, 2017).

Liga para a Protecção da Natureza (LPN), created in 1948, was the first Portuguese Environmental Non-Governmental Organization (ENGO). For decades it had an almost exclusive scientific focus, for the twin reasons that its founders were scientists, and that Portugal lived under an authoritarian political regime. The National Commission for the Environment was created in 1971, to prepare Portugal's participation in the UN Stockholm Conference on the Human Environment (1972). After the revolution and the establishment of democracy in 1974, civil society exploded. However, it was only in the early 1980s that old and new environmental NGO began to have a significant public presence, together with a few politicians who recognized the Environment as a critical field for the future. Joining the European

Economic Community (EEC) in 1986 opened Portugal not only economically but also to new ideas. The turning point for national environmental policy occurred in 1987, with unanimous approval in Parliament of the "Lei de Bases do Ambiente", the national Environmental Policy Act, at the time a pioneer legislation. Although still a minority current of opinion, the Environment had become of age, a permanent presence in the political arena. In the following years the civic environmental movement became more organized and very active, while remarkably outside the sphere of influence of the political parties (Melo and Pimenta, 1993).

Other important milestones for environmental awareness were, internationally, the United Nations Conference on Environment and Development in Rio de Janeiro (1992); and nationally the "Open Presidency for the Environment", an initiative by President of the Republic Mário Soares, who in April 1994 toured the country for 21 days providing unparalleled debate and media coverage to environmental issues. Environment had become mainstream. However, it was due to external pressures and events, particularly European law, that environmental policies reached the country (Schmidt, 2008). There has always been a large gap between the discourse, the approved policies and actual achievements regarding most environmental indicators (Mota and Melo, 2017)

Internationally, current environmental concerns can be illustrated by events such as: the creation of the Sustainable Development Goals by the UN (2015); the encyclical letter "Laudato Si': On Care for Our Common Home" by Pope Francis (2015); the negotiation of the Paris Agreement on climate change; the worldwide growth of renewable energy, particularly solar power, as an alternative to fossil fuels; and the embrace of the environmental cause by growing numbers of the young generation, personified by the activist Greta Thunberg. However, many scientists and activists have alerted that we are still not "walking the talk". The current pandemic is a stark reminder that we are ill-treating Nature.

Although there is much literature on the political debate on the environmental domain, there is little research in Portugal on the mechanisms that lead to the establishment of environmental concerns in public policies, and in particular on the role of environmental professionals in political parties and in the political process. This is one of the main motivations of this paper. This research purports to gain a better understanding of how the political parties and the Parliament operate regarding environmental policies, and particularly how the presence of environment professionals affects the formulation of public policies and the decision of the electorate in their choices.

2. Methods

2.1. Planning and conducting surveys

Following the approach by Holmes and Clark (2008), who aimed to relate the use of science to the formulation of environmental and regulatory policies in the UK, this methodology was based primarily on qualitative research: contact with people, places or facts that are the subject of the research. This favours collaboration between the researcher and the research participants, and may include their perspective on the reality studied, as well as being sensitive to the study of the processes leading to certain results (Guba and Lincoln, 1989; Denzin and Lincoln, 2000 *apud* Silva, 2012). Holmes and Clark selected certain key actors for their interviews, in order to have a wide range of points of view and cover different roles. Therefore, the fieldwork consisted of conducting surveys of specific groups relevant to environmental policy in Portugal.

Two instruments were used to conduct the surveys: individual or group interviews and questionnaires. The survey by interview was the instrument mostly used, as it allowed more information and data to be collected. Although the group interview had the advantage of saving time, it was more difficult to reconcile the schedules of the participants, thus the individual interview was the predominant research tool. Audio records were made in all interviews using the "Dictaphone" app, with due authorisation from the participants. The questionnaire was used in cases of incompatibility of schedules with the participants.

The survey process had four steps, as can be seen in Figure 1.

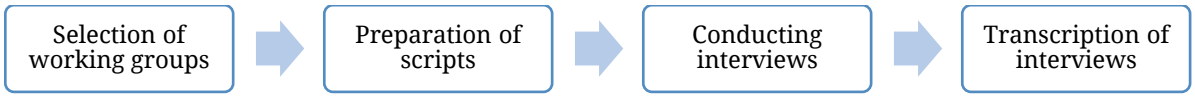

Figure 1. *Steps of the survey process.*

Regarding the quantitative questions about the importance, the scale considered was the following (Figure 2):

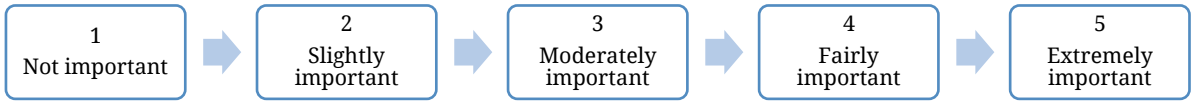

Figure 2. *Scale of importance regarding the quantitative questions.*

Regarding the quantitative questions about the available means, the scale considered was the following (Figure 3):

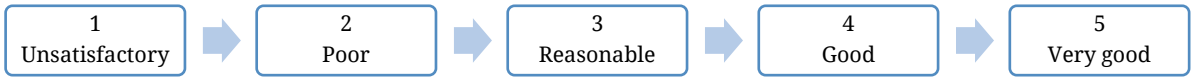

Figure 3. *Scale of the available means regarding the quantitative questions.*

2.2. The groups

The survey focused on five target groups:

Group 1 refers to public and political officeholders with a relevant role in environmental policy: political party leaders, representatives of parliamentary groups, directors-general and members of government. In particular, we tried to interview people in charge of parliamentary party groups (group leaders, chiefs of staff) and members of the Committee on the Environment, Spatial Planning, Decentralization, Local Government and Housing (CAOTDPLH)

Group 2 included members of former governments and a former director-general - the first Environmental Engineer to hold such a position. This group is based on the critical role that stakeholders have played in the environmental field, allowing the perspective of current and previous officeholders to be compared.

Group 3 targeted environmental professionals, i.e. professionals with a distinct basic training (Environmental Engineering, Civil Engineering, Biology, Physics, Landscape Architecture and Sociology), but with work in the area of environmental policy.

Group 4 focused on environmental journalists, as the media is a tool that can contribute with correct environmental information, aiming not only to inform the population, but also to transform their thinking and behaviour.

Group 5 integrated ENGO leaders, given their prominence in the fight for environmental protection, information provision, education and environmental awareness. In addition, a representative of a professional environmental association was interviewed.

Five different scripts have been developed, according to the type of question, in order to investigate the importance given to the Environment in Portuguese politics and the contribution of environmental professionals in political parties. Table 1 shows the list of questions asked to participants.

Table 1. *List of questions asked to participants.*

N. º	Question	1a. Political parties, Environment Committee, Government	1b. Directors General	2. Former Officeholders	3. Environmental Professionals	4. Environmental Journalists	5. Environmental Associations
1	On a scale of 1 to 5, how do you rate the importance of environmental issues? Why?	✓	✓	✓	✓	✓	✓
2	On a scale of 1 to 5, how important do you consider the presence of environmental professionals in political parties? Why?	✓	✓	✓	✓	✓	✓
3	What are the most important milestones in the historical evolution of environmental policies in Portugal?	✓	✓	✓	✓	✓	✓
4	What do you consider to be the greatest future challenges in environmental policies in Portugal?	✓	✓	✓	✓	✓	✓
5	Regarding one or more transitions in environmental policies, how decisive was the technical support to reach the decisions taken?	✓	✓	✓	✓	✓	✓
6	On a scale of 1 to 5, how do you rate the means at your disposal to fulfil the mission of the institution/body?	✓	✓			✓	
7	What technical support do you have regarding the Environment?	✓				✓	
8	Do you work with environmental professionals? How would you describe your relationship with them?	✓					
9	What journalistic works have impressed you most on environmental policy? Why?						✓

2.3. Brief characterisation of respondents

In order to carry out the surveys, 23 individual interviews, 2 group interviews and 7 questionnaires were conducted, making a total of 34 interviewees. The respondents were selected according to their professional title or category, regardless of gender, age, or other.

Table 2 shows the groups and names of respondents, the date and type of survey conducted, their educational background, and their position or professional category.

Table 2. *List of personalities interviewed*

Group	Name	Date	Training	Professional title / category
1. Public and Political Officeholders	Cristina Rodrigues	02/10/2018	Law	Chief of Staff of the parliamentary group of PAN
	Nuno Banza	08/10/2018	Environmental Engineering	Inspector General of IGAMAOT
	José Brito e Silva		Law	Sub-Inspector General of IGAMAOT
	Joana Silva	09/10/2018	Sociology	Chief of Staff of the parliamentary group of PEV
	Victor Cavaco		Env. Engineering	Member of the Nat. Exec. Committee of political party PEV
	António Silva	18/10/2018	Economy	Vice-Chair of the PSD Parliamentary Group/member of CAOTDPLH
	Orlando Borges	23/10/2018	Geography	President of ERSAR
	José Mendes	23/10/2018	Civil Engineering	Assistant Secretary of State and for Mobility
	Assunção Cristas	26/10/2018	Law	President of the political party CDS-PP
	Pedro Soares	12/11/2018	Geography	Chairperson of CAOTDPLH/member of the Parliamentary Group BE
	Filipe Duarte Santos	13/11/2018	Geophysics	Chairperson of CNADS
	Carlos Teixeira	27/11/2018	Biology	Founder of the political party LIVRE
	Ângela Moreira	03/01/2019	Nursing	Coordinator of the Parliamentary Group PCP at CAOTDPLH
	Nuno Lacasta	04/01/2019	Law	Chairperson of APA
	Maria Manuel Rola	08/01/2019	Graphic Design	Coordinator of the Parliamentary Group BE at CAOTDPLH
	Miguel Freitas	09/01/2019	Agricultural Eng.	Secretary of State for Forests and Rural Development
	Renato Sampaio	18/01/2019	Public Admin.	Coordinator of the Parliamentary Group PS at CAOTDPLH
2. Former Public and Political Officeholders	Carlos Pimenta	15/10/2018	Electrical Eng.	Former Secretary of State for Environment
	Humberto Rosa	26/10/2018	Biology	Former Secretary of State for Environment
	Elisa Ferreira	21/11/2018	Economy	Former Minister for the Environment
	Paula Sarmento	18/12/2018	Environmental Engineering	Former President of ICNF
	António Capucho	07/01/2019	Business Organisation and Managem.	Former Minister for Quality of Life
3. Environmental Professionals	António Rodrigues	04/10/2018	Civil Engineering	Assistant Professor at FCT NOVA
	Félix Rodrigues	08/11/2018	Physics	Assistant Professor at the University of the Azores
	Luísa Schmidt	05/12/2018	Sociology	Principal Investigator at ICS-ULisboa
	Gonçalo Anastácio	20/12/2018	Landscape Archit.	Landscape Architect at Cascais City Hall
	Ivone Martins	07/01/2019	Environmental Engineering	Strategic Coordinator at EEA
4. Environmental Journalists	Arminda Deusdado	29/10/2018	Historical Sciences	General Coordinator of “Biosfera”
	Ricardo Garcia	26/11/2018	History	Freelance Journalist
	Carla Castelo	13/12/2018	Media	Journalist at the TV station SIC
5. Environmental Associations	Francisco Ferreira	10/10/2018	Environmental Engineering	President of ZERO
	Francisco Andrade	16/10/2018	Biology	Vice-President of Portuguese Order of Biologists
	Eugénio Sequeira	10/12/2018	Agronomic Engineering	President of LPN
	Marlene Marques	22/02/2019	Environmental Engineering	President of GEOTA

Legend: Group interviews | Individual interviews | Questionnaires

3. Results and Discussion

3.1. Importance of environmental issues

All groups were inquired on this aspect. Globally, most respondents rated environmental issues as being of high importance, (Figure 4).

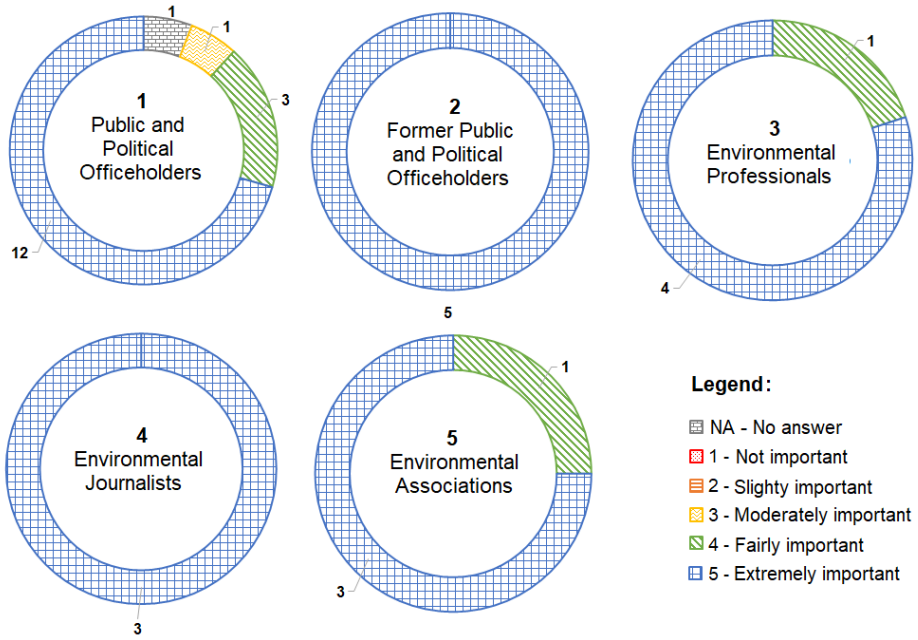

Figure 4. *Global rating of environmental issues in each group.*

In general, the respondents consider these issues as a major challenge that Portugal is facing. They are vital not only from a ecological point of view, but also from the point of view of life in society, and from a political point of view. The sustainability of the planet is very much based on environmental policies.

Three public and political officeholders (group n. º 1) considered environmental issues to be very important, but not a priority: the environmental issue is a concern, but it cuts across other areas, and cannot be placed above social and economic policies. To deal with these issues, one cannot deal with each one in isolation. This is in line with the justification given by the other groups who gave the same ranking.

The representative of the political party PSD (group n. º 1) was the only respondent to classify the environmental issues as moderately important. This may be because he has interpreted the issue in the current political context and not what he thinks it should be, as he argues that environmental issues should have a bigger political space.

Many respondents consider that environmental policies in Portugal have made good progress due to pressure from the European Union, leading the country to address these issues with more commitment.

Although it is pointed out that environmental issues are of central importance in this Government actions, namely in saving resources and energy efficiency, the opposite is also referred: the weak treatment of these issues in Portugal is condemned by the groups of journalists (group n. º 4) and leaders of environmental associations (group n. º 5). A discrepancy between words and actions and limited coherence between policies, discourse and actions are highlighted. Furthermore, the effectiveness of the treatment of these issues is questioned, as no environmental assessment studies are carried out for each measure to be taken, and the measures that are taken are not framed as a package.

It has been repeatedly mentioned that public opinion only awakens at times of environmental crisis, such as forest fires and droughts, or the pollution of the River Tagus. In Portugal there is still a problem in passing the environmental sensitivity to actions, a fact that was reported by many of the respondents is corroborated by the poor performance of environmental policy in many indicators in the past 25 years (Mota and Melo, 2017). However, it is also noted that the level of sensitivity to environmental issues has increased, both among professionals and the population at large, prompting politicians to follow suit. In fact, the Parliamentary elections of 2019 were the first ever in Portugal where the Environment was a major campaign issue.

According to a study by the Observatory of Conscious Consumption and the National Index of Conscious Consumption (INCC), 69% of the Portuguese admit to being more concerned about the Environment, however, they are still unwilling to pay more for sustainable products or environmental taxes, and the levels of public participation are low (GPA, 2018).

According to Mota and Melo (2017), "most of the time it is accepted, with levity, that what is proposed is not fulfilled, either due to lack of information, lack of means or lack of political will". He states that decision making based on technical and scientific knowledge can do much to promote this change, but on its own it is not enough, since social consultation and civic intervention are also determinants, implying that passage from sensitivity to action.

3.2. Importance of the presence of environmental professionals in political parties

All groups were asked about this aspect. Globally, the results of this question are more diverse, as shown in Figure 5. Public and political officeholders (group n. º 1) and journalists (group n. º 4) gave the best rating; former public and political officeholders (group n. º 2) and leaders of environmental associations (group n. º 5) considered it both unimportant and fundamental; the ranking of environmental professionals (group n. º 2) varied from moderately to extremely important.

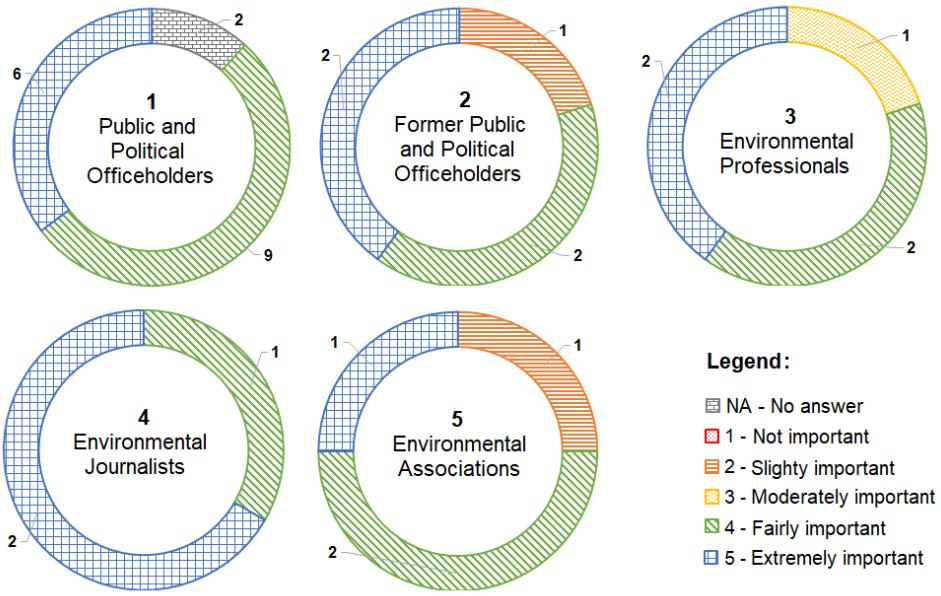

Figure 5. *Global ranking of the importance of the presence of environmental professionals in political parties in each group*

Regarding public and political officeholders (group n. º 1), the presence of environmental professionals in political parties was widely supported. Significant importance was given to the hiring of an environmental professional by the political party PAN, as they lacked in-depth technical knowledge in this area. In the same line of thought, it is recognised that the political party CDS needs an environmental professional, although it has had such professionals in the past. In addition, it is regretted by many that the political parties have few qualified people in the field of environmental.

Journalists (group n. º 4) highlight the importance of multidisciplinarity in political parties, namely through professionals who know how to ground political decisions on technical and scientific data, something crucial in environmental topics.

The high quality of Environmental Engineers in Portugal is valued, as they have the ability to look at problems in a comprehensive and integrated way, and it is recognized that the knowledge acquired in areas transversal to the Environment has provided a greater capacity to deal with these issues. In fact, the joint work between several environmental professionals should provide a wider range of solutions.

It is noted that the presence of these professionals is just as important as that of specialists from other areas, with the work of these professionals in ENGO and the media standing out rather than their presence in political parties.

Some respondents do not see the entry of these professionals into political parties as a necessity, as there seem to be no correlation between their presence and political decision-making. Opinions here ssem to stem not so much from their professional category, but rather their professional experience.

It is recognised that political leaders should have professional experience prior to their political functions to ensure enough knowledge and environmental sensitivity. For example, it was possible to sensitize the PSD due to the action of António Capucho as General Secretary, together with Carlos Pimenta, who was admittedly someone with a lot of prestige in the Environment area. A case in point was the fight between 1982 and 1984 against the National Energy Plan, which intended to install nuclear power plants in Portugal.

3.3. Historic milestones of the Environment in Portugal

All groups were asked about this aspect. Given the high variety of responses obtained, the most frequently mentioned groups of milestones and the main individual milestones were selected. Additionally, the negative milestones were investigated.

Figure 6 shows the main groups of milestones. It can be concluded that the dominant group is the environmental legislation, mentioned by 24 out of 34 respondents.

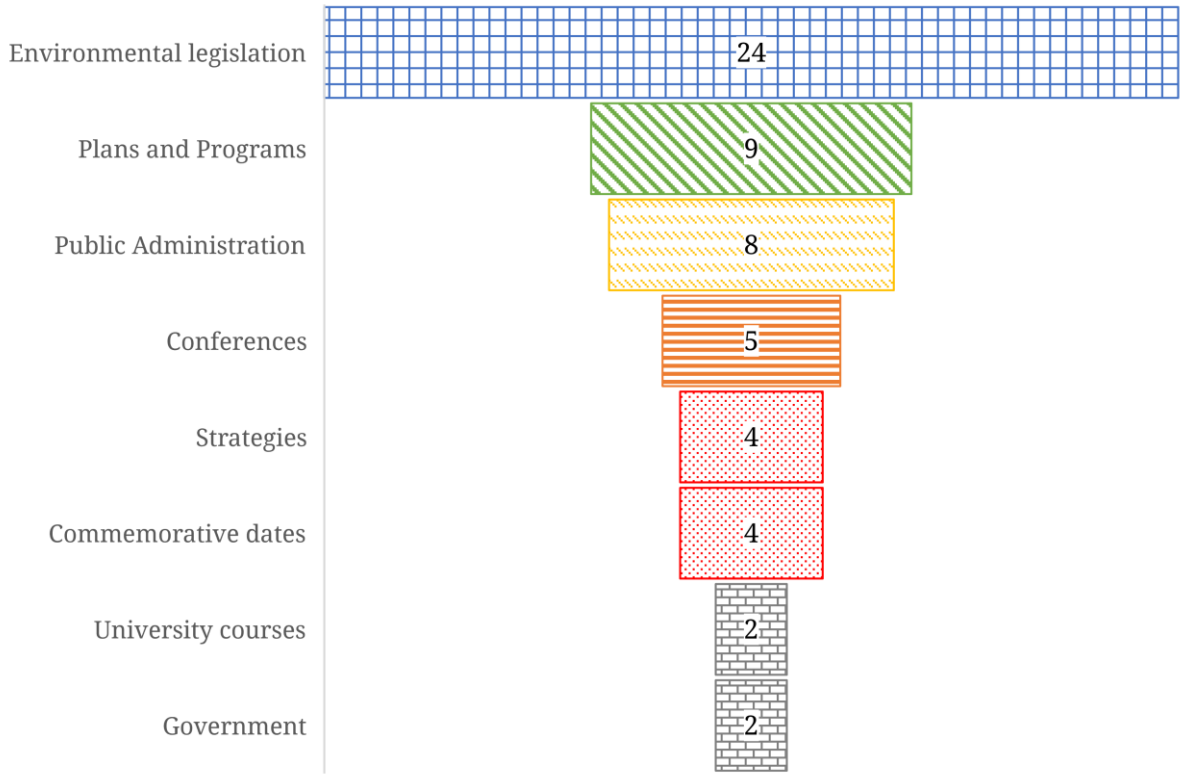

Figure 6. *Groups of environmental policy milestones most mentioned by respondents.*

Figure 7 highlights the main individual milestones (referred by at least three respondents).

Fifteen out of 34 respondents selected the Framework Law on the Environment (1987) as the main environmental milestone. This law was approved without a single vote against in Parliament. Through a scientific committee lead by Carlos Pimenta, it was possible to carry out a rigorous analysis, article by article, highlighting the importance of technical work.

Portugal joining the EEC was the second most mentioned milestone, as it boosted domestic environmental policy. Investment in the Environment has been made through Community funds, and the implementation of these funds has required the preparation of plans, particularly spatial planning.

The water and sanitation category included access to drinking water and basic sanitation for the Portuguese population. It is considered a gradual milestone, as well as urban waste management.

The Constitution of the Portuguese Republic stands out as an innovative instrument, declaring the fundamental rights of the Environment in Article 66, being the seventh most mentioned milestone.

Respondents consider that the Water Law and the boosting of renewable energies were important milestones. Between 2005 and 2008, Portugal went from 17% electricity produced by renewable energies to 36.5% (APREN *apud* Fernandes, 2014). It was also during this period that the Kyoto Protocol came into force. By 2016, for 107 consecutive hours, renewable energies (wind, solar and hydro) have ensured all electricity consumption in mainland Portugal.

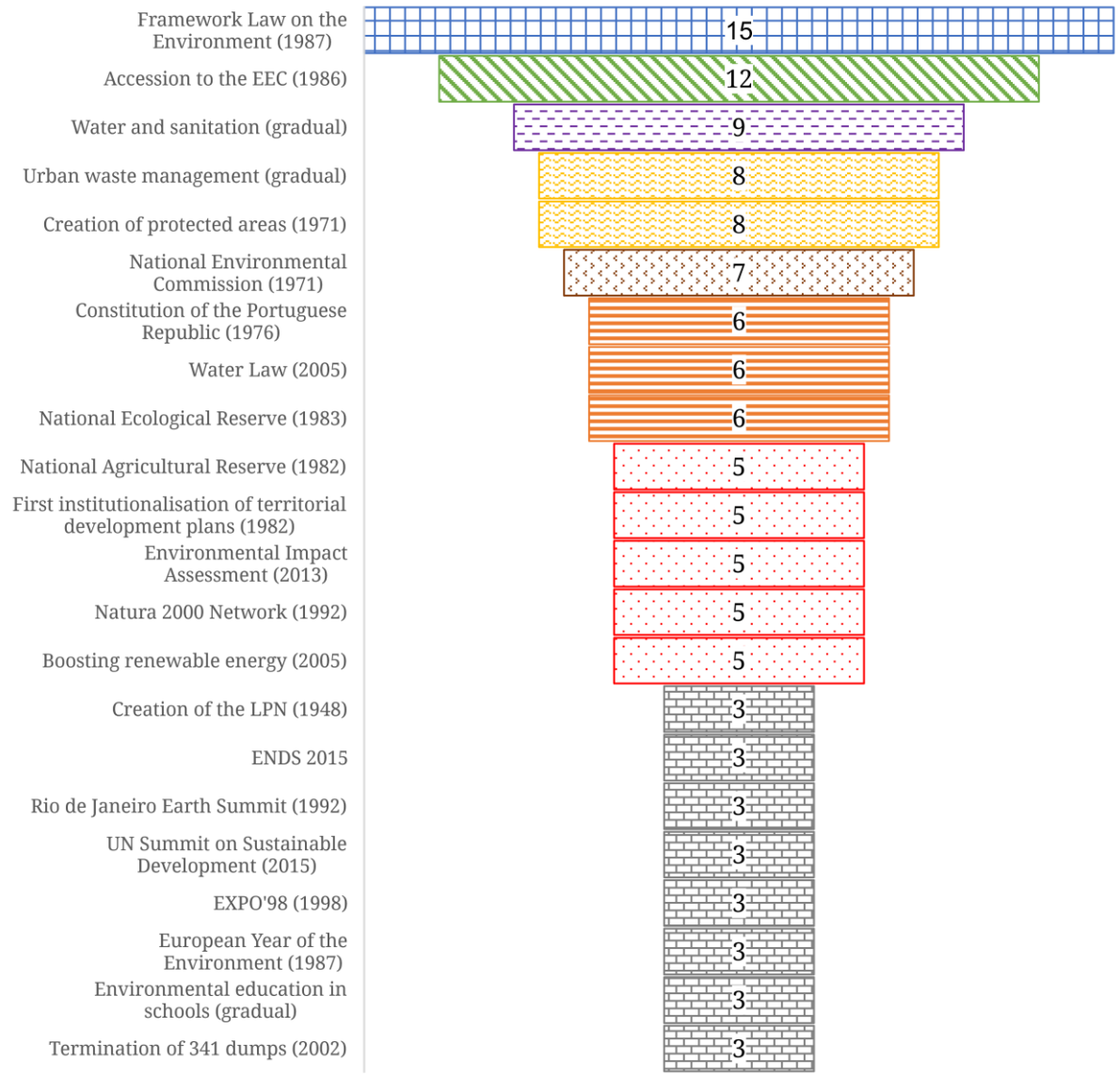

Figure 7. *Individual historical milestones of environmental policies most mentioned by respondents.*

The negative milestones mentioned are the following:

- Weakening of Water Management/Extinction of the Hydrographic Regions Administration;
- National Program of Dams with High Hydroelectric Potential;
- Privatization of water;
- Liberalisation of the Public Transport sector;
- Concession contracts for prospecting, research, development and production of hydrocarbons in the Algarve and Alentejo regions;
- Over dimensioning of the motorway network and disinvestment in railways.
- Promotion of monoculture and liberalization of eucalyptus.

The National Programme of High-Potential Hydroelectric Dams is considered a negative milestone by several respondents. The programme would contribute only 0.4% of the national energy and 1.7% of the electricity produced, with a proven cost between five and ten times greater than the available alternatives,

with an insignificant return given the social, environmental, cultural and economic impacts of the programme (GEOTA, 2016).

3.4. Main environmental challenges for Portugal

All groups were asked about this aspect. Given the high variety of responses obtained, the most frequently mentioned groups of challenges were selected, as well as the main individual challenges.

Figure 8 shows the main groups of challenges. It can be concluded that the dominant group is the natural resources group, mentioned by 10 out of 34 respondents, which includes efficient use of water, preservation of the ocean and integrated management of natural resources.

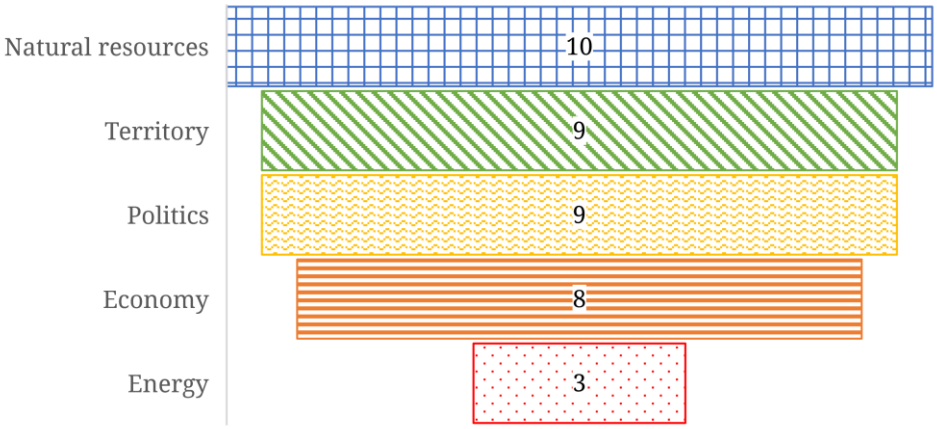

Figure 8. *Groups of environmental challenges most mentioned by respondents.*

Figure 9 illustrates the main individual challenges. Given the high number of responses, only three or more responses to the same milestone were considered. It can be concluded that 15 out of 34 respondents selected climate change as the main challenge Portugal is facing, not only in terms of mitigation but also adaptation. Furthermore, the decarbonisation of transport, particularly through investment in urban mobility, is highlighted within this topic.

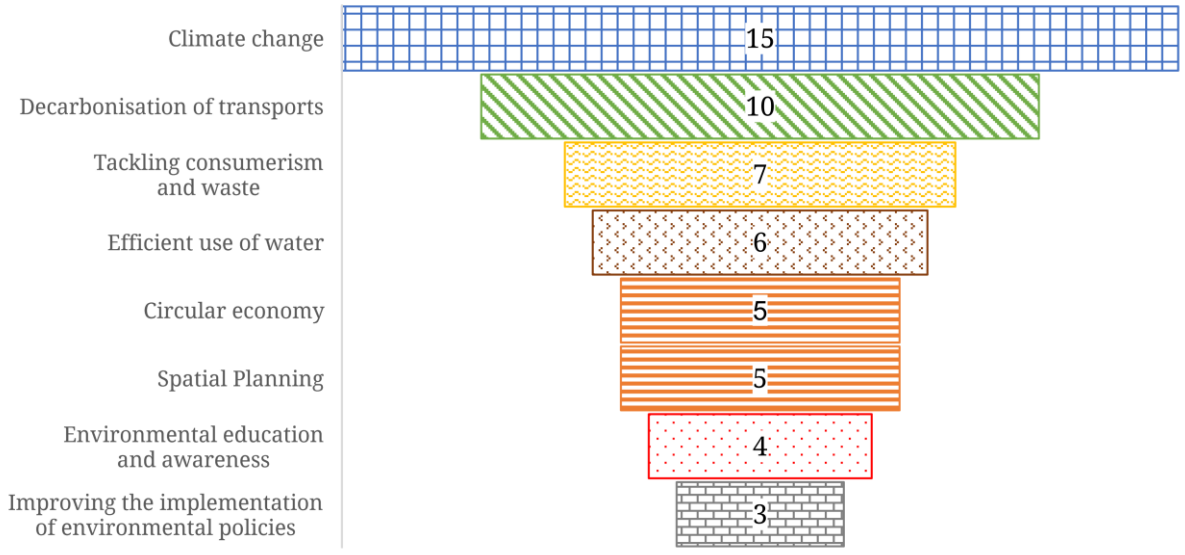

Figure 9. *Individual environmental challenges most mentioned by respondents.*

Most former public and political officeholders (group n. º 2) and journalists (group n. º 4) see climate change as the greatest challenge. About half of the public and political officeholders (group n. º 1) mentioned climate change or decarbonisation of transport as a potential challenge. The leaders of environmental associations (group n. º 5) paid attention to environmental education and sustainable development.

According to the Special Report of the Intergovernmental Panel on Climate Change (IPCC), released in 2018, Portugal is one of the countries expected to be most negatively affected by climate change, although the impacts may be reduced by limiting warming to 1.5°C (Tobin *et al.*, 2018 *apud* IPCC, 2018).

The transport sector represents almost a quarter of the annual emissions of CO_2 in Portugal, being one of the priorities of current government policies (at least in the discourse). To tackle this problem, it is necessary to reduce unnecessary travel, encourage the use of public transport and invest in sustainable mobility.

The growing concern about consumerism and waste is highlighted, and the problem of the excessive use of plastic is mentioned several times. It is, however, only a small fraction of the problem, as it also includes shared responsibility and behavioural change. According to Eurostat data (2016), Portugal is the sixth largest consumer of plastic in the European Union (Statista, 2019), revisiting the problem of passing on the sensitivity to actions**,** in line with Mota and Melo (2017) key points.

Portugal is located in the Mediterranean region, where the increase in temperature may have a greater impact, especially regarding water availability and management. Another issue of the natural resources group is the concern with ocean pollution, where the problem of plastics once again stands out.

The territory group was the second most mentioned, in particular because of the current problem of poor land use management. This involves both the interior of the country and the coastal strip. The prevention of forest fires and the gradual retreat of buildings too close to the coastline are considered major challenges, due to coastal erosion and the issue of rising sea levels, being linked to climate change.

Regarding politics, the integration of the various policies is advocated, whether transport, agriculture, economy, environment or ocean. This is a complex problem, not only in the definition of tasks and competences, but also in the organic way in which the issues are done from an administrative point of view. There is a great deal of difficulty in implementing environmental policies in Portugal, which involves better supervision and monitoring, and it is very important to strengthen the State's means to that end.

3.5. Importance of technical support in decision making

Some respondents rated the technical support as what "is", while other respondents rated it as what "should be". This assessment is assumed to have been made based on their own experience, as they all consider the technical support itself to be fundamental. Although this was not a quantitative question, Figure 10 shows the global findings through a scale based on the results.

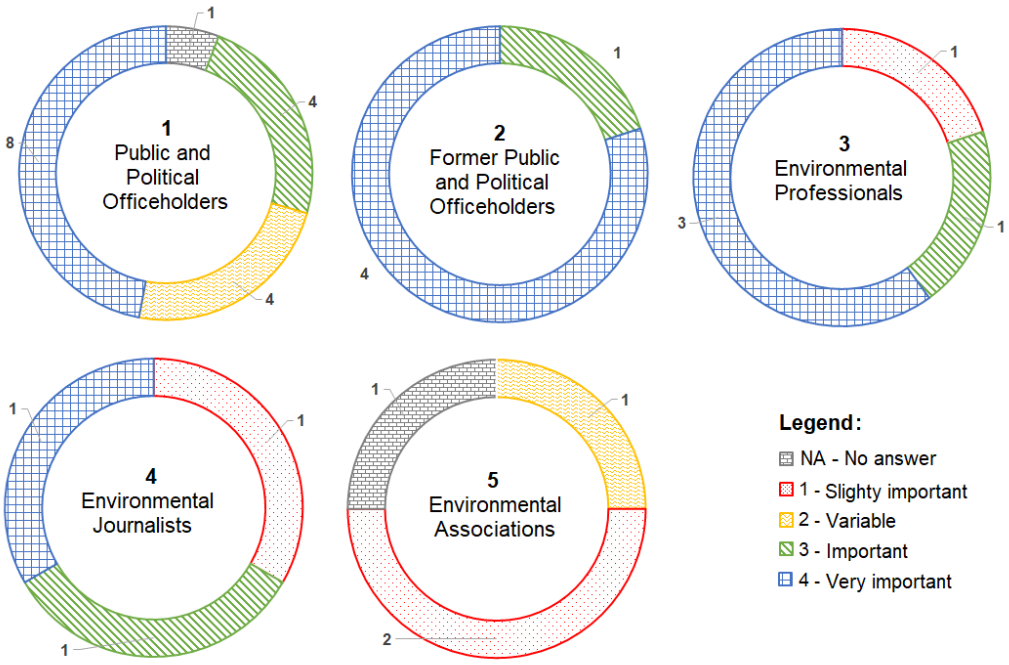

Figure 10. *Global assessment of the relationship between technical support and decision making.*

It is noted that 23 out of 34 respondents attributed 'important' or 'very important' to technical support for decision making, being the dominant response. While some consider it to be the current condition, others believe it should be.

Although public and political officeholders (group n. º 1) do attribute importance to it, there are mixed opinions. Not everyone considers that the technical support provided has a direct relation with the final political decision: it cannot be generalized, since environmental policy is transversal to other ministries; it cannot be separated from the intervention of environmental professionals, since they all have their importance; it is up to the political decision-maker, not the technician.

Most former public and political officeholders (group n. º 2) consider the work of environmental professionals to be essential for decision making, based on their own professional experience. There is, however, a difference of degree: while the majority considers it absolutely decisive, some considered it important but not decisive.

Environmental professionals (group n. º 3) either consider it to be of high importance or of low importance. Although everyone considers it important, it is said that technicians are not always heard by the policy maker. This means that the negative rating was based on what 'is' and not what 'should be'.

Similarly, journalists (group n. º 4) also give positive and negative ratings. Often economic interests are considered more important than technical information, ultimately affecting the final decision and obliterating the work of environmental professionals. Thus, although technical support is considered to be important, it may not be applied at the end of the day.

The leaders of the environmental associations (group n. º 5) have not given a positive assessment. Although many decisions have been technically supported, it is considered that there are three variants: decisions that did not have the necessary technical support; decisions with a high technical support; political decisions made against the technical support. Therefore, in practice there is not a direct relation between

technical support and decision making. It is also noted that the role of environmental professionals is not relevant enough and is losing importance. Decision-making processes must be well supported technically for sounder and more coherent decisions, but there are many political decisions that are not based on the criteria advocated by the professionals themselves, as, again, there are other interests at stake.

3.6. Ranking of available means

In order to verify whether the current means are satisfactory for contributing to a continuous improvement of environmental policies, public and political officeholders (group n. º 1) and leaders of environmental associations (group n. º 5) have been asked about this aspect.

Globally, the results of the means show diversity, fluctuating between weak and good, as shown in Figure 11.

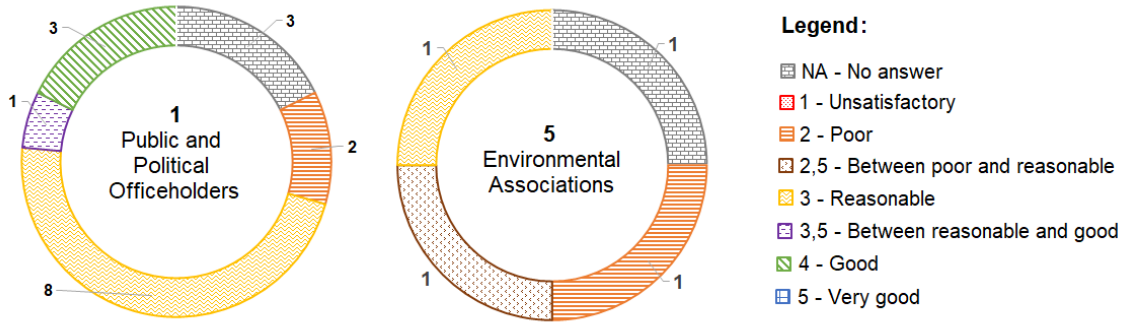

Figure 11. *Global ranking on available means.*

Analysing the results of the parliamentary parties (group n. º 1), one can conclude that the number of deputies elected to the Parliament is in line with the classified means, i.e. PS and PSD consider that they have the best means and PAN the worst — no surprise here, as those are the parties with larger and smaller representation.

The means ranked by the leaders of the environmental associations (group n. º 5) have not exceeded what is reasonable. ENGOs regret their weak financial capacity, although the technical capacity is good. The leader of GEOTA also criticizes the little airtime on the media made available to ENGO.

Therefore, it is concluded that the political parties (group n. º 1) with the highest representation in the Parliament have the best means. On the contrary, the leaders of the environmental associations (group n. º 5) show that they have the worst means, particularly because of the lack of funding, with State support lagging behind.

3.7. Technical support available for the Environment

Currently, the Portuguese Parliament is composed of 230 deputies. In order to ascertain their multidisciplinarity, research has been done on their academic backgrounds. It is possible to conclude that more than half of the Parliament is composed of deputies trained in Law, Economy and Management, as shown in Table 3.

Table 3. *Training of Members of Parliament and of members of the Parliamentary Environment Committee. Source: Parliament, 2019a & Parliament, 2019b*

Training	Parliament		Environment Committee (CAOTDPLH)	
	N. º	%	N. º	%
Law	80	35%	13	27%
Economy and Management	38	17%	4	8%
Other Social and Human Sciences	72	31%	19	39%
Natural, Exact and Engineering Sciences and Technologies	25	11%	9	18%
Medical and Health Sciences	8	3%	2	4%
Not available	7	3%	2	4%
Total	**230**	**100%**	**49**	**100%**

Table 4 shows there are 30% of graduates in Social Sciences, Commerce and Law (PORDATA, 2018) versus 52% of members of Parliament trained only in Law, Economics and Management. Similarly, the ratio of Natural Sciences, Exact Sciences and Engineering and Technology should be much higher than what is currently the case in Parliament: 29% of graduates in the Science and Engineering groups versus 11% of members of Parliament trained in Natural, Exact and Engineering Sciences and Technologies.

Table 4*. Graduates in higher education: total and by area of education and training.*

Group	Graduates in higher education (N. º)	Graduates in higher education (%)
Social Sciences, Commerce and Law	23342	30%
Education, Arts and Humanities	11395	15%
Science, Mathematics and Computer Science	6307	8%
Engineering, Manufacturing and Construction	16105	21%
Agriculture	1711	2%
Health and Social Protection	13412	17%
Serviços	4735	6%
Total	**77034**	**100%**

During the investigation carried out on parliamentary advisory, it was found that it was the most difficult information to collect, as it is not published on the Parliament's website, unlike the Government. During the interviews, it was sometimes not possible to obtain a concrete number of advisers or information on their training, which indicates the need for better management. Part of the information was obtained gradually, through communication via e-mail.

Comparing the current technical support with the issue of the importance of environmental professionals in political parties, it can be concluded that PSD, BE, PEV and PAN are in line with the ranking given, as shown in Table 5.

Table 5. *Technical staff to parliamentary political parties.*

Parliamentary Groups No. technical staff	PSD	PS	CDS-PP	BE	PCP	PEV	PAN
Total in the Parliamentary Group	18	14	17	15	NA	10	4
With environmental training	2	0	0	1	NA	2	2

NA – Not Available

It appears that, although the representative of PS considers it extremely important, the party does not have an environmental professional to deal with environmental issues, same as CDS-PP. Additionally, it is concluded that the municipal advisor of LIVRE is linked to urban and territorial planning, being specialized in a matter transversal to the Environment.

It is necessary to increase the multidisciplinarity in the Parliament, through the widening of the spectrum of professionals, namely in the field of Engineering and Natural and Exact Sciences. This is an essential factor in maximising resources in the response to some of the environmental problems faced by Portugal, making it possible to reconcile the points of view of the various specialities.

In the office of the Minister of the Environment and Energy Transition, there is an Environmental Engineer and a Law Graduate, who is attending a master's degree in Law and Legal Practice: Specialisation in Environmental, Natural Resources and Energy Law. In the office of the Assistant Secretary of State for Mobility, a Civil Engineer, with a master's degree in Regional and Urban Planning, stands out.

The office of the Minister of Agriculture, Forestry and Rural Development is further strengthened with technical support. An Agronomic Engineer and a Law Graduate with a Postgraduate Degree in Planning, Urban Planning and Environmental Law are also present.

Regarding the environmental associations, the technical support is in line with the available means: the Order of Biologists has the smallest number of people working full time, and the means are considered weak, and GEOTA has the largest number of employees, whose means were considered reasonable. The higher the number of employees, the better the means to contribute to a continuous improvement of environmental policies, something that the State should support with greater commitment.

3.8. Relationship with environmental professionals

In order to investigate what kind of connection political officeholders (group n. º 1) have with environmental professionals, investigations have been carried out into this aspect.

Political parties

The representative of the political party PS has always worked with environmental professionals, classifying it as a good relationship: "environmental issues often lead to heated discussions. I have always listened to environmental associations, environmental technicians, and whenever I need to, I resort to technicians who can give me information and use the necessary data to take the stands I want".

The representative of the political party PSD considers that the human-nature relationship is vital for the development of the Alentejo region, being a great instrument of the future. His relationship with environmental professionals is very positive.

In a professional logic, with a paid position in the party, the leader of the political party CDS admits not to work with environmental professionals. However, in the research department of CDS, there are professionals who have brought support by working on a voluntary basis.

For the representative of the political party PCP, the work extends beyond just environmental professionals, as she values cooperation with workers who have been committed to the environment for 30, 40 years. She considers the relationship with all these professionals to be excellent.

The representative of the political party BE is a Professor at the Institute of Geography and Spatial Planning, where he has developed his professional activity. He has a very strong relationship with

environmental professionals, namely in spatial planning. Currently, in the Environment Committee of Parliament, he has a close connection with a wide range of entities and people linked to the Environment.

The representatives of the political party PEV have a good relationship with professionals working in the field of the Environment, recalling that, in public parliamentary hearings on various topics, the party often invites environmental associations.

For the representative of the political party PAN, the hiring of an environmental professional in the political party was very helpful and their relationship is positive. She considers that there is a complementarity between their knowledge: "we managed to bring the two together, mine alone is incomplete, hers alone is incomplete for what we want to do here, and therefore the combination of the two is very important".

The representative of the political party LIVRE is a researcher and considers his relationship with environmental professionals very positive. He cooperates with Environmental Engineers, Forest Engineers, Biologists, Physicists, Agronomists, all working in Environment, in its various components, but always in a multidisciplinary way. In his opinion, environmental professionals who get involved in ENGOs "end up having a broader vision than those who stay in their respective disciplines only as researchers".

Government

Assistant Secretary of State and for Mobility states that his relations with environmental professionals in his role as Secretary of State have been "marked by mutual cordiality and cooperation, always with the aim of finding the best solutions to the challenges we face every day, especially in the relationship between transport, mobility and climate change".

Secretary of State for Forests and Rural Development recalls that, as a former member of Parliament, his direct advisor was an Environmental Engineer, considering him one of the best advisors he has had to date. Although he does not consider himself to be an environmental professional, he believes to be a professional with high environmental sensitivity. He considers that the environmental professional includes "not only the Environmental Engineer, but all the complementary and supplementary professions of Environmental Engineering". Sustainability issues are the core issues of his State Department, where he focuses his work and feels that the environmental issue is increasingly the issue of the future. As an agronomist, he feels that some colleagues have a level of perception and sensitivity below what would be desirable.

Globally, political office holders rank their relationship with environmental professionals between positive and very positive.

3.9. Most outstanding environmental journalistic work

The media plays an important role in the transmission of information, thought reassessment and behavioural change. It seeks to make citizens more participatory in modern society, which is indispensable in environmental issues. In order to investigate the type of journalistic work related to environmental issues, the journalists in question (group n. º 4) were interviewed on this aspect.

The following case-studies are merely anecdotal, as they stem directly from the personal experience of the journalists who were interviewed. They do however illustrate the workings of the media towards the environment and the influence that committed journalism may have on the public opinion.

Firstly, it was recalled that the “Biosphere” TV programme has been in the air for 13 years and is cited in numerous master and doctoral thesis. It is a weekly magazine that highlights environmental issues, stating that it fulfils its mission of reaching the public, as well as Parliament and political circles.

A documentary one respondent considers important is the construction of the Baixo Sabor Dam and the environmental consequences for the natural balance of the region, “before being entangled in that dementia that was that dam”. Following the same issue, the most striking report for another journalist was “The Large Dams”, about the National Programme of High Potential Hydroelectric Dams. In her opinion, “it became very clear that the options that were taken were against the collective interest and that they favoured the interest of the hydroelectric power stations, in the case of EDP, Iberdrola and Endesa. It was a programme aimed at favouring hydroelectric companies and the construction sector”.

In terms of emissions and contamination, it was recalled the remarkable work on radioactivity, with the exploitation of uranium.

One respondent followed closely the whole problem of waste. His first articles, in 1988, focused on waste and the “transition of a completely chaotic policy”, recalling the 350 dumps that existed throughout Portugal and the subsequent creation of solutions to this problem. More recently, the subject of climate change has taken up 80% of his time, namely international negotiations. For 10 years, he wrote a weekly chronicle based on his own experience, about the difficulties of being sustainable in daily life, in which he told his stories and took the opportunity to transmit some content, being something he intends to take up again. He points out that it was the best way he found to pass content that reached people, and he has never had so much positive feedback.

The coverage of the Climate Summit in Copenhagen (2009) was stated as remarkable. It was a summit with high expectations for the creation of a robust and binding agreement, with a massive presence of heads of state from all over the world, which turned out to be a failure. She witnessed “how things end up working a bit under the table, the lack of transparency, international politics, international diplomacy”. Although she believes in the political system and understands that one should not have a general view of politicians, “we have repeatedly seen situations where decisions are taken, or agreements end up with an outcome that is not transparent, that does not take into account the global interest or the national interest”.

4. Conclusions

The objective of this research was to investigate the importance given to the Environment in Portuguese politics, and more specifically, the contribution of environmental professionals in political parties.

The point of view of the respondents is guided by their own professional experience, and not so much by their professional title or category.

According to most respondents, the treatment of environmental issues in Portugal does not exceed what is reasonable, considered by some even weak. Although environmental issues are mostly defended by the respondents as something important, a problem of passing on from the sensitivity to acts is mentioned. This means that, although there is already some sensitivity on the part of the population, there is still no actual change in behaviour. These responses fit with findings in the literature about the performance of environmental policies in Portugal.

Another aspect addressed was the presence of environmental professionals in political parties. In general, technical and scientific information is universally considered essential, but not all parties employ these professionals as advisors, and once again there is a gap between declared concerns and practice.

The main environmental milestones achieved in Portugal were questioned. Although Portugal was innovative in creating a law dedicated to environmental issues — the Environmental Policy Act of 1987 — it was due to the imposition of European policies that it developed most of the environmental policies. Voluntary action, experts and some politicians with high environmental sensitivity, from various parties, were key to the (slow) progress of environmental policy.

The main challenge mentioned by respondents is climate change. This also implies sound technical performance to develop appropriate environmental policies. Associated with this challenge is the decarbonisation of transport, efficient water-use and circular economy. Concern has also been shown about consumerism and waste, especially plastics, the problem of spatial planning and environmental education.

It is recognised that politics lack qualified people in the field of the Environment. In decision-making, information is not always enough, but the key issue is that even when such knowledge exists, it often overruled by other interests, economic, small politics or even corruption.

Parliament shows little multidisciplinarity. Lawyers are over-represented, while there is a reduced presence of science and technology graduates of any field, particularly the environmental.

The environmental professional as a political leader is not essential, as this involves other qualities such as charisma and leadership capacity. The success of political leaders in the environmental field are predicated on (i) a vision of the future, and (ii) their ability to surround themselves with competent environmental professionals as advisors.

When asked about the relation of political respondents with environmental professionals, they all described a positive situation.

Faced with a relatively weak civil society (by European standards), it seems that journalistic and ENGO activities appear as voices independent of power, which transmit information and raise awareness among the population, and the politicians, being indispensable to the success and practice of environmental policies.

Acknowledgments

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Legal Aspects of Sustainable Development

Right to be heard in tax procedures; how to build a more sustainable tax procedural environment.

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Abstract

Background context: Although environmental, social and economic aspects are the "three pillars" commonly accepted throughout the literature in the field of sustainability, there are other enabling factors as the institutional dimension of sustainability which refers to the interaction between institutions and citizens in a sustainable way. It is linked to the broader theme of citizen participation in administrative procedures and, in the field of taxation, to the specific topic of the taxpayer involvement in tax procedures. Due to the European Union policies, based on the "indirect execution", Member States are free to fix rules in compliance with the National Law and ensuring a homogeneous interpretation and application of European Union Law. Therefore, legislation is fragmented, often legally non-binding, and, eventually, incomplete or absent. Nevertheless, with the entry into force of the Lisbon Treaty, the Charter of fundamental rights became legally binding for every Member State and, particularly, Article 41 which expressly states that 'every person has the right to be heard before any individual measure which would affect him or her adversely is taken'. The principle is extremely relevant to increase tax compliance and trust in Tax Authorities and an important role in its building was played by the European Court of Justice and the European Court of Human Rights. As a result, some Member States, like Italy, started to issue rules in order to acknowledge the European Union's boost facing the difficult challenge of getting on well their internal vision with that arising from the European Union's institutions.

Research argument: Starting from the background context, the paper is focused on deepening the development of the right to be heard principle in tax procedures in the European Union context with a brief overview of the Italian tax procedural system, provided that the more Tax Authorities and legislator seek to achieve a sustainable tax system, the better they must support a right imposition allowing an easier interaction with taxpayers.

Aim: The objective of the researcher is to clarify the importance of a dynamic interaction between the two parties of the tax obligation for taxpayers to settle up their duties, with the additional goals of increasing trust in Tax Authorities and, at least, of fighting against illegal tax avoidance and tax evasion.

Methods: The method selected initially proposes a theoretical framework briefly describing the European Union policy in the area of administrative procedures and then, it extensively deepens the growth and the development of the right to be heard principle in tax procedures. Furthermore, through an essential in-depth analysis of the Italian solution the researcher tries to highlight the difficulties in applying a principle shareable by all the Member States while respecting their internal peculiarities.

Findings: Clarifying the relevance of the right to be heard principle through its potential in encouraging compliant behaviors and enhancing confidence in Tax Authorities.

Conclusions: Although with a limitation coming from the single case study, the paper may contribute to remark the importance of the investigated factors pointing out their role in enhancing cooperation and in preventing tax litigation. It may also be of interest for European policymakers interested in adopting similar measures to improve their tax systems, warning them to pay attention not to decrease the right to be heard principle consequently increasing the burden of taxpayers.

Keywords: Right to be heard, Tax procedures, Taxpayer participation, Cooperation, Sustainable tax system

1. Introduction

The first concept of sustainable development was defined in 1992 when the United Nations Conference on Environment and Development signed the Rio Declaration. It was based on the traditional 'triangle' formed by *People*, *Planet* and *Profit* (Barbier,1987), which are considered the three fundamental pillars (Mitcham, 1995; Mebratu, 1998). The economic side of sustainability is linked to the firm ability to make profits, ensuring long-term survival, fighting poverty and, seeking equity and income redistribution. The social aspects depend on the human capital involved and the related skills and experience, while the need for preserving biological elements and processes to ensure human survival represents the environmental sphere. Nevertheless, the broad debate on sustainability in the following years soon clarified that beyond the "three pillars" commonly accepted throughout the literature, there are other neglected enabling factors. This point of view was confirmed by the approval of the 2030 Agenda for Sustainable Development which placed Peace and Partnership side by side the initial triangle. Indeed, while *Partnership* highlights the need for strengthened global solidarity in favor of the poorest and most vulnerable, *Peace* is essentially attributed to the institutional dimension of sustainability intended as the effort to assure access to justice for all and build effective, accountable and inclusive institutions at all levels. Furthermore, concerning

institutions, it refers to the interaction between them and citizens and to how the former perceives the latter expectations managing the mutual relationship in a sustainable way (Pfahl, 2005; Turcu, 2013).

In the field of taxation, the concept of institutional sustainability affects the relationship between Tax Authorities and taxpayers and it represents an essential factor if a Government decides to design a tax reform; as a matter of fact, sustainable tax policies have to enforce not only growth and stability, encouraging the ability of a given community to economically bear the tax burden or to improve well-being conditions and social cohesion and to input its tax system to "green". At least, the fairness of a tax system is essential and it requires evaluating Tax Legislator's and Tax Authorities' capability of guarantee clearness, intelligibility, and transparency of rules and procedures, as well as the chance of simple access and real participation (Schick, 2005).

Needless to say that institutional sustainability impacts on tax rules, tax administrative requirements, the awareness to taxpayers' instances, the ability to address interaction, accountability and their consolidation over time. In this context, the link between a sustainable tax procedural environment - based on a dynamic interaction between the two parties of the tax obligation - and the willingness of taxpayers to settle up their duties, sure that they are subjected to a right tax obligation burden, has to be highlighted. The complexity of these factors creates an additional burden on individuals and businesses which has not to be underestimated. Indeed, it could represent an obstacle to loyal cooperation, trust and confidence between the taxpayers and Tax Administration strongly suggested by the European Union (European Commission, 2012) to prevent disputes and ensure alternative resolutions. As a result, to improve the enhanced behavior, the Commission supported good tax administrative practices in the Member States and recommended to issue and apply a taxpayers' code to reinforce a more effective tax collection. In addition to this, another aspect has to be considered; enhancing tax compliance while assuring a constant dialogue makes the two parties involved in tax relationship - taxpayers and Tax Authorities - sure they share a common understanding of the tax matters minimizing the need for time and money to be spent on tax specialists to avoid tax burden and supporting entrepreneurship. To sum up, better using existing instruments, improving coordination and further legislative action addressed to tax compliance there is a tangible opportunity in achieving both the not negligible goals of increasing trust in Tax Authorities and of fighting against illegal tax avoidance and tax evasion with reasonable expectations of success (Council of European Union, 2009; European Commission, 2012; European Commission, 2013; OECD International Tax conference 2016).

Therefore, confirmed that a sustainable tax procedural environment is mainly linked to the broader theme of citizen involvement in administrative procedures and, in the field of taxation, to the specific topic of taxpayer's involvement in tax procedures, in this context we tend to distinguish three different ways; a) informative involvement: taxpayer provides simple informative and/or documentary elements, not adding any subjective observations; b) cooperative involvement: taxpayer can implement the institutional activities of the Offices playing its role by adding subjective observations; c) defensive involvement: taxpayer controls the right taxation and can arrange a defense and Tax Authorities have to consider its observations. The latter is the context in which the *right to be heard* flourishes. It is the right of the citizen - in the deepening case, of the taxpayer - to be informed about the circumstance that a measure that will adversely affect his/her interests is arranging. It also includes the right of access to the documents relates, and the right to have ensured enough time to manage the defense.

Building the principle in the European Union was a hard task; although a clear need for common rules and common procedures was often highlighted by the Member States, it is due to notice that, in the general field of administrative procedures and, consequently of tax procedures, the European Union policies were, initially, based on the "indirect execution". Member States were free to fix rules in compliance with the National Law while ensuring a homogeneous interpretation and application of European Union Law (Chiti and Franchini, 2003). Consequently, every Member States provided tax procedural rules in line with rights considered fundamental at a European level. Despite the previous circumstances, with the entry into force of the Lisbon Treaty, according to articles 290, 291 and 298 TFEU, it was stated that

the Commission, if uniform conditions for implementing legally binding acts of the Union are needed, can exercise his power (Schwarze, 2012). According to the new framework, there was a gradual increase in the European Community's interventions to uniform tax procedures implemented by the Member States especially using the *soft law*, whose contents - as it is commonly known - are official, but not legally binding. Furthermore, due to the Lisbon Treaty, the Charter of fundamental rights became legally binding for every Member State. This means that, first of all, Articles 47 and 48 which ensure respect for both the rights of the defense and the right to a fair trial in all judicial proceedings have to be applied. In addition to this, about administrative procedures preceding litigation, Article 41 legitimized for the first time into a precise rule the general right to good administration and the essence of the right to be heard principle, expressly stating that 'every person has the right to be heard before any individual measure which would affect him or her adversely is taken'.

In the following years, an important role in building the principle was played by the European Courts (Craig, 2011), the Court of Justice and the European Court of Human Rights in different ways (Cocconi, 2010); the EHR Court was involved in its development inside the human rights of the European citizen in the broad sense. Instead, the Court of Justice favored the protection of residents in the Member States in the general field of the right of defense to avoid the risk of affecting taxpayer's interests deriving from the issue of a notice of assessment.

While the first case in which the European Court of Justice recognized a general principle of administrative law - that has to be guaranteed by all the Member States to all citizens - to assure a good and fair administration dates back to 1962[1], concerning tax law, the first leading case in which the Institution upholds the principle was Sopropé case[2] (Ragucci, 2009). It states that in case of a decision adversely affecting a subject (individual or legal entity), it must be allowed to express its point of view before taking the decision. The field considered was customs legislation and, in line with the previous framework, the Court underlined that its task is to ensure observance of fundamental rights while respecting the constitutional traditions of the Member States and the Treaties checking their compatibility with the Eu rules and principles. Indeed, the respect of the right to be heard is a general principle of the Union Law that finds application whenever the Public Administration, including Tax Authorities, proposes to issue against a subject a deed potentially damaging him or her.

The Eu Court underlined that the observance of the right to be heard is required even if the current legislation does not expressly provide it. Nevertheless, It referred the issue back to national courts to decide the implications of the Eu Court's indications.

Moreover, due to the joined cases, C129/13 and C130/13 Kamino International Logistics Datema Hellmann Worldwide Logistics BV (Marcheselli, 2014) - issued in July 2014 and commonly considered the second leading case - the Court clarifies that the right to be heard in all procedures is affirmed not only in Articles 47 and 48 of the Charter of Fundamental Rights - which ensure respect for both the rights of the defense and the right to fair legal process in all judicial proceedings - but also in Article 41 of the Charter, which guarantees the right to good administration. The previous assumption means that the authorities of the Member States have to assure the application of the principle, even though the EU legislation applicable does not expressly provide for such a procedural requirement. Nevertheless, the conditions under which observance of the rights of the defense is to be ensured and the consequences of the infringement of those rights are governed by national law, provided that the rules adopted to that effect are the same as those to which individuals in comparable situations under national law are subject. As a result, they can not make it impossible in practice or excessively difficult to exercise the rights of defense conferred by the EU legal order. In addition to this, the Court finally suggested that

1 CGUE 4 July 1963, C- 32/62 Maurice Alvis v Council of the European Economic Community.

2 CGUE, 18 December 2008, C-349/07 Sopropé c. Fazenda Pública

the national court *may* consider that such an infringement entails the annulment of the decision taken at the end of the administrative procedure at issue only if, had it not been for such an irregularity, the outcome of the procedure might have been different. To assure a better understanding of the following observations, it is due to highlight, that the Court used the word *may*, *peut* in the French version of the text; nevertheless, It introduced the suggestion of a *test of resistance* for the taxpayer.

Concerning the EHR Court set up in Strasbourg, the European Convention on Human Rights ("the Convention"), signed in Rome in 1950 allows citizens of the States which signed it to claim the protection of the rights guaranteed by the Convention in front of the Court, in the event of restrictive measures adopted by their Institutions. Thanks to the Lisbon Treaty, the Convention became part of UE law, resulting in general principles directly affecting Member States' legal orders. As a result, the European Court of Human Rights, intending to apply the right to be heard, has to deal with the assumption that the Art. 6 ECHR guaranteeing the right to a fair trial can't be applied to tax matters due to the difficulty to link the tax procedures to those regarding "the civil rights and civil duties" or those that are "criminal".

The guidelines of the EHR Court seem to keep tax litigation out from the application of article 6 ECHR (Del Federico, 2010). However, this restrictive interpretation during the years was overtaken by the Strasbourg Court's case. One of the most recent and interesting cases allowing a clear comprehension of the topic is *Ravon and others vs France* in which the Court applied Art. 6 ECHR to the preliminary investigation in the domicile of the taxpayer. Indeed, according to the European judges, the domicile is an object of civil protection and, therefore, the litigation was not of a tax nature, even though it originated from a tax inspection.

According to the previous framework, some Member States started to issue rules with the objective to acknowledge the European Union's boost facing the difficult challenge of getting on well their internal vision with the one arising from the European Union's institutions.

Nevertheless, owing to the choice of indirect execution, balancing the principles developed by the commixture between Eu legislation and case-law with the internal implementation of administrative and tax procedures is an extremely hard task for every Member State. Furthermore, it is a fight producing consequences in terms of rules still fragmented, often legally non-binding, and, also, contradictories. Besides a different complexity of the tax administrative procedures in the various Member States, often deriving from a general complexity and Tax Authorities' "bad" practices, has to be remarked.

A clear example of the previous circumstances is the strategy privileged by the Italian Government and legislator to implement tax procedures lightening the burden of the taxpayer and the interaction with the Tax Authorities; starting in the 2000s, Italian policymakers have carried on a synergic action based on the introduction of new and clearer rules and simplified procedures and the improvement of the Tax Administration.

Paying attention to the latter goal, the Italian Government initially decided not only to modernize Tax Administration's structure strongly supporting its digitalization but also to put its stakeholders - the taxpayers - in mutual contact with Offices by stimulating compliant behaviors. In the highlighted context, it is clear that the right to be heard principle played a relevant role. Indeed, gradually, it was extended from the procedural rules concerning trial to administrative rules impacting on administrative and tax procedures. As a matter of fact, there is no difference between the two expressions of the principle when it is necessary to formulate a judgment, or to carry out an evaluation, taking into account the interests of two opposing parties; the only real difference is how this goal will be achieved. In the case of a jurisdictional function, the judgment will be issued by a judge who stands as a *tertium inter pares*. While, in the hypothesis of implementation of the executive function, it will be one of the interested parties to formulate the aforementioned evaluation. As a result, in both cases, it is important to ensure the application of the right to be heard in the broader need of assuring the general right of defense, however, in the second case, it is to remark that the task also contributes to achieving a mutual view on the imposition.

What just highlighted clarifies why allowing citizens to expose their point of view before an act potentially prejudicial to their legal-patrimonial sphere is issued is a relevant opportunity.

Before reaching the acquisition of the right of a taxpayer to dialogue with Tax Authorities, a more general right of the citizen to dialogue with the Public Administration in the phase of arranging a deed potentially damaging his interests had been consolidated. The principle is clearly linked to art. 97 of the Italian Constitution which guarantees the impartiality and good performance of the Public Administration also through the possibility granted to the citizen to dialogue with the Public Administration, in general. Nevertheless, the change of view strengthening the significance of the rule was achieved due to the law no. 241 of 1990 about the citizens' involvement in administrative procedures. Indeed, the law became an inspiration for the tax legislator to better regulate the relationship between taxpayers and Tax Authorities creating a model of collaboration and facilitating the dialogue between the two parties, to make sure they share a common understanding of the tax matters. Therefore, Italy was the first European country elaborating primary rights and obligations into a taxpayers' charter - the Italian Taxpayer Bill of Rights (State Law no. 212/2000), substantially inspired by the previous general administrative legislation. The related objective was the improvement of the institutional sustainability of its tax systems and compliance by protecting the rights of the taxpayers in the dynamics of the tax obligation (Marongiu, 2008; Uricchio 2008). The Bill collects new rules designed by the tax legislator as general "immanent" principles of the tax system binding the interpreter to make their meaning compatible with the constitutional principles referred to.

As a result, the first Italian rule regulating taxpayer involvement in tax procedures, which was for a long time considered the landmark for the application of the right to be heard principle, is art. 12 ph. 7 of the Taxpayer's Bill of Right (Muleo, 2012).

It states that «in compliance with the principle of cooperation between the administration and the taxpayer, after the delivery of the copy of the final report of inspections, the taxpayer can express within 60 days observations and requests that have to be evaluated by the offices. The assessment notice cannot be issued before the expiry of the aforementioned term, except in cases of particular and justified urgency».

Initially, the rule appeared unclear especially due to the lack of a specific provision of invalidity of the assessment notice (cannot is different from must not) in case of neglecting the application of the principle. Therefore, for a long time, the doctrine debated the significance of the words, nevertheless, only ten years later, in the case no. 18184/2013 Italian Supreme Court of Cassation expressly recognized that a notice of assessment issued before sixty days has to be declared illegitimate, firstly underlining a substantial fault of the deed and enforcing the solidity of the principle hidden in the art. 12 rules (Tundo, 2013). Then, the Joined Sections of the Court (Cases no. 19667 and no. 19668/2014) seemed to have taken a step forward, sanctioning a true "general right to be heard" not connected with the notice of assessment but related to all kind of tax procedures ending with a notice, suitable to impact on the patrimonial integrity of the taxpayer. This statement is independent of the nature of the act and the segment of the proceedings, since the question deepened by Supreme judges concerned a lien inscription.

Furthermore, Legislative Decree 15 August 2015, no. 128, introducing in the Taxpayers' Bill of Right the art. 10 *bis*, fixed the application of the right to be heard principle in the case of abuse of right. Indeed, the new rule states that «without prejudice to the further assessment, the abuse of right is ascertained by a special deed preceded by the notification to the taxpayer of a request for clarification to be provided within the term of sixty days, in which are indicated the reasons for which abuse of the right is considered configurable». The choice of the Italian legislator was considered a step further in the development of a general and complete principle.

Unfortunately, starting with the following case no. 24823/2015 the same Joined sections of the Supreme Court restricted the application of the principle (Lovisolo, 2014). In particular, it was stated that applying the right to be heard before issuing the act is not a general duty unless it is expressly provided by law or by consolidates cases from the Court. On the contrary, in case of "harmonized" taxes (as VAT) the principle has to be applied due to the European Union framework but taking into account the fact that such an infringement involved the annulment of the decision taken at the end of the administrative procedures examined only if, in the absence of the aforementioned irregularity, the procedures could have led to a different

result. Therefore, although the principle preserves its effectiveness in the second case, to obtain the sanction of invalidity of the deed, the taxpayer has to produce evidence proving those circumstances and achieving the previously highlighted *test of resistance*. A relevant and not neglectable consequence is that in case of sole inspection involving different taxes (as Vat and Income tax) comes up the paradoxical effect of the application of the principle only at the Vat outcomes.

Moreover, the Court clarified another aspect linked to the investigations carried out in the Office. Tax Authorities exercising the powers of investigations, often choose to directly access to the places where the taxpayer exercises his activity looking for and acquiring useful documents and all other elements inspected and verifying findings. Nevertheless, they can also carry out "desk" activities, generally based on evidence already in possession of the Offices or immediately acquirable by inviting the taxpayer to present it or eventually submitting questionnaires, data and information provided by the same Offices, as well as by third parties (other administrations, banks and credit institutions, etc.). The Court stated that in this case there isn't a provision referred to this kind of investigation since art. 12 no. 7 is considered as a rule involving only the access to the previous places whose power of investigation is considered more intrusive.

Although part of Italian doctrine (Salvini, 2009; La Scala A. E., 2015) believes that not all investigations require interaction in advance with taxpayers, otherwise, the work of the Revenue Agency could become extremely complex, it is due to notice that, in the last years, desk activities are the most used by the Offices. Therefore, the assumption cannot be shared if investigations are part of a procedural sequence ending with a deed potentially damaging the taxpayer.

Paying attention to the peculiarities of desk activities, the officials of Revenue Agency draw evidence by comparing data with other documents in their possession; it appears that this kind of control - mainly based on documentary elements - needs to be adapted to the real situation of taxpayers and, eventually, refuted by the latter; Needless to say that the main goal of a fair imposition is to achieve shared outcomes closer to reality as much as it is possible, even in this case.

However, this strict and not agreeable point of view was recently confirmed by the issue of a new rule "Obligatory invitation" included in the Decree-Law no. 34/2019, better known as *Growth Decree*, which keeps out desk activities and partial assessment and makes the so-called *test of resistance* a burden for the taxpayer.

Current consequences are the application of the principle only if there is an express Italian rule or under consolidated cases from the jurisprudence - as in the hypothesis of standardized assessment, based on elaborations of average and generalized data, used in support of the "mixed" or analytical inductive method of investigation - or, as previously explained, if the assessment concerns harmonized taxes.

This is a clear example of the Italian institutional and regulatory complexity often engaging economic and business dynamics and affecting national growth. Therefore, the outcomes of these peculiar circumstances are the reference point for our following analysis, to better highlight consequences arising by trying to achieve a compromise between the European framework and internal complexities.

2. Methods

As clarified in the introduction, the method selected consists of various steps. First of all, it is due to notice that the research is based on a case study method, favoring the deductive/testing approach proposed by Yin (2003) which develops a theory at the beginning of the research and focuses on testing and validating the theory in case settings. Nevertheless, the only case considered is Italy and this could represent a limitation of the research to slower with further in-depth analysis.

Therefore, after having underlining the link between institutional sustainability and the right to be heard principle starting from a broader context and then highlighting the neglected side strictly impacting on the principle - extremely relevant in the need for a more friendly tax procedural environment - the second step was achieved by proposing the previous theoretical framework briefly describing the European Union policy in the area of administrative procedures and extensively deepening

the growth and the development of the right to be heard principle in tax procedures, due to the contribution of the European Union Courts and the entry into force of the Charter of Fundamental Rights and the European Convention on Human Rights.

The third and following step is an essential in-depth analysis of the Italian solution. In our country, for a long time, we witnessed the development of the principle, while in the last five years we have to highlight a sort of demolition not without consequences. Therefore, Italy is a proper example for our purposes consisting of clarifying the difficulties in building a principle while complying with Eu rules and respecting internal peculiarities. As a result, to better explain the sense of the research, it was essential summing up how the Legislator and the Government, in the last twenty years, have managed to make the tax system, and particularly the tax administration, more friendly. the objective was fully achieved developing the right to be heard principle. Thus, to support the initial assumption, the outcomes of the Italian policies are summarized and discussed, underlining how the intermittent choices carried out by the Italian Legislator impact on the trend of compliance registered in the reports of the Italian Revenue Agency, and on its strategy. As shown in the conclusions of the recent "circular" addressing the future behavior of the Agency's officials. Therefore the highlighted documents are the tangible side of our work.

Finally, it is worth emphasizing the purpose and significance of this study by underlining suggestions and recommendations for the European Member States building a favorable tax procedural environment and enhancing trust in Revenue Institutions. Indeed, the framework can serve as a model, even though perhaps imperfect, for European policymakers developing fiscal policies with the same goal for growth and sustainability of the tax system.

3. Results and Discussion

According to the previous underlined internal framework, Italy represents a clear case of the difficulties in enhancing a principle shared by the Eu Members States while dealing with their internal peculiarities.

In particular, the choice of the Italian legislator recently restricting the dimension of the right to be heard seems to be in a countertrend with the Italian Revenue Agency policies which, as appears from the annual performance reports (Italian Revenue Agency, 2015-2020) in the last five years has tried to stimulate tax compliance favoring interaction between the two parties of the tax obligation and fixing a sort of preventive measure in achieving a common assessment of circumstances. It is due to notice that the Italian policy was well evaluated by the OECD Centre for Tax Policy and Administration and the International Monetary Fund (Oecd, 2017) because increasing compliance is linked with the best practises included in the Action Plan BEPS and the in the ATAD (Anti Tax Avoidance) Directive in order to address taxpayers to respect tax laws. Due to the directive, Tax Authorities are involved in proposing alternative dispute resolutions with the added value to address taxpayers towards spontaneous fulfilment. Indeed, the enhanced importance of the right to be heard and its acknowledgement concerning every hypothesis of tax procedure ending with a notice certainly influenced the substantial increase of the tax index of compliance during the years between 2015-2017 (Accordino, 2018).

This new perspective of the Agency, now well established, certainly originates from the need to assure a balance between the tax collection interest and the rights of the taxpayers. Furthermore, building a taxpaying culture and confidence in Tax Authorities help the fight against illegal tax avoidance and tax evasion. In our country, there is a noticeable difference between the two phenomena; illegal tax avoidance is the apparent use of lawful and legitimate methods of tax planning and tax management that are usually punished by administrative penalty. While tax evasion is an activity clearly illegal punished by criminal penalties. In addition to this, there is another relevant factor to consider; in the tax procedures as in the administrative ones, not only in Italy but undoubtedly there where the evidence is outlined in an almost definitive way in the phase of the procedure preceding litigation. Then, it affects the trial - unlike what happens in civil and criminal trials, where the evidence finds its fullness in the trial itself - since the evidence is mainly documental. Therefore, traditionally means such as testimony and the oath are not admitted while investigating powers of the judges are limited; the model selected leaves the allegation of the main circumstances in charge of the parties. As a matter of fact, the taxpayer's participation in the

phase in which the evidence formation is predominantly carried out becomes essential. This is the only way to ensure the right allocation of the burden of proof between the parties involved, in line with Article 111 of the Italian Constitution which guarantees the right trial and the right procedures.

In conclusion, the remarkable outcomes obtained - due to the strengthening of the institutional sustainability and the implementation of clear and simple rules and procedures - confirm the need to ensure the application of the principle to all kinds of procedures, overcoming the strict limitation. As a result, according to the previous outcomes and aware of the "falling trend" of the right to be heard principle ascribable to the narrow view of the Italian Supreme Court and of the legislator, the Agency, at the end of 2019, issued a "circular" (no. 19E/2019), which is a document with internal value for all the Offices, highlighting strategic goals for 2019-2021 to prevent tax evasion and manage advisory activities, litigation, and collection. In the outlined document the Agency specifically underlines that the inspections carried out on self-employed workers and individuals will have to be aimed at clearly defining the tax claim and at achieving the right imposition by ensuring the taxpayer's effective participation in the assessment. Consequently, the right to be heard, also with the assistance and advice of a qualified professional defender, becomes fundamental.

Nevertheless, evaluating the current Italian framework, it is clear that the Legislator's and Courts'position is extremely different, and the introduced test of resistance burdens the taxpayer with an excessive commitment comparable with the well-known *probatio diabolica*, consequently, unbalancing the positions of the parties in favour of the Tax Authorities. The dichotomy between cases to which the test had to be applied - an astonishing double-track between harmonized taxes or not (Beghin, 2016) - made unacceptable the statement examined. Furthermore, the violation of constitutional principles set out in Articles 97, 53 and 111 and the contrast with European rules and principles, such as Article 41 of the Charter of Fundamental Rights of the EU, as well as the principles of "equivalence" and "effectiveness" is incontrovertible. Especially considering the right to be heard principle an immanent canon, essential not only to guarantee the taxpayer's rights of defence but, above all, a correct and shared exercise of the tax function.

In this way, the recent rigidity of the Italian legislator - which has evidently considered necessary to normatively limit the right to be heard, not only excluding it in the case of partial notices of assessment and desk activities but also expressly binding, in a lot of cases, the application of the principle to the test of resistance - counterbalances the recent point of view of the Tax Authorities which appears, in some way, to mitigate the burden of proof for the taxpayer.

4. Conclusions

The aim of the paper is filling the existing gap in the literature to contribute to remarking some relevant factors enhancing cooperation and preventing tax litigation. First of all, the current research intends to clarify the importance of institutional sustainability in ensuring the involvement of taxpayers in tax procedures, with the clear objective of achieving a mutual view about the concept of a right imposition. As a result, it is possible to ensure a suitable exercise of the tax function by the Administration itself. In this context, the principle of the right to be heard represents an incontrovertible need. And its importance is higher in case of deeds not immediately challengeable in front of a Court, as is the final deed drafted at the end of direct access in the places where it is allowed to looking for the evidence related to the taxpayer. Evidently, the chance of interaction between the two parties involved in the assessment in this phase preliminary at the issue of the deed may lead to an obvious deflating effect of the tax litigation. Indeed, since the debate between taxpayers and Tax Authorities has to be "substantial" the latter have to pay real attention to the reconstruction of the circumstances carried out by the taxpayer and they have to manage clear statements of the reason justifying a denial of acceptance; therefore, the respect of the rules could avoid issuing the following notice of assessment and the probable starting of tax litigation.

However, while the common feeling of the Italian doctrine appears confirming the immanence of the principle (Colli Vignarelli, 2017), highly supported by the Eu framework and also by the internal constitutional principle, the view of the Italian Supreme Court and Legislator is extremely different. Indeed, it seems to prevail the conviction to limit the principle

and conditioning it to a test of resistance weighing on the taxpayer wit a concrete risk of reducing its effect.

The underlined position is in contrast with the conclusion that those who are subject to tax law tend to be more cooperative if they perceive the willingness of the Legislator and Tax Authorities not only to carry on a constant dialogue but, above all, also to take into account any complaints. In order to make less "hostile" for taxpayers submitting to the various means used by the Offices to fulfil their function, often compressing the legal sphere of the taxpayer (from a personal and patrimonial point of view), the chance of interacting and acquiring the awareness of being "taken into consideration" becomes essential. Such involvement is also useful to the Tax Administration, to the extent that it reinforces its reliability, especially if its action allows obtaining outcomes which bring the taxable income as close as possible to the real data.

Considering that the results deriving from the report of Tax Authorities and the recent policies carried on to confirm the opportunity of increasing institutional sustainability and the application of the right to be heard in every situation in which the potential issuing of a deed without the chance for the taxpayer to express his point of view could affect its interest, it is clear that the recent choice of the Italian Legislator is not in line with the European framework while linked with an internal limitation that has to be overcome.

However there is a limitation coming from the single case study, the previous conclusions may be of interest for European policymakers in order to adopt similar measures to improve their tax systems paying attention not to decrease the right to be heard principle consequently increasing the burden of taxpayers. Furthermore, in future studies we aim at including in the analysis the outcomes of other European Countries which have adopted similar policies, to improve the validity of the Italian outcomes as a model.

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Sustainability Issues of the Intelligent and Autonomous Vehicles

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Abstract

The present article deals with the sustainability aspects of the autonomous and intelligent vehicles with special regard to the relevant Sustainable Development Goals (SDGs). The background of the study is the sustainability benefit or advantage offered by the cost-efficient and fuel-saving prudent planning of routes and transportation methods by autonomous/self-driving vehicles. Sustainability benefits are equivalent to societal benefits, as well, since one of the three pillars of sustainable development is the social aspect (the others are the ecologic and economical pillars). The research argument and the main aim is to carry out an analysis of the eco-friendlier and sustainable usage of autonomous vehicles by the smart and intelligent planning of the driving method, using fuels, and parking. According to many (however, US-based) sources, intelligent planning could save more energy and can transform transportation into an energy-saving mode. The presentation offers a legal analysis of these methods, their legal opportunities, for instance the issue of permission and the environmental legal issues. The presentation takes into account the above-mentioned six SDGs legal content and their potential application to autonomous vehicles.

Keywords: SDGs, autonomous vehicles, automation, fuel-saving, transportation

1. Introduction

The present study deals with the sustainability aspects of the intelligent and autonomous vehicles/cars (the later phrase is equal to self-driving vehicles/cars, which will be used identically). Nowadays, there is no doubt that one of the biggest advantages and positive outcomes of automation is the environment-friendly way of guaranteeing mobility. There is no need for an in-depth explanation that automation generated by technological advances and environmental sustainability are among the most important global challenges of our time. This study examines the relationship of intelligent and autonomous vehicles and the goals of sustainability, more specifically the United Nations Sustainable Development Goals adopted in 2015.
The starting point of analysis of this study is heavily based on the technical capabilities of our contemporary period, which is for the time being quickly developing and shifting due to rapid technological changes, as well. It is worth mentioning that the "*technical communis opinio*" of autonomous vehicles and sustainable development itself is not crystal-clear, both terms and phenomena are full of uncertainties and self-contradiction.
The paper is aiming to draw conclusions on the potential advantages and benefits of the autonomous vehicles with regard to the SDGs and their specified targets, especially their

fuel-saving mode being important for tackling climate change and lowering greenhouse gas emissions. However, the present analysis has its natural deficiencies due to uncertainties and the sources, data of this subject are almost exclusively from the United States and other highly industrialized economies and states. Therefore, there is no worldwide model of potential benefits, thus equal and congenial roadmap for sustainable automation cannot be achieved. The approach is rather policy-based due to the specifics of the subject but the required ecological side is also touched upon in a narrower manner.
The findings and the conclusion will focus on the justification that the intelligent planning and network of autonomous vehicles could foster to achieve SDGs and a more sustainable future. The content of some SDGs could be clarified with such newly invented and highly attentive technical solutions such as the autonomous vehicles.

2. Sustainability and the SDGs

The concept of sustainable development (Schrijver, 2008) has certainly become a magic world and commonplace in the last few decades, especially in recent decades. As described by Our Common Future report of the United Nations World Commission on Environment and Development in 1987, the phrase reads as follows, “sustainable development seeks to meet the needs and aspirations of the present without compromising the ability to meet those of the future." (Our Common Future, 1987)
Since then, the term ‘sustainable development’ has gained many layers and new levels of interpretation in world summits, policy papers and legal documents, as well. The meaning of sustainable development has 3 pillars as of i) social, ii) economic and iii) environmental (ecological) phenomenon, thus sustainability shall be interpreted and achieved simultaneously in social, economic and environmental ways.
As a Millennium commitment and manifesto by the UN member states for the year 2000, 189 nations adopted the Millennium Development Goals (MDGs) for a 15-year-period as a general agenda. In 2015, after being aware of the shortages and negative experiences of the MDGs by their deficient implementation, the UN Agenda for Sustainable Development and the Sustainable Development Goals (hereinafter: SDGs) had been completed and adopted by all UN member states (in 2015, it represented 193 states) as a replacement of MDGs and further commitment to global goals (Crowther et al., 2018, Monkelbaam, 2019). The UN member states set out the SDGs to be achieved by 2030 as global but soft law, policy-based commitments. As the 2030 Agenda of UN member states reads, „the 17 Sustainable Development Goals and 169 targets which we are announcing today demonstrate the scale and ambition of this new universal Agenda. They seek to build on the Millennium Development Goals and complete what they did not achieve.” (Transforming Our World, 2015). Along with the 17 goals and 169 targets, 232 further indicators had been conceived by the states too (Transforming Our World, 2015). We are now 10 years before from the end of this period, therefore we cannot draw conclusions on the fulfillment and outcome of SDGs in 2020.

3. About Autonomous Vehicles in General

The self-driving or autonomous vehicles (Cheng, 2011, Jurgen, 2013, Meyer and Beiker,

2014, Glancy, 2015, Glassbrook, 2017) became a symbol of robotization, automation and rapid technological development in the late 2010s and early 2020s. These vehicles seem to be a forerunner and marker of the newest technological inventions being able to change our life and mobility habits significantly in the 21st century. According to the forecast of Institute of Electrical and Electronics Engineers, the intelligent and autonomous vehicles will dominate the automotive market (but not necessarily road transport) by 2040. These forecasts are, however, highly uncertain and they are exposed to several societal and technological changes.

The Society of Automotive Engineers (SAE) defined the six levels of automation of vehicles in its 2014 report, this categorization is considered the basis classification since then.

According to this, the levels of automation are as follows (SAE Taxonomy, 2014):

(i) "Level 0 - No Automation: The full-time performance by the human driver of all aspects of the dynamic driving task, even when enhanced by warning or intervention systems.
(ii) Level 1 - Driver Assistance: The driving mode-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the human driver performs all remaining aspects of the dynamic driving task.
(iii) Level 2 - Partial Automation: The driving mode-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the human driver performs all remaining aspects of the dynamic driving task.
(iv) Level 3 - Conditional Automation: The driving mode-specific performance by an Automated Driving System of all aspects of the dynamic driving task with the expectation that the human driver will respond appropriately to a request to intervene.
(v) Level 4 - High Automation: The driving mode-specific performance by an Automated Driving System of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene.
(vi) Level 5 - Full Automation: The full-time performance by an Automated Driving System of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver."

It is possible to divide the control and permissions of autonomous vehicles by state regulatory solutions into three groups, whether the state permits the autonomous vehicles

(i) in road traffic (currently only in some US states);
(ii) on road test mode, as well (in several EU Member States, including Hungary);
(iii) only on test track (in many states).

Undoubtedly, the real ecological and environmental benefits of autonomous vehicles can appear only in the most concessive road traffic mode. It is worth highlighting that the issue of autonomous vehicles is still under the exclusive regulatory jurisdiction of a sovereign state, while international legislation cannot be excluded for the sake of regional and global harmonization of global transportation and mobility.

There is no doubt that one of the main issues to be addressed in the coming decades will be the change in the individual internal road traffic rules, taking into account the rules facilitating automation and autonomous vehicles. In 2017, the United States Congress

amended the law on the federal transportation authority's competence over highly automated vehicles. (H. R. 3388, 2017) and in the same year the United States Senate Commerce Committee passed a bill to support the development of highly automated vehicle safety technology (To support the development, 2017).

4. The Framework and Role of Autonomous Vehicles and Sustainable Issues in General

One of the overall benefits of the autonomous vehicles is that it makes life more comfortable, healthier (van Schwalkwyk and Mindell, 2018) and more efficient, while minimizing the number of accidents in a fully automated system with a huge network controlled by safe, secure algorythms.

The most cited and predicted benefits and advantages of autonomous vehicles are allegedly intelligent design, innovative public transport, and simpler algorithmic identification of the shortest (and most cost-effective) route that plays a key role in reducing fuel and pollutant emissions during the movements of the vehicles (Fagnant and Kockelman, 2014, Greenblatt and Shaheen, 2015, McEvoy, 2015). But one of its disadvantages is that the benefits of such vehicles only arise if the vast majority of road vehicles are based on automation and through network-controlling algorithms' (Shariff et al., 2017). Furthermore, it has to be noted that in recent years, some players in the automotive industry have been hit by major scandals due to a number of environmental obligations and the falsification of their emissions data, which somewhat eroded their fame in the serious combat against climate change issues.

The United Nations, under the auspices of the International Telecommunication Union as a specialized agency complemented by scientists and industry, has been organizing meetings on AI for several years (AI for Good Global Summit), and this body promotes its role in the technical applications of Artificial Intelligence for Sustainable Development Goals. The United Nations Regional Economic Commission for Europe has set up the World Forum for the Harmonization of Vehicle Regulations, which develops frameworks for the technical development of cleaner and safer vehicles, and since 2014 it has been working on a regulatory framework for intelligent and autonomous vehicles.

The United Nations Economic Commission for Europe is also co-organizing the Future Networked Car series with the International Telecommunication Union, which, together with industry, discusses the ethical, technological and sustainability aspects of the next generation of the automotive industry. The two bodies also regularly organize the United for Smart Sustainable Cities Initiative, which also involves 16 UN agencies.

In regional way, the EU Automotive Strategy 2030 (GEAR 2030 Strategy 2015-2017 - Comparative Analysis of the Competitive Position of the EU Automotive Industry and its Impact on the Introduction of Autonomous Vehicles) also gives priority to self-driving vehicles in the 2030 plans, and also takes into account the relevant rules and trends of major automobile industries (beyond Europe, Japan, China, USA, South Korea, India).

The EU has (most certainly at Member State level) the most concrete and effective sustainability, environmental regulation system and integrates support for self-driving vehicles into its ambitious climate commitments.

In the context of climate protection issues and artificial intelligence, the Council of the European Union discussed in detail two innovation topics of major importance for the future of the Union. The effects of artificial intelligence and the climate-friendly economy can play a role in the next generation of automotive technologies, especially intelligent

vehicles.
With regard to the climate-friendly economy, the Council dealt in detail with the European Commission's "A Clean Planet for All". Ministers in the Council have unanimously identified the reduction of greenhouse gas emissions as a priority. It has been formulated that „*a combination of decarbonised, decentralised and digitalised power, more efficient and sustainable batteries, highly efficient electric powertrains, connectivity and autonomous driving offers prospects to decarbonise road transport with strong overall benefits including clean air, reduced noise, accident-free traffic, altogether generating major health benefits for citizens and the European economy.*" (A Clean Planet for All, 2018).

5. Intelligent and Autonomous Vehicles and SDGs

By shifting transportation into a fuel-saving, more sustainable and low emission mode, the benefits of autonomous vehicles are closely linked to almost all the SDGs, transportation is set out in 8 SDGs from the 17 goals (Martin, 2019). By means of targets, transportation has a high importance within several SDGs which are not dominantly and directly attached to the intelligent mobility issues. Globally, transport is responsible for 14% of global greenhouse gas emissions, for example, in the United States alone, it is responsible for 27% (in the European Union it is approximately 26%). There is no doubt that a network-based algorithm can achieve shorter and more cost-effective paths through smart route planning.
A joint study by Fulton, Mason and Meroux clearly shows that the three main challenges are electrification, automation and shared mobility (Fulton et al., 2017). They pointed out that only vehicle automation (without electrification and the shared mobility) the greenhouse gas emission of the transportation will be 50% higher in decades, however, the triad of combination (automation, electricity and shared mobility) could jointly lower the emission by 80% in decades." (Fulton et al., 2017).
Autonomous vehicles are expected to significantly reduce their greenhouse gas emissions (up to 90% per mile) by 2030 (Greenblatt and Saxena, 2015). The intelligent and automated systems can reduce greenhouse gas emissions by 80% until 2050. Otherwise, in the absence of car sharing or the electric car revolution, gas emissions would increase by 50% (Fulton et al., 2017).
According to a US Transportation Authority report, there is an average of only 1.67 passengers per car in the US (approximately the car utilization is only 35%), public transport and generally self-driving vehicles can certainly improve the utilization of that. According to a research, 30% to 60% of driving time within a city is spent for looking for parking lots, increasing fuel consumption by 40% per trip in the US. According to a study of the Texas Transportation Institute study, a Texan wastes 19.5 gallons (about 72 liters) of gas per year for finding parking lot (Infante, 2014). Americans spend 5 billion hours in traffic jams, burning nearly 3 billion gallons (~ 11.4 billion liters) of fuel. In the United States, the benefits of more efficient autonomous vehicles are estimated to reduce emissions by 94% per vehicle per mile by 2030. Without a doubt, a more intelligent design and planning would easily lower these costs and emissions.
Goal 2 Zero Hunger (*End hunger, achieve food security and improved nutrition and promote sustainable agriculture*) require to reduce agriculture costs through autonomous vehicle provisions, and to provide vehicle access to farmers who might not have had it previously.

Goal 3 (*Ensure healthy lives and promote well-being for all at all ages*) focuses on reductions in deaths from road traffic accidents through improved road safety as well as to contribute to reduced automotive emissions and improved air quality and health.
Goal 7 Affordable and Clean Energy (*Ensure access to affordable, reliable, sustainable and modern energy for all*) aims to achieve by 2030, inter alia, (i) primary access to clean fuel and (clean) technology for the public; (ii) increasing the share of renewable energy in both production and consumption; (iii) significantly increasing energy efficiency; (iv) investing in clean infrastructure and clean energy technology and (v) assisting developing countries in research and development of clean and renewable energy.
Goal 9 Industry, Innovation and Infrastructure (*Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation*) and the interlinking targets, indicators include building adaptive infrastructure, creating comprehensive and sustainable industrialization, and supporting innovation by i) introducing of technologies that enable reduction in carbon footprint through greater efficiencies; ii) efficient use of people by removing the limiting conditions surrounding certain roles; and iii) providing opportunities for new and innovative products and service models.
The targets and indicators of Goal 11 Sustainable Cities and Communities (*Make cities and human settlements inclusive, safe, resilient and sustainable*) are focusing on the realization of sustainable, inclusive, safe and adaptable cities and human settlements (Lim and Taeihagh, 2018). Transport-related indicators for these targets indicate that priority should be given to improving road safety by 2030, for example by improving and providing the accessibility and comfort of public transport, with special attention given to vulnerable people, women, children, disabled and elderly people. There is no doubt, therefore, that the concept of smart and sustainable cities is closely linked to the phenomenon of car-sharing and self-driving vehicles (U.N.G.A. Resolution 71/313, 2016).
Caragliu, Del Bo and Nijkamp rank the network infrastructure as one of the 6 criteria for smart cities (Caragliu et al., 2011).
These six criteria are:
1. utilization of networked infrastructure to improve economic and political efficiency and enable social, cultural and urban development;
2. underlying emphasis on business-led urban development;
3. the social inclusion of various urban residents in public services;
4. high-tech and creative industries in long-run urban growth;
5. social and relational capital in urban development;
6. social and environmental sustainability as a major strategic component of smart cities.

In addition, according to Bruun and Givoni, “Scientists and planners urgently need to understand the significance of changes in urban development plans on the construction and operating costs of all aspects of the built environment, on total urban energy consumption, on living standards and on space consumption. To accomplish this, universities and urban governments need to break down traditional borders between disciplines and professional responsibilities.” (Bruun and Givoni, 2015).
Goal 12 Responsible Consumption and Production (*Ensure sustainable consumption and production patterns*) highlights the responsible use of resources with targets such as improving sustainable consumption and production patterns. Indicators include (i) the adoption of a 10-year Framework for Sustainable Consumption and Production Patterns, led

by developed countries, (ii) sustainable and efficient use and management of natural resources, and (iii) re-use and halving food waste through supply chains.
In the framework of Goal 13 Climate Action (*Take urgent action to combat climate change and its impacts*), there shall be a contribution to improving the climate through the combined effects of air quality improvements and reduced fossil fuel usage, besides the development of resilience and adaptation capacity to climate change challenges and natural disasters (e.g. through risk reduction and disaster management programs) shall be achieved with all integrated climate change policies, strategies.
The last of the SDGs, Goal 17 Partnership for Achieving Goals (*Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development*) addresses the implementation. The UN General Assembly Resolution on Indicators addresses the need for (i) financing of sustainability instruments, (ii) increasing access to technology, (iii) capacity building, (iv) trade, and (v) the system approach.
A common feature of the goals, targets and indicators above is to emphasize the distinctive role of the developed countries, their financial responsibility, and the access of the population to modern technologies (Newman et al., 2015).

6. Conclusions

The conclusions of the study are full of uncertainty even if they are not futuristic. As described at the outset, comparing an autonomous driving system tested with a currently recognized and quickly shifting technological specification does not allow the conclusion of the thesis to reach the highest degree of certainty. Thus, the author of these lines is therefore aware that the findings of the work are mostly predictions, lacking a highest degree of scientific knowledge, and most of the findings are valid only in an environment where the number of autonomous vehicles on the world's roads significantly exceeds the number of traditional vehicles.
The author strongly believes that the abstract concept of sustainability can be approached at global, regional or national level simultaneously, however, the activities as well as the means and measures can differ significantly. In sum, it has to be mentioned that, as a thesis, the benefits of autonomous vehicles in sustainable development issues are the following:

(i) the vehicles are able to drive faster, more economically and use less fuel with more efficient design;
(ii) the vehicles will cause fewer and fewer accidents and less stress on the roads;
(iii) they do not cause traffic jams or traffic jams by using an appropriate algorithm, since an integrated system would be able to handle this with a large number of self-driving vehicles connected to the network;
(iv) they are able to create a new kind of public transport (special car-sharing), which reduces the number of cars;
(v) due to fewer parking lots, spaces and heavy traffic, there is less space in an urban settlement, so more prudent space utilization, "greening" of urban settlements may be an existing option instead of parking lots and places;
(vi) light and noise pollution and vibes can be reduced due to an additional benefit based upon the aforementioned advantages.

A study pointed out that eco-driving, platooning, intersection connectivity and faster highway speeds can easily be direct effects of automated vehicles, therefore the energy use as well as GHG emissions can be reduced by 9% (Gawron, 2018).
However, we should take into account and pay attention to the words of Jacques Leslie, who wrote that unless the "revolutionization" of mobility and innovation are "guided by sound public policies, the future of transportation could lead to more pollution, more emissions, and more gridlock." (Leslie, 2018).

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The Encyclical Letter "Laudato sì" between sustainable development and integral ecology

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Abstract

Background context: The latest Pope Francis' I Encyclical Letter "Laudato sì" addresses the care of our common home and it is linked to the path already traced by the previous Popes.

Indeed, it is widely acknowledged that the Encyclical Letters *Populorum progressio* by Paul VI, *Sollecitudo Rei Socialis* by John Paul II and, *Caritas in Veritate* by Benedict XVI, share the same central idea that is the aspiration to a Human ecology.

The Catholic Church has always shown a deep interest in the creation and its safeguarding.

Due to the Encyclical letter, Pope Francis took another step forward in the previous context highlighting the importance of an integral ecology pointing out how the care of nature, equity for the poor, and social tasks are inextricably connected to joy and inner peace

As a matter of fact, there is a close relationship between environment (intended as landscape protection and right to health, ecology (which means soil, air and water defense from pollution) and eradication of poverty, care of poor and fair access to planetary resources.

After having stigmatized the culture of waste and scrapes, Pope Francis stated that cultivating and safeguarding the creation does not include only the relationship between us and the environment but also concerns human relationships due to the fact that environmental and human ecology walk together.

Research argument: The paper intends to deepen the topic of the environment and its care by the Canon Law point of view.

Aim: The objective of the research is to clarify how, in the Christian religion, man occupies a privileged place among all creatures and it has to be considered at the center of creation. From this perspective, he has to take on responsibility in protecting all living beings. The concept of "creation", indeed, not only represents the crucial factor of the Christian religion but also implies rights and duties hold up by the one to whom the creation was entrusted: the man.

Methods: Starting from the analysis of the juridical nature of the environment and deepening the different theories expressed by the doctrine - divergent between an anthropocentric and an ecocentric overview - the author faces the question of a clear definition of the concepts of "environment", and "creation", typical of religions, above all those revealed.

The main part of the paper is focused on the contents of the Encyclical "Laudato sì", paying particular attention to the guidelines and suggested activities such as ecumenical commitment and dialogue in international and local policies.

Findings: Highlighting the outcomes achieved such as the convocation of the Synod on the Amazon in 2019, as well as the measures taken by the Vatican on photovoltaics and, generally, on a more sustainable economy.

Conclusions: The research wants to clarify the need to understand that a large-scale cultural conflict on nature is underway: on the one hand there are the most extreme environmental trend introducing a new deification of nature, on the other hand, there is the theological contribution of Christianity which push us not to reduce nature to a mere substrate of manipulation and use, nor to overlap it on the human beings' dignity.

Keywords: Encyclical, Environment, Protection, Human ecology, Ecumenical commitment.

1. Introduction

The latest Pope Francis's Encyclical Letter "Laudato sì" addresses the care of our common home(1) and it is linked to the path already traced by the previous Popes(2).

[1] "Laudato si" is the second Pope Francis's Encyclical Letter, after *Lumen fidei* which was released in 2013, and has the subtitle "on care for our common home". In it, the Holy Father critiques consumerism and irresponsible development, laments environmental degradation and global warming, and calls all people of the world to take "swift and unified global action".

The Encyclical, dated 24 May 2015, was officially published at noon on 18 June 2015, accompanied by a news conference. The title of the social Encyclical is an from Francis of Assisi's 13th-century "Canticle of the Sun" (also called the Canticle of the Creatures), a poem and prayer in which God is praised for the creation of the different creatures and aspects of the Earth.

2 More than fifty years ago, when the world was entering a nuclear crisis, Pope Saint John XXIII wrote an Encyclical which not only rejected war but offered a proposal for peace. He addressed his message *Pacem in Terris* to the entire "Catholic world" and indeed "to all men and women of good will". Now, faced as we are with global environmental deterioration, the

Indeed, it is widely acknowledged that the Encyclical Letters *Populorum progressio* by Paul VI(3), *Sollecitudo Rei Socialis* by John Paul II(4) and *Caritas in Veritate* by Benedict XVI(5), share the same central idea that is the aspiration to a Human ecology.

The Catholic Church has always shown a deep interest in the creation and its safeguarding.

Due to the Encyclical Letter, Pope Francis took another step forward in the previous context highlighting the importance of an integral ecology pointing out how the care of nature, equity for the poor, and social tasks are inextricably connected to joy and inner peace.

As a matter of fact, there is a close relationship between environment (intended as landscape protection and right to health), ecology (which means soil, air and water defense from pollution), and eradication of poverty, care of poor and fair access to planetary resources.

After having stigmatized the culture of waste and scrapes, the Holy Father stated that cultivating and safeguarding the creation does not include only the relationship between us and the environment but also concerns human relationships due to the fact that environmental and human ecology walk together.

2. Methods

The objective of the research is to clarify how, in the Christian religion, man occupies a privileged place among all the creatures and it has to be considered at the center of Creation.

The paper intends to deepen the topic of the environment and its care by the Canon Law point of view.

From this perspective, he has to take on responsibility in protecting all living beings. The concept of "Creation", indeed, not only represents the crucial factor of the Christian religion but also implies rights and duties hold up by the one to whom the Creation was entrusted: the man(6).

Starting from the analysis of the contents of the Encyclical "Laudato sì", using the inductive method, paying particular attention to the guidelines and suggested activities such as ecumenical commitment and dialogue in international and local policies.

I intende to demonstrate that this Encyclical on care for our common home is perfectly consistent with the ultimate aim and principles of Canon law.

Holy Father Francis wishes to address every person living on this planet. In his Apostolic Exhortation *Evangelii Gaudium*, he wrote to all the members of the Church with the aim of encouraging ongoing missionary renewal. In this Encyclical, he would like to enter into dialogue with all people about our common home.

3 In 1971, eight years after *Pacem in Terris*, Blessed Pope Paul VI referred to the ecological concern as "a tragic consequence" of unchecked human activity: «Due to an ill-considered exploitation of nature, humanity runs the risk of destroying it and becoming in turn a victim of this degradation». He spoke in similar terms to the Food and Agriculture Organization of the United Nations about the potential for an «ecological catastrophe under the effective explosion of industrial civilization», and stressed «the urgent need for a radical change in the conduct of humanity», because «the most extraordinary scientific advances, the most amazing technical abilities, the most astonishing economic growth, unless they are accompanied by authentic social and moral progress, will definitively turn against man». Apostolic Letter *Octogesima Adveniens* (14 May 1971), 21: AAS 63 (1971), 416-417; Address to FAO on the 25th Anniversary of its Institution (16 November 1970), 4: AAS 62 (1970), 833.

4 Saint John Paul II became increasingly concerned about this issue. In his first Encyclical, he warned that human beings frequently seem «to see no other meaning in their natural environment than what serves for immediate use and consumption». Subsequently, he would call for a global ecological conversion. At the same time, he noted that little effort had been made to «safeguard the moral conditions for an authentic human ecology». The destruction of the human environment is extremely serious, not only because God has entrusted the world to us men and women, but because human life is itself a gift which must be defended from various forms of debasement. Every effort to protect and improve our world entails profound changes in «lifestyles, models of production and consumption, and the established structures of power which today govern societies». Authentic human development has a moral character. It presumes full respect for the human person, but it must also be concerned for the world around us and «take into account the nature of each being and of its mutual connection in an ordered system». Encyclical Letter *Redemptor Hominis* (4 March 1979), 15: AAS 71 (1979), 287; Encyclical Letter *Centesimus Annus* (1 May 1991), 38: AAS 83 (1991), 841; Encyclical Letter *Sollicitudo Rei Socialis* (30 December 1987), 34: AAS 80 (1988), 559.

5 Benedict XVI likewise proposed «eliminating the structural causes of the dysfunctions of the world economy and correcting models of growth which have proved incapable of ensuring respect for the environment». He observed that the world cannot be analyzed by isolating only one of its aspects, since «the book of nature is one and indivisible», and includes the environment, life, sexuality, the family, social relations, and so forth. It follows that «the deterioration of nature is closely connected to the culture which shapes human coexistence». Address to the Diplomatic Corps Accredited to the Holy See (8 January 2007): AAS 99 (2007), 73; Encyclical Letter *Caritas in Veritate* (29 June 2009), 51: AAS 101 (2009), 687.

6 In the Judaeo-Christian tradition, the word "creation" has a broader meaning than "nature", for it has to do with God's loving plan in which every creature has its own value and significance. Nature is usually seen as a system which can be studied, understood and controlled, whereas creation can only be understood as a gift from the outstretched hand of the Father of all, and as a reality illuminated by the love which calls us together into universal communion.

Therefore the main part of the paper is focused on the contents of the Encyclical "Laudato sì", divided in an Introduction and six chapters, the sequence of which outlines a precise itinerary.

In particular, the first chapter is dedicated to environment and the title is: *What is happening to our common home*. It contents some paragraphers like as *Pollution and climate change* in which the Pope says that some forms of pollution are part of people's daily experience. Exposure to atmospheric pollutants produces a broad spectrum of health hazards, especially for the poor, and causes millions of premature deaths. People take sick, for example, from breathing high levels of smoke from fuels used in cooking or heating. There is also pollution that affects everyone, caused by transport, industrial fumes, substances which contribute to the acidification of soil and water, fertilizers, insecticides, fungicides, herbicides and agrotoxins in general. Technology, which, linked to business interests, is presented as the only way of solving these problems, in fact proves incapable of seeing the mysterious network of relations between things and so sometimes solves one problem only to create others(7).

These problems are closely linked to a throwaway culture which affects the excluded just as it quickly reduces things to rubbish.

Also climate is a common good. At the global level, it is a complex system linked to many of the essential conditions for human life. We are presently witnessing a disturbing warming of the climatic system. In recent decades this warming has been accompanied by a constant rise in the sea level and, it would appear, by an increase of extreme weather events.

Warming has effects on the carbon cycle. It creates a vicious circle which aggravates the situation even more, affecting the availability of essential resources like drinking water, energy and agricultural production in warmer regions, and leading to the extinction of part of the planet's biodiversity. The melting in the polar ice caps and in high altitude plains can lead to the dangerous release of methane gas, while the decomposition of frozen organic material can further increase the emission of carbon dioxide. Things are made worse by the loss of tropical forests which would otherwise help to mitigate climate change. Carbon dioxide pollution increases the acidification of the oceans and compromises the marine food chain. Climate change is a global problem with grave implications: environmental, social, economic, political and for the distribution of goods. It represents one of the principal challenges facing humanity in our day.

Others important problems are *The issue of water* and *Loss of biodiversity*. Fresh drinking water is an issue of primary importance, since it is indispensable for human life and for supporting terrestrial and aquatic ecosystems. Sources of fresh water are necessary for health care, agriculture and industry. Water supplies used to be relatively constant, but now in many places demand exceeds the sustainable supply, with dramatic consequences in the short and long term. Large cities dependent on significant supplies of water have experienced periods of shortage, and at critical moments these have not always been administered with sufficient oversight and impartiality. Water poverty especially affects Africa where large sectors of the population have no access to safe drinking water or experience droughts which impede agricultural production. Some countries have areas rich in water while others endure drastic scarcity.

Also the loss of forests and woodlands entails the loss of species which may constitute extremely important resources in the future, not only for food but also for curing disease and other uses. Some countries have made significant progress in establishing sanctuaries on land and in the oceans where any human intervention is prohibited which might modify their features or alter their original structures. In the protection of biodiversity, specialists insist on the need for particular attention to be shown to areas richer both in the number of species and in endemic, rare or less protected species. Certain places need greater protection because of their immense importance for the global ecosystem, or because they represent important water reserves and thus safeguard other forms of life8.

The second chapter is dedicated to *The Gospel of Creation*. Without repeating the entire theology of creation, Pope Francis asks what the great biblical narratives say about the relationship of human beings with the world. The creation accounts in the book of Genesis contain, in their own symbolic and narrative language, profound teachings about human existence and its historical reality. They suggest that human life is grounded in three fundamental and closely intertwined relationships: with God, with our neighbour and with the earth itself.

The biblical texts are to be read in their context, with an appropriate hermeneutic, recognizing that they tell us to "till and keep" the garden of the world (cf. Gen 2:15). "Tilling" refers to cultivating, ploughing or working, while "keeping" means caring, protecting, overseeing and preserving. This implies a relationship of mutual responsibility between human beings and nature.

Chapter three is titled *The human roots of the ecological crisis*. Pope Francis says that humanity has entered a new era in which our technical prowess has brought us to a crossroads. We are the beneficiaries of two centuries of enormous waves of change: steam engines, railways, the telegraph, electricity, automobiles, aeroplanes, chemical industries, modern medicine, information technology and, more recently, the digital revolution, robotics, biotechnologies and nanotechnologies. It is right to rejoice in these advances and to be excited by the immense possibilities which they continue to open up before us, for «science and technology are wonderful products of a God-given human creativity» (John Paul II, 1981).The modification of nature for useful purposes has distinguished the human family from the beginning; technology itself «expresses the inner tension that impels man gradually to overcome material limitations» (Benedict VI, 2009).Technology has remedied countless evils which used to harm and limit human beings. Now we must be grateful for this progress, especially in the fields of medicine, engineering and communications.

7 Account must also be taken of the pollution produced by residue, including dangerous waste present in different areas. Each year hundreds of millions of tons of waste are generated, much of it non-biodegradable, highly toxic and radioactive, from homes and businesses, from construction and demolition sites, from clinical, electronic and industrial sources.

8 Let us mention, for example, those richly biodiverse lungs of our planet which are the Amazon and the Congo basins, or the great aquifers and glaciers. We know how important these are for the entire earth and for the future of humanity. The ecosystems of tropical forests possess an enormously complex biodiversity which is almost impossible to appreciate fully, yet when these forests are burned down or levelled for purposes of cultivation, within the space of a few years countless species are lost and the areas frequently become arid wastelands.

Yet it must also be recognized that nuclear energy, biotechnology, information technology, knowledge of our DNA, and many other abilities which we have acquired, have given us tremendous power. But the basic problem is the globalization of the technocratic paradigm.

The technocratic paradigm also tends to dominate economic and political life. The economy accepts every advance in technology with a view to profit, without concern for its potentially negative impact on human beings. Finance overwhelms the real economy.

The chapter four is the most important and central of the Encyclical. It is titled *Integral ecology* and represents the fulcrum of Pope Francis' exhortation.

Since everything is closely interrelated, and today's problems call for a vision capable of taking into account every aspect of the global crisis, the Holy Father suggestes that we now consider some elements of an integral ecology, one which clearly respects its human and social dimensions.

Ecology studies the relationship between living organisms and the environment in which they develop. This necessarily entails reflection and debate about the conditions required for the life and survival of society, and the honesty needed to question certain models of development, production and consumption. It cannot be emphasized enough how everything is interconnected. Time and space are not independent of one another, and not even atoms or subatomic particles can be considered in isolation. Just as the different aspects of the planet – physical, chemical and biological – are interrelated, so too living species are part of a network which we will never fully explore and understand.

For Pope Francis, when we speak of the "environment", what we really mean is a relationship existing between nature and the society which lives in it. Nature cannot be regarded as something separate from ourselves or as a mere setting in which we live. We are part of nature, included in it and thus in constant interaction with it. Recognizing the reasons why a given area is polluted requires a study of the workings of society, its economy, its behaviour patterns, and the ways it grasps reality. Given the scale of change, it is no longer possible to find a specific, discrete answer for each part of the problem. It is essential to seek comprehensive solutions which consider the interactions within natural systems themselves and with social systems. We are faced not with two separate crises, one environmental and the other social, but rather with one complex crisis which is both social and environmental. Strategies for a solution demand an integrated approach to combating poverty, restoring dignity to the excluded, and at the same time protecting nature.

We need only recall how ecosystems interact in dispersing carbon dioxide, purifying water, controlling illnesses and epidemics, forming soil, breaking down waste, and in many other ways which we overlook or simply do not know about.

Economic growth, for its part, tends to produce predictable reactions and a certain standardization with the aim of simplifying procedures and reducing costs. This suggests the need for an "economic ecology" capable of appealing to a broader vision of reality. The protection of the environment is in fact «an integral part of the development process and cannot be considered in isolation from it»(9). We urgently need a humanism capable of bringing together the different fields of knowledge, including economics, in the service of a more integral and integrating vision. Today, the analysis of environmental problems cannot be separated from the analysis of human, family, work-related and urban contexts, nor from how individuals relate to themselves, which leads in turn to how they relate to others and to the environment. There is an interrelation between ecosystems and between the various spheres of social interaction.

If everything is related, then the health of a society's institutions has consequences for the environment and the quality of human life. In this sense, social ecology is necessarily institutional, and gradually extends to the whole of society, from the primary social group, the family, to the wider local, national and international communities.

According to Pope Francis, there is also a *cultural ecology*. Together with the patrimony of nature, there is also an historic, artistic and cultural heritage which is likewise under threat. This heritage is a part of the shared identity of each place and a foundation upon which to build a habitable city. Ecology, then, also involves protecting the cultural treasures of humanity in the broadest sense. More specifically, it calls for greater attention to local cultures when studying environmental problems, favouring a dialogue between scientific-technical language and the language of the people. Culture is more than what we have inherited from the past; it is also, and above all, a living, dynamic and participatory present reality, which cannot be excluded as we rethink the relationship between human beings and the environment.

The disappearance of a culture can be just as serious, or even more serious, than the disappearance of a species of plant or animal. The imposition of a dominant lifestyle linked to a single form of production can be just as harmful as the altering of ecosystems.

Authentic development includes efforts to bring about an integral improvement in the quality of human life, and this entails considering the setting in which people live their lives.

Definitely, an integral ecology is inseparable from the notion of the common good, a central and unifying principle of social ethics. The common good is «the sum of those conditions of social life which allow social groups and their individual members relatively thorough and ready access to their own fulfilment»(10).

3. Results and Discussion

The positive results of my research are proven by the fact that the Synod for the Amazon has been convened after Encyclical Letter "Laudato sì".

Highlighting the outcomes achieved such as the convocation of the Synod on the Amazon in 2019 - as well as the measures taken by the Vatican on photovoltaics and, generally, on a more sustainable economy - the importance and relevance of my research are demonstrated by the fact that Synod for the Amazon is the son of the Encyclical "Laudato si" and gave to the demands of that text a visible body, referring to a region and the peoples who inhabit it.

9 Rio declaration on the environment and development (14 june 1992), Principle 4.

10 SECOND VATICAN ECUMENICAL COUNCIL, Pastoral Constitution on the Church in the Modern World *Gaudium et Spes*, 26.

The relationship between Christianity and the life of the world appeared innervated by a healthy realism, beyond any ideology, finally taking the traits of a commitment decided by the global value, always the fruit of the evangelical impulse that requires an «ecological conversion». The theological themes in the Synod Hall have always been closely intertwined with the concrete life of peoples, geopolitical tensions and the care of the «common home».
By the point of view of Canon law, the salvation of the soul represents the ultimate aim of the Catholic Church order.
The fact that the concern for salvation - *salus animarum* - was deeply connected to that for the destiny of the Earth and of the whole of humanity was a proof of the theological and ecclesiological maturity of this Synod.
However, some have criticised the environmental Encyclical sayng that «Church has no particular expertise in science ... the Church has got no mandate from the Lord to pronounce on scientific matters. We believe in the autonomy of science».
On the other hand, Pope Francis's Encyclical "Laudato si" has been welcomed by many environmental organisations of different faiths.
Three days before the Encyclical was released, the 14th Dalai Lama issued a Twitter message stating: «Since climate change and the global economy now affect us all, we have to develop a sense of the oneness of humanity».
Two days before the Encyclical was released, Archbishop of Canterbury Justin Welby, head of the Anglican Communion, issued a "green declaration" (also signed by the Methodist Conference as well as representatives of the Catholic Church in England and Wales and the British Muslim, Sikh and Jewish communities) urging a transition to a low-carbon economy and fasting and prayer for success at the December 2015 United Nations Climate Change Conference in Paris.
The Secretary-General of the United Nations, Ban Ki-moon, welcomed the Encyclical in a statement on the day it was released.
Kofi Annan, the former UN secretary-general and current chair of the Africa Progress Panel, also issued a statement in support of the Encyclical, stating «As Pope Francis reaffirms, climate change is an all-encompassing threat. … I applaud the Pope for his strong moral and ethical leadership. We need more of such inspired leadership».

4. Conclusions

Unlike other Encyclicals of previous Popes, the Encyclical "Laudato si" is addressed to all society, not only to catholics.
The appeal of Pope Francis is addressed to «all men of good will».
Then, he urgently appeals for a new dialogue about how we are shaping the future of our planet. We need a conversation which includes everyone, since the environmental challenge we are undergoing, and its human roots, concern and affect us all.
The addresses of appeal are legislators, rulers, economists, industrials, engineers, architects, entrepreneurs, international organizations, etc.
The research wants to clarify the need to understand that a large-scale cultural conflict on nature is underway: on the one hand, there are the most extreme environmental trend introducing a new deification of nature; on the other hand, there is the theological contribution of Christianity which push us not to reduce nature to a mere substrate of manipulation and use, nor to overlap it on the human beings' dignity.
I realized that there are aspects of research that should be explored.
One of these could be the comparison with others religions (Hindi, Buddhists, etc.); another one could be the post-synodal apostolic exhortation "Querida Amazonia" which remind us of the need for an integral human development and respect for inalienable human rights.

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The Roles of and Barriers to Policy and Legal Framework for Carbon Capture, Utilisation and Storage (CCUS) in the Asian Pacific Region

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Abstract

Since the Paris Agreement of 12 December 2015 brought all nations together for the first time to share the responsibility of combatting climate change and adapting to its effects, there has been wide discussion about Carbon Capture Utilisation and Storage (CCUS) (which often refers to including Carbon Capture and Storage: CCS and/or Carbon Capture and Utilisation: CCU) considered as one of the significant approaches to greatly reduce CO2 to the global atmosphere while limiting fossil-fuel emissions. To date, the current status of the world has yet to be widely demonstrated at a commercial scale, and CCUS implementation has still been low. It is a key challenge for governments, who are responsible to prepare for a relevant policy and legal framework for CCUS, in order to operate practically and successfully at the global and regional levels. This study aims at comprising an analytical method and applying it to address any relevant policy for and legal barriers to developing the future opportunities for CCUS technologies in the Asia Pacific Region, especially in the Association of Southeast Asian Nations (ASEAN) countries.

Keywords: Carbon capture utilisation and storage, the Asia Pacific Region, the ASEAN region, Policy, Law

1. Introduction

In terms of the emission levels in the Asia Pacific Region (APR), during the past two decades, a number of governmental reports have clearly indicated that the GHG emissions from the region, particularly CO2, have been dramatically increased, due to rapid industrialisation and population growth such as in China and India. Moreover, four of the ten countries with the highest CO2 emissions from fossil-fuel use are located in the region including China, India, Japan, and South Korea. Subsequently, other fast growth countries within the region, such as Indonesia, the Philippines and Vietnam, have rapidly been increasing their fossil-fuel based CO2 emissions (ESCAP, 2016).

The APR includes developed, developing and emerging nations and it models, at the sub-national level, the broader problem of developed/developing country engagement in climate change. There is a need to build strong governance for facilitating more cooperative climate action between developed and developing countries at the regional level beyond the efforts already achieved by the European Union (EU). In order to meet the global climate target, it is essential to act regionally and technological solutions should be considered urgently (Crowley and Nakamura, 2018). Carbon Capture, Utilisation and Storage (CCUS) could be one of the tools to achieve this, especially dealing with a number of fast growing countries in the APR (Hart et al., 2012). In this regard, specifically, this paper has featured an urgent area of case studies within the APR, which is the Association of Southeast Asian Nations (ASEAN) countries, including Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam. The countries within the ASEAN group have shown significant records of contributing GHG emissions in recent years, especially in Indonesia, Thailand and Vietnam (GCCSI, 2014). Figures 1 below show the primary energy demand forecast in the ASEAN group.

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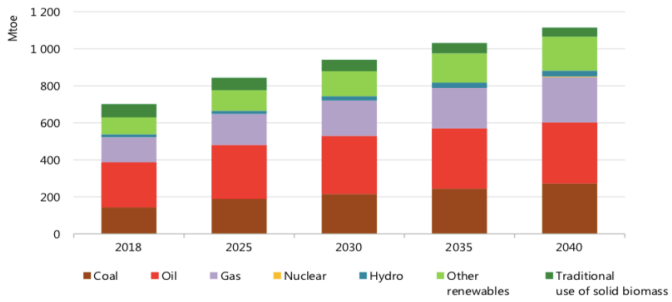
Figure 1: Primary Energy Demand in ASEAN Countries



(Source: IEA 2019)

It has been estimated that those countries will be among the highest economic growth countries for the next 30-50 years, while contributing to a large amount of global GHG emissions (Shogenova et al., 2013). This will not only mean the region has become responsible for reducing the emissions, but also has potentially become a key player in creating huge opportunities for trading CO2 sources and technologies by using the CCUS technologies. Thus, it is worth exploring the roles and barriers to the future CCUS policy and legal frameworks in the ASEAN countries, selected as a key group of the emerging countries within the APR towards the reduction of GHG emissions at the regional and global levels for the next decades throughout this study.

This paper suggests that a regional approach to developing CCUS implementation will play a significant role in achieving the GHG mitigation activities towards the global commitment. This will clarify the key roles of policy and legal framework for regional action, and will also examine the existing barriers to them in order to expand potential opportunities to apply CCUS technologies in the ASEAN countries.

2. Methods

This study offers a framework of comparative analysis that is mainly drawn from the theories and literature of CCUS policy and legal studies, which it broadens in order to assess any relevant policy for, legal roles of and barriers to developing the opportunities for CCUS technologies within the APR, especially for the ASEAN countries. In addition, as mentioned, learning from the experience in the EU, as a regional approach to CCUS development, is also one of the key factors of this study. This is because the EU's CCUS experience has been widely accepted as a leadership in the CCUS technological transfer among the EU member states at the regional level (Kapetaki et al. 2016). The concept of approaches and common aspects and barriers can be a basis for understanding and analysing the circumstances from the ASEAN countries. Thus, the findings of the study should be further discussed with the issues and/or gaps from the circumstances of the EU. Concerning this, firstly, this study comprises an analytical framework. Secondly, it applies the framework for the situation in the ASEAN countries by using governmental reports and legal documents. It then discusses the current and future issues in relation to the roles of policy and barriers to the policy and legal framework for the ASEAN countries.

Before designing the analytical framework, this paper addresses a number of key aspects in order to achieve our study outcome. These are: Challenges for Climate Change in the APR (i.e. ASEAN countries), the Role of CCUS in the ASEAN, the Role of Policy and Legal Framework for a Regional Approach to CCUS, and Learning from the EU's experience. Considering the number of theories and literature relevant to the study, we have selected various analytical issues to be examined in the regional study.

3. Relevant literature

3.1 Regional Analysis and Challenges for Climate Change in the APR

The APR is known as one of the regions extremely vulnerable to climate change due to overpopulation, extreme poverty, the emissions burden of rapid economic development, and high baseline levels of flooding, drought and extreme temperatures (World Bank, 2014). IPCC acknowledged the countries in the APR will play a significant role both in climate change mitigation and adaptation activities (IPCC, 2014). Crowley and Nakamura (2018) emphasised that the importance of 'Regional Climate Leadership' theory specifically in the APR is important in terms of achieving the global climate change action both for mitigation and adaptation activities.

This article's regional analysis of the role of and barriers to APR specifically raises a regional approach to developing CCUS technologies, with a particular focus on the ASEAN group. 'Climate leadership theory' has been widely developed in the context of the EU and has conceptualised a successful regional platform towards climate change action (Andresen and Agrawala, 2002; Grojean et al., 2004; Karlsson et al., 2011; Keohane and Victor, 2011; Eckersley, 2012). However, the effectiveness of regional forms can be differentiated in different contexts, background and geological circumstances. It is important to look at the regional approach in the APR as one of the emerging regions for climate change actions. Any transfer of lessons must contend with issues of comparability (Crowley and Nakamura, 2018). In contrast with the EU region, the Asia Pacific is populated by predominantly developing rather than developed nations, including major emitters like China that dwarf the EU's emissions (WRI, 2017). The Asia Pacific has no regional governance with capabilities comparable to the EU to facilitate a regional approach to climate action with differentiated responsibilities between

developed and developing nations. Due to the absence of regional governance, there has yet to be established a clear mechanism for identifying and potentially transferring the mitigation and adaptation lessons learned by countries within the APR. While the EU could offer historical lessons on regional climate governance and action, not only could these not be easily transferred to the Asia Pacific context, they are also now dated as the EU's influence has waned (Bals et al., 2013).

One of the most recent analyses shows the global and Asian energy system projections; strong economic growth leads to a doubling of Asian energy consumption, which drives the global demand. Global demand is driven by Asia with an energy mix still dominated by fossil fuels, especially coal. 74% of the demand growth over 2015-2040 will come from Asia, and 15% from Africa. In the power sector, the share of fossil fuels input decreases from 84% to 66% between 2015 and 2040. Energy-related emissions from Asian countries are projected to increase twice as fast as global emissions. Asian energy-related emissions will account for more than half of the global emissions (Enerdata, 2018). It is thus clear that the demand and influence of climate action have been shifted from European to Asian dominance as the latter region seeks competitiveness advantages, in terms of jobs and growth, of investing in the low-carbon sector (Climate Institute, 2013). However, the APR cannot simply manage the shift of the trend, by following the regional development and coordination process in the EU as no EU-style Asia Pacific Community exists (Lee, 2010). Thus, exploring the current and future climate action in the APR will be crucial not only to contribute to leading the global climate action, but also to establish its own regional frameworks and approaches to regional and global responsibilities and initiatives.

3.2 Roles and benefits of CCUS

The Paris Agreement of 12 December 2015 brought all nations together for the first time to share the responsibility of combatting climate change and adapting to its effects. Since then there has been ongoing discussion about CCUS considered as one of the significant approaches to greatly reduce CO2 emission to the global atmosphere while limiting fossil-fuel based emissions (Qiu and Liu 2018). The Paris Agreement has brought the importance of technology to meet the goals. Industrial projects related to CCUS technologies are likely to contain elements of use alongside storage and the term CCUS thus often refers to including Carbon Capture and Storage: CCS and/or Carbon Capture and Utilisation: CCU (ZEP, 2018). Particularly, it is believed that application of CCUS will significantly become effective in fossil-fuel based CO2 emissions.

CCS associated with CCU could potentially prevent large amounts of CO2 from being released into the atmosphere. CCUS is an integrated suite of technologies that has a proven 90% capture rate of the CO2 produced from the use of fossil fuels in electricity generation and industrial processes, preventing the CO2 from entering the atmosphere. The future CCUS projects are expected to have much improved capture rates, including zero-emissions from coal (WCA, 2018), and/or the combination with renewable energy and/or biomass (Gough and Upham, 2011)._ IPCC's fifth assessment report (2014) identified CCS as a solution for reducing lifecycle GHG emissions of fossil fuel power plants. CCS has been recognised as the only proven technology, enabling us to capture at least 90% of CO2 emissions from the largest emitters. Consequently, this will make it possible for a significant reduction of CO2 from large- scale fossil fuel for power generation and from energy-intensive industry.

With Bio-energy with CCS (BECCS) known as CCUS, we can even achieve net negative emissions as it is the only large-scale technology that can actually remove CO2 from the atmosphere. However, large-scale deployment has yet to be implemented. There are also other CCUS technologies considered globally (e.g. Enhanced Oil Recovery: EOR). The IEA (2017), in its publication, Energy Technology Perspectives 2017, says meeting the 2-degree target requires an inclusive approach combining energy efficiency (40%), renewables (35%), CCS (14%), nuclear (6%), and fuel switching (5%). Furthermore, shifting from the IEA 2-degree scenario (2DS) to its below 2°C Scenario (B2DS), the IEA maintains that CCS would be required to increase, making up 32% of extra effort. Thus, it is clearly identified that CCUS technologies have been considered as significant tools to achieve the global targets.

There are a number of potential benefits from CCUS technologies. CCU has the potential to strengthen business models for industrial emission reduction while contributing to emissions reduction. While some CCU processes permanently avoid CO2 reaching the atmosphere, other forms may only constitute a postponement of emission (IPCC, 2005; Olfe-Kräutlein et al., 2016). It is also important to note that the application of CCU does not alone prevent the large amounts of CO2 from being released into the atmosphere. A CCS project with additional economic value of CCU via a CO2-based product generation could facilitate further investments in CCS (EC, 2018). Furthermore, CO2 can be transferred to various products throughout the process of chemical, biochemical, photochemical or electrochemical reactions (Psarras et al., 2017). These products could also create feedstock for value added bio-chemicals (e.g. organic and inorganic carbonates, polymers and urea), or as a medium for intermediate energy storage (e.g. methane and syngas). These processes may contribute to reducing the GHG emissions, although their individual projects are neither abating CO2 nor economically feasible as stand-alone projects (ZEP, 2013). CCS and CCU technologies may involve minor differences (e.g. purpose, storage duration, injection depth and rate, fluid and reservoir types, scheme of drilling, completion and monitoring) (Liu H et al., 2017). However, the IEA notes that the two integrated technologies should be considered and developing and implementing their projects in parallel will contribute to achieving a significant part of the global action (IEA, 2018). The key development areas should be the relevant selection of project applications considering economic, social and environmental aspects at all levels of operation, while demonstrating regional, domestic and local levels (Liu H et al., 2017). There have been significant steps towards the wider deployment of CCUS. The Sleipner project in Norway, the first commercial one, has been operational since 1996. The recent database by the Global CCS Institute shows there were 38 large-scale CCUS projects in operation or under the stage of construction and planning. There were also 88 pilot-scale engineering CCUS projects worldwide (GCCSI, 2018). Given this, CCUS has a significant role in contributing to climate mitigation action towards the Paris Agreement.

3.3 Learning from the EU's experience

The EU has a long history of studying 'global climate regimes', 'climate club' and 'climate leadership theory' in terms of

developing a regional action for climate change activities (e.g. Andresen and Agrawala, 2002; Grojean et al., 2004; Karlsson et al., 2011; Keohane and Victor, 2011; Eckersley, 2012). This section will broadly address the EU climate leadership, its regional approach to CCUS, and its key development and issues.

In terms of climate action, the EU championed its climate leadership on the basis of emphasising the European integration process, protecting the energy security and supporting multilateralism towards the regional climate policy in the EU (Oberthür and Kelly, 2008). Furthermore, the EU has established a unique form of regional governance known as a 'supranational organisation'. The EU is 'a supranational entity with a neo-functionalist tradition' due to the institutional set-up of the European Commission (EC), the European Parliament, and the Court of Justice of the European Union as well as the way in which the policy process is delivered. As a consequence, the EU leadership has been built by the unique elements in the EU, which have also assisted in building the EU climate leadership (Gupta and Ringius, 2001). Although the EU economic and political crises have resulted in weakening its climate leadership in recent years, the region is still in the position to recover the leadership role in order to create the decarbonisation of the world economy in the sustainable development by topping up climate finance, while incorporating with developing countries and neighbouring countries (i.e. the EU members and non-members) (Barandi 2016; Oberthür 2016). Thus, as an example of climate leaders, the EU is still relevant due to the region consisting of the geographical neighbour countries and sharing a regional climate action.

With regard to the regional approach to introducing CCUS technologies for climate change mitigation activities, the EU is the key development area. In particular, CCS has gained more political attention in the EU since 2005. The first CCS communication dates from 2006. In 2007, CCS was included in the European agenda as an important tool to keep climate change in control. In 2009, the EU Directive on geological storage of CO2, the so-called 'EU-CCS Directive' was published. CCS projects have benefited from funding mechanisms both at EU and domestic levels for R&D and demonstration. Other significant legislation with an impact on CCS includes the EU Emissions Trading System (ETS). The ETS is intended to drive investment in low-carbon technologies. The EU is committed to the GHG emissions reduction by 80-95% below levels by 2050 (EC, 2009). The 'Energy Roadmap 2050' published in 2011 aims at achieving a decarbonisation society, while ensuring the energy security and competitiveness. The Roadmap suggests that the various scenarios between 7% and 32% of power generation would need to be equipped with CCS by 2050. It also indicates CCS would play a significant role in reducing CO2 emissions from industrial processes in the EU by 2035 (EC, 2013). The IEA also suggests that Europe needs the contribution of CCS in industry to achieve its low carbon society, and it is essential that CCS and other low emission technologies should be developed in parallel, such as wind and solar. The IEA also noted that the cost of reducing emissions would be 40% greater without CCS deployment (IEA, 2013).

Since the EC's 2007 decision was made to support up to 12 large-scale demonstration projects by 2015, the Commission prepared to establish a common regulatory and demonstration support framework. The CCS Directive was adopted to provide a legal framework for CO2 transport pipelines, which was included in Europe's Energy Infrastructure Priorities (EIP) tabled in November 2010 and in the Regulation on 'Guidelines for Trans European Energy Infrastructure' adopted in April 2013. CCS has also become a key part of EU R&D efforts, in the frame of the European Industrial Initiative (EII) on CCS that is part of the Strategy Energy Technology (SET) Plan. Two financial support programmes have been introduced: the European Energy Programme for Recovery (EEPR) and the NER 300 programme funded by EU-ETS allowances to access substantial EU funding for large scale demonstration projects (EC, 2013) The amended EU ETS is also a significant financial tool for any leakage incidence through CCS projects (ECCSDPN, 2018).

Although the above efforts have been made in establishing legal support and funding programmes, CCS has failed to develop to meet xpectation. A 2013 consultation organised by the EC examined the progress of the current CCS status as inviting views on creating the future development. To date, the European Energy Programme for Recovery (EEPR) spent €424 million on six CCS projects in Germany, Poland, Italy, the Netherlands, the UK and Spain. Four out of the six co-funded projects had ended after the grant agreement was terminated. One project ended without being completed. The only completed project did not represent a commercial scale project. Moreover, some CCS awarded NER300 grants were never completed; as a result, the money was never spent (European Court of Auditors 2018). Furthermore, at the current low carbon prices, companies are not motivated to invest in CCS technologies. A first-generation CCS power plant is expected to be 60% to 100% more expensive than a similar conventional plant. The cost of CCS is expected to decrease in the long-term operation as more technological development and growing industrial experience are built (EC, 2018). As previously mentioned, the IEA (2017) indicates CCS would contribute as much as 14% of global CO2 emission reduction by 2060. However, whilst the number of CCS projects in operation has increased from 7 to 15 over the past 7 years, deployment in Europe has stalled with all the major proposals for projects having been cancelled (e.g. the Norwegian full-scale Monstad project; and the UK CCS Commercialisation Programme) or mothballed (the Dutch 'Rotterdam Capture and Storage Demonstration Project' ROAD project) (Billson and Pourkashanian, 2017). As a consequence, there is a failure of funding sources by the EU-ETS due to the trend of lower carbon price, and the limited funding of NER300 not suitable to developing CCS projects, conditional availability, and a lack of potential operators to share the cost burden. This has resulted in causing the cancellation of CCS projects. Billson and Pourkashanian (2017) concluded that there are mainly three problems causing the failure of the EU's CCUS initiatives and political willingness. First, there is a lack of communication with stakeholders. Stakeholders should learn clearly about why CCS is important. Second, there is an absence of political willingness from governments, which are not motivated to invest the high costs of the first CCS projects. Third, there are weak market-based structures and/or mechanisms. As a result, the technological developments have relied on government subsidy and other fiscal support (e.g. loans), ending up with leaving and not completing projects, resulting in a lack of political feasibility. (Billson & Pourkashanian 2017). Given this, the level of political willingness and leadership, communication with stakeholders, public awareness and financial support and/or mechanisms remain the key issues in the EU. These issues will also continue in the regional CCS activities.

3.4 Constructing assessment criteria

From a number of theories and literature relevant to the EU experience, we have selected various analytical issues to be examined in the regional study. The main aspects selected are: the roles of policy and legal framework; and barriers to policy and legal framework as described in the following sections.

3.4.1. Roles of policy and legal framework for a regional approach to CCUS

In terms of assisting CCUS technology deployment at the regional level, there are a number of key roles of a policy and legal framework to be addressed. We have selected four common elements for the roles in a broad context, which are: (1) A CCUS policy and legal framework should aim at the purpose of climate mitigation activities; (2) it should ensure financial support and mechanisms to realise the deployment; (3) it should design long-term management; (4) the framework should aim at designing a direction towards the commercial scale of CCUS projects; and (5) it should design a basis of approaches to CCUS activities.

Firstly, it is essential to note that CCUS projects aim to achieve the large amount of GHG emission reduction especially for CO2 in this world. IPCC (2007) clearly acknowledged that CCUS will play a significant role in contributing to climate change mitigation action. Without the technology, it would not be possible to meet the Paris Agreement (GCCSI, 2017). Secondly, one of the critical issues of the slow progress of introducing CCUS technology at the commercial scale is the expense. Thus, CCUS policy and legal framework need to ensure financial support, incentives, sources and the mechanism to assist both in developing and promoting the technologies (IEA, 2010, 2012; ZEP 2018). Thirdly, long-term management for CCUS needs to be carefully considered. Both policies and regulations should consider the entire life cycle of projects (i.e. assessment and licence of CCUS projects, assess property rights (CO2 ownership), operation of CCUS facilities, transportation issues, monitoring and verification, decommissions and post-decommissioning liabilities). This long-term management should also consider economic, social and environmental aspects. Social acceptability and public awareness have been critical issues under the social aspect (IEA, 2010; 2012). Fourthly, the policy and legal framework should aim at designing a direction towards the commercial scale of CCUS projects (IEA, 2010; 2012; EASAC, 2013). A number of CCUS projects have been introduced in the world to date, however, CCUS implementation has still been low. The CCUS development at the commercial scale enables the realisation of the balance of reducing CO2 emissions and marketability (IEA, 2010; 2012; EC, 2013). Fifthly, a regional policy and legal framework must be specifically considered in a specific region. Crowley and Nakamura (2018) suggest that a polycentric setting at the regional level is important for promoting, transferring and accelerating climate policy learning and action of mutual benefit to neighbouring countries and should be facilitated by a regional governance, in the geographic context. Each region carefully addresses the policy direction and legal approaches, which need to be clearly interpreted and transferred to the individual nations (EC, 2015). These five key aspects are the key roles of policy and legal framework for a regional approach to CCUS.

3.4.2. Barriers to policy framework

With regard to the barriers to policy framework in the region, we have selected the following six elements:

Political leadership (global and regional)-indicates a commitment to a global decarbonisation agreement (i.e. the Paris Agreement) by addressing the role of CCUS technologies. For the regional approach, it is not only to respond to a global commitment, but also to commit as a region. This leadership will identify the responsibility and help deliver climate action efficiently (CIAB, 2016).

Target Setting (regional and domestic)-indicates the specific target settings, including the role of CCUS technologies both at the regional and domestic levels. This will allow the region and countries to be self-motivated to meet their targets (IEA, 2012; CIAB, 2016).

Internal Financial Support and mechanism (regional and domestic-public grants)- indicates a region and countries haveaccess to financial supports and mechanisms to promote and/or implement CCUS technologies within the region and/or countries. This will allow the region and countries to generate the CCUS activities internally (IEA, 2012; CIAB, 2016).

External Financial Support (i.e. international investments & funding opportunities) - indicates a region and countries have access to financial investments and funding opportunities from outside of the region and/or countries to promote and/or implement CCUS technologies. This will allow the region and countries to promote and implement CCUS projects efficiently, supported and invested in by countries outside of the region (CIAB, 2016; Kapetaki and Scowcrift, 2017).

Institutional arrangement (regional level or among countries)-indicates a region has institutionalised the political power at the regional level such as the EU (Christie, 2009). This will allow the region to create a 'regionalisation' and/or 'supranational structure' within the region for leading their regional activities (Wang, 2013).

Access to UN mechanisms (financial & technological support) (i.e. Clean Development Mechanism: CDM) based on the Kyoto mechanism or UNFCCC guidelines-indicate a region has access to any financial and technological mechanism with UN mechanisms. This will enable motivation of the region to implement CCUS, but also to encourage developed countries to support their climate action (IEA, 2012; CIAB, 2016).

Social Acceptability-indicates public awareness and acceptability have been critical issues under the social aspect of CCUS development (IEA, 2010; 2012), thus regional action needs to ensure the level of communication with stakeholders and public for regional and/or domestic CCUS action (EC, 2013).

3.4.3. Barriers to legal framework

Apropos of the barriers to legal framework in the region, we have selected the following seven elements:

The scope of international treaties relevant to the purpose of marine disposal of CO2 and/or CCUS implementation (e.g. the London Protocol: 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972) indicates a region and/or its countries have access to any international treaties relevant to the application of CCUS technologies. This will allow the region and countries to be in line with other international agreements to act on their CCUS activities (L.E.K., 2009). The London Protocol is globally recognised as the major international treaty, relevant to CCS applications in the marine environment. The London Convention and Protocol are the global agreements regulating dumping of wastes at sea. The Protocol requires a prohibition of dumping of wastes or other matter at sea and in the sub-seabed except those specifically requested in its Annex 1, and these require permission with impact assessments, conditions and monitoring. Examples of wastes or other matter which may be dumped include dredged material, fish waste, inert, and inorganic geological material. According to the 2006 amendment, CO2 streams for disposal in sub-seabed geological formations. The amendment entered into force in February 2007 (MoE, 2008). In response to providing the assessments and conditions required in issuing a permit, CO2 Specific Guidelines were introduced in 2007. The main issue for CCS at the Protocol since the 2006 amendment is the topic of trans-boundary exporting of CO2 for sub-seabed geological storage. The London Protocol Article 6 requires a prohibition of exports of wastes for dumping in the marine environment (Dixon et al., 2014). A number of international treaties would be relevant to the CCUS activities in the APR (i.e. ASEAN) including the London Protocol, the OSPAR Convention (The Convention for the Protection of the Marine Environment of the North-East Atlantic), the Basel Convention (The Basel Convention on the Control of Trans-Boundary Movements of Hazardous Wastes and their Disposal, 1989), the MARPOL Convention (The International Convention for the Prevention of Pollution from Ships) and the UNCLOS (The United Nations Convention on the Law of the Sea), although some of them are not applicable to the ASEAN region.

The capability of a regional law framework such as a political feasibility of ASEAN countries (e.g. the EU group)-indicates whether a region has institutionalised the power to be politically feasible for controlling the region. This will allow the region to design regional activities by their own regional regime (CEPS, 2008).

Institutional Arrangement such as the European Commission (EC)-indicates whether a region has institutionalised the centre for managing the regional activities. This will allow the region to institutionalise a committee to advise, lead and/or manage CCUS activities (Damro et al., 2008; Averchenkova et al., 2016).

International Law within the APR (bilateral and multilateral) relevant to the purpose of marine disposal especially for CO2 (e.g. CCS-Directive)-indicates whether a region has arranged any legal framework for CCUS activities. This will allow the region to set a minimum legal framework for CCS activities (GCCSI, 2015).

Financial Mechanism for liability issues among the countries such as ETS regime for CO2 leakage in the EU- indicates a region and/or its countries have organised a financial mechanism, which can be used for funding and/or supporting CCUS activities. This will allow the region to share the values, opportunities, and risk controls and managements for CCUS activities (IEA, 2010; EC, 2014).

Compatibility of future trading CO2 as products such as possible physical pipelines and grid–indicates whether a region has set any bilateral and/or multilateral agreements for trading CO2 products. This will allow the countries within the region to share CCUS activities and market opportunities (GCCSI 2016; The World Bank, 2011).

Compatibility of technological and/or infrastructure standards–indicates whether a region has set any bilateral and/or multilateral agreements for setting standards for CCUS technologies and/or infrastructures (e.g. pipelines). This will allow the region and/or countries to share the minimum protocols and standards for the technological application (EU, 2015).

The Existing CCUS legal frameworks-indicates whether countries within a region have any existing legal frameworks. This will allow the countries and their region to potentially encourage a regional framework and interact with each other (EC, 2015).

Table 1: Key Assessment Criteria

	Key Criteria	Rationale
Barriers to policy framework	Political leadership (global and regional)	To identify the responsibility of the region and help in delivering climate action efficiently at the regional and global levels.
	Target Setting (regional and domestic)	To show the region to be self-motivated to meet their targets for the global commitment.

	Internal Financial Support and mechanism (domestic-public grants)	To ensure the region promotes and implements CCUS projects by generating their own financial supports.
	External Financial Support (i.e. international investment & funding opportunities)	To ensure the region promotes and implements CCUS projects efficiently by generating external financial support from outside of the region.
	Institutional arrangement (regional level or among countries)	To identify a regionalisation and/or supranational structure within the region for leading their regional activities.
	Access to UN mechanisms (financial & technological support) (i.e. CDM) based on the Kyoto mechanism or UNFCCC	To motivate the region and/or other developed countries to individually and collaboratively implement CCUS to achieve the global commitment.
	Ensuring social acceptability (i.e. public awareness and acceptability)	To ensure the level of communication with stakeholders and public for regional and/or domestic CCUS action in the region and/or its countries.
Barriers to legal framework	International Agreements relevant to the purpose of marine disposal of CO2 and CCUS implementation (e.g. London Protocol).	To ensure the region is in line with other international treaties relevant to CCUS activities.
	International Law within the APR (bilateral and multilateral) relevant to the purpose of marine disposal especially for CO2 (e.g. CCS-Directive).	To identify the region designs regional activities by setting and following its own regional regime.
	The capability of a regional law framework such as a political feasibility of ASEAN countries (e.g. the EU group)	To ensure the region institutionalises a political power for the regional activities.
	Institutional Arrangement such as the European Commission (EC)	To identify that the region institutionalises a regional committee to share the values, opportunities, and risk controls and managements for CCUS activities.
	Financial Mechanism for liability issues among the countries such as ETS regime for CO2 leakage in the EU.	To identify the region establishes a legal system to control a financial mechanism (such as EU-ETS) environmental values, opportunities, and risk controls and managements for CCUS activities.
	Compatibility of future trading CO2 as products such as possible physical pipelines and grid.	To identify the region shares CCUS activities and market opportunities.
	Compatibility of technical standards for technologies and/or infrastructure (e.g. pipeline.)	To ensure the region shares technical standards relevant to CCUS.
	The Existing CCUS legal frameworks	To identify the countries within the region that have any existing legal frameworks.

4. Challenges for the ASEAN countries

The climate change issue is at a serious level overall in the ASEAN group. The expansion in worldwide production of CO2 is the major driver of global warming which is one of the most significant concerns today [1]. Anthropogenic climate change due to combustion of fossil fuels has been found as the primary cause of CO2 discharges into the air that lead to global warming (ESCAP, 2016). As the profiles of economic growth have changed over time, the trend of producing a high volume of CO2 emissions has shifted into the APR, especially in the Southeast Region (Nor et al., 2016). Sustainable energy development incorporated with regional economic growth has become a critical issue in the ASEAN countries. With the launch of the ASEAN Economic Community in 2015, energy demand in the region is expected to increase due to the economic expansion and integration (GCCSI, 2014). Within the APR, the role of ASEAN countries has become crucial in terms of contributing to the GHG mitigation activities. ASEAN's GDP is well over US$2trn, larger than India's, and its population is just over 600 million, greater than the EU's. It is also a region that will experience continued robust economic growth. It has been estimated that the average of annual economic growth will be 5.2% among ASEAN economies between 2019 and 2023, which is well above the global average, and is further expected to grow in the next decade. Strong economic growth, combined with rising per capita income, continued population growth, and higher energy consumption mean that the region's GHG emissions will continue to significantly increase (OECD, 2018). According to the 3rd ASEAN Energy Outlook under a business-as usual scenario, the region's primary energy consumption will grow at 4.5% per annum from 2007 to 2030, resulting in a corresponding 5.7% growth in CO2 emissions. This is largely due to the fast growth of carbon-intensive fossil fuels such as coal, as well as oil and natural gas consumption (GCCSI, 2014). Therefore, there is an urgent need for ASEAN's role to play in contributing to the global commitment to reducing GHG emissions, and to initiating a regional climate action (ECN, 2016). Recently, the IEA estimated CCS in the climate change portfolio of energy technology for ASEAN, which modelled a lowest cost scenario to achieve the required CO2 emissions towards the 2-degree target to pre-industrial times between 2009 and 2050. It estimated the portfolio of the technology to achieve necessary emissions reduction in ASEAN and CCS could contribute 14% of global emission reduction up to 2050 (GCCSI, 2014).

5. Table 2. *The barriers to CCUS policy and legal framework in the ASEAN region*

Barriers to policy framework	Barriers to legal framework
Political leadership (global and regional) - The ASEAN Plan of Action for Energy Co-operation: 2016-2025 of action states that, EE&C-SSNa is responsible for achieving the aspirational goal of reducing energy intensity in ASEAN by 20% by 2020 as a medium-term target and 30% by 2025 as a long-term target based on the 2005 levels. -ASEAN has identified climate change as a priority issue since the 2007 ASEAN Summit in Singapore. There was an unclear agenda, discussion and deliberation in the latest ASEAN Summit (2017) in Manila. -There is an absence of a clear political leadership in the region in relation to GHG mitigation action. -Nine out of ten countries have ratified the Paris Agreement (i.e. not Myanmar). Target Setting (regional and domestic) -The ASEAN Plan has yet to set a specific target for CO2 emissions reduction. -Some of its countries have their own targets as Nationally Determined Contribution: NDC (e.g. 26% reduction of GHG emissions by 2020, and 41% reduction with the assistance of international communities in Indonesia; 40% reduction in carbon intensity of GDP by 2020 based on the 2005 levels in Malaysia; and 7% to 11% reduction of GHG emissions by 2020, and 36% reduction of GHG emissions intensity by 2030 from 2005 levels in Singapore). Internal Financial Support and mechanism (domestic-public grants) -Not available yet External Financial Support (i.e. international investment & funding opportunities) -E.g. a pilot CCS project "Gundih CCS project" in Indonesia has been supported by the Asian Development Bank (ADB), the Japan International Cooperation Agency (JICA) and Pertamina since 2012. -Financial support from Japan and China for building the infrastructure and expanding the coal industry in the region has been dramatically increased (e.g. U.S$230 billion by Japan, U.S$155 billion by China invested in regional infrastructure since 2000; and China, Japan and South Korea were involved in 18 of 22 coal deals in Indonesia during 2010-2017) Institutional arrangement (regional level or among countries) - There has not been a strong form of regionalisation available in the ASEAN region (e.g. ASEAN is an inter-governmental organisation). Access to UN mechanisms (i.e. CDM) based on the Kyoto mechanism or UNFCCC -CCS projects are eligible for CDM, but currently no project approved. -Japan has initiated the Joint Crediting Mechanism (JCM)/ Bilateral Offset Credit Mechanism (BOCM): (e.g. JCM feasibility studies for CCUS in Indonesia since 2010). Social acceptability (i.e. public awareness and acceptability) -The relevant data are not yet available.	International agreements relevant to the purpose of marine disposal of CO2 and/or CCUS implementation (e.g. London Protocol). -The London Protocolb: Only the Philippines ratified -The OSPAR Conventionc: Not ratified -The Basel Conventiond: All the countries ratified -MARPOL Conventione: Five out of ten countries ratified (i.e. Indonesia, Malaysia, Philippines, Singapore and Vietnam). -UNCLOSf: Nine out of ten countries ratified (expect for Cambodia). -The MEPSEAS Projectg: Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, Thailand, and Vietnam have initiated the four-year project (2018-2012) to consider their potential agreements with international marine treaties. International Law within the APR (bilateral and multilateral) relevant to the purpose of marine disposal especially for CO2 (e.g. CCS-Directive). -Currently, there is no legal framework for CCUS in the region. The capability of a regional law framework such as a political feasibility of ASEAN countries (e.g. the EU group) -ASEAN is an inter-governmental organisation. -ASEAN does not have a Parliament. -ASEAN takes all its decisions by consensus. Institutional Arrangement such as the European Commission (EC) -ASEAN does not have a commission with the power to put forward proposals for legislation (i.e. ASEAN Charter has the Secretary-General without the power to put forward proposals for legislation). Financial Mechanism for liability issues among the countries such as ETS regime for CO2 leakage in the EU. -Currently no market-based instrument for climate change has been available in the region (i.e. ETS). Compatibility of future trading CO2 as products such as possible physical pipelines and grid. -This has not been considered yet. -However, Potential Off-grid Distributed Energy System (DES) for transporting renewable energy supply has been widely discussed for the ASEAN region. -Transporting CO2 products has not been considered yet. Compatibility of technological standards (e.g. ISO) -This has not been considered yet. Existing CCUS legal frameworks at the domestic level. -No existing CCUS legal framework in the countries.

Source: ACE 2017; IEA 2017; Fulton et al., 2017; IMO, 2018; ASEAN, 2018; Leong, 2018.

aEE&C-SSN: The Energy Efficiency and Conservation Sub-sector Network

bThe London Protocol: 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972

cThe OSPAR Convention: The Convention for the Protection of the Marine Environment of the North-East Atlantic

dThe Basel Convention: The Basel Convention on the Control of Trans-Boundary Movements of Hazardous Wastes and their Disposal, 1989

eThe MARPOL Convention: The International Convention for the Prevention of Pollution from Ships

fThe UNCLOS: The United Nations Convention on the Law of the Sea

gThe MEPSEAS Project: The Marine Environment Protection for Southeast Asia Seas Project

6. Results: Meeting the roles of CCUS policy and legal framework?

Firstly, the ASEAN region/countries have responded to the Paris Agreement collectively and individually. ASEAN will play a significant role in contributing to GHG mitigation activities globally, due to the rapid population and economic growth and high demand for the future energy supply. However, the level of the regional commitment still shows uncertainties. There is an absence of the enforceability or target obligation for reducing GHG emissions under the Paris

Agreement. As a consequence, the ASEAN countries have not been asked for the obligation, and most of their short and middle term targets are also focusing on energy efficiency rather than reducing GHG emissions, while renewable energy sources are being strongly encouraged both at the regional and domestic levels. Furthermore, there is no clear target, either in the region or its countries, for the long term. As expanding the coal industry is continuously stimulated, there is no clear action for reducing the emissions. Given this, the ASEAN region and its countries may need to improve their responsibility and accountability toward the global climate mitigation activities, especially for the Paris Agreement.

In response, ensuring financial support and a mechanism for the future CCUS deployment will need to be improved in the region. Through the current CDM rules under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, a CCS project has been located in developing countries to generate tradable carbon offsets for developed country (UNFCCC 2018), however, none of the projects has been approved and implemented yet (Minh et al. 2017). For the external financial support, Japan, China and South Korea are the major countries for expanding the coal industry in the region, which may potentially become a main financial source for the future CCUS deployment in the region. Further amendment of the current CDM and the prosperity of a potential JCM initiated by the Government of Japan, may encourage the future development of CCUS technologies in the region. JCM is a project-based bilateral offset crediting mechanism to cooperate with developing countries for reducing GHG emissions, resulting in the reduction assessed as contribution by both partner countries and Japan since 2011 (i.e. a total of 17 partner countries, and Cambodia, Indonesia, Myanmar, the Philippines, Thailand and Vietnam have become partners) (CME, 2018). A sense of the long-term management relevant to CCUS technologies has yet to be found specifically, due to the lack of policy and legal framework in the region and/or its countries. The relevant data for addressing the level of social acceptability in the region is not yet available. The results also show that there is still a long way to go to realise a commercial scale of the projects. The existing policies and laws both at the regional and domestic levels and unclear direction of climate change activities will not encourage drawing a clear pathway towards a low and/or zero carbon society and the role of CCUS technologies. The first step still requires a number of projects at the pilot and demonstration levels, which have not been actively implemented, due to the lack of policy commitment and financial support both internally and externally. In terms of adapting regional and national CCUS policy and legal frameworks, it is essential that the region and its countries firstly draw up a clear vision and role of climate change activities at the regional and domestic levels, as well as improve the institutional arrangement for the regionalisation, in order to design the policy and legal framework. Moreover, it is also important for them to adapt a number of international laws (e.g. the London Protocol), however, there is an absence of access to those major international treaties relevant to CCUS activities. Given this, the region and its countries will need to clearly address their commitments and policy directions, and their regional measures and activities as well as share a design of common and individual policy and legal frameworks.

7. Discussion

6.1 Governance and political feasibility

In terms of establishing a regional approach to climate change activities, it is essential to ensure the level of governance and political feasibility of the regional community and/or its regime. Climate leadership theory requires a strong political leadership and feasibility, dynamism of governance and sharing economic, social and environmental values, and global responsibility (Oberthür and Kelly, 2008; Gupta and Ringius, 2001). This study has clarified that the ASEAN and EU regions have shown a common interest of the meaning of governance, namely, aiming at the regional economic growth and social progress and sharing their global responsibility towards global climate action. However, ASEAN, ASEAN Plus Three grouping, East Asia Summit (EAS) and ASEAN Regional Forum, and the existing arrangements in the regions are based on the form of consensus, voluntarism and consultation, resulting in less political power and potential for effectiveness than the EU (Beeson and Lee-Brown 2017). As for climate action, the 2010 ASEAN Action Plan on Joint Response to Climate Change has been criticised for being conceptually weak and is yet to be implemented (Kheng-Lian and Karim 2017). Our findings also addressed the point that ASEAN is an inter-governmental organisation and does not comprise a strong form of regionalisation such as the ‘supranational organisation’ in the EU. ASEAN has the power of the Secretary-General, who acts in reporting annual compliance reports for the countries’ obligations, however, its political power and feasibility seem to be limited. The absence of a common trading pool of the sovereignties for member states creates opportunities for directing a trading framework for regional activities.

The EU Court of Justice comprises commitments for regional measures and actions. Neither of these feasibilities currently exists in ASEAN. Furthermore, the EC in the EU, plays a role in assisting in proposing, designing and monitoring regional policy, law, strategy, implementation, financial budget and international activities, which ASEAN does not. Crowley and Nakamura (2018) suggest that a polycentric setting at the regional level is important for promoting, transferring and accelerating climate policy learning and action of mutual benefit to neighbouring countries, facilitated by a regional governance, in the geographic context. This can be achieved by being incorporated with developed countries and regional leadership may potentially be created by developing countries. However, the current status and form of regionalisation in ASEAN may need these institutional functions in order to build the level of a strong governance and leadership at the regional level. These institutional aspects have clarified that the ASEAN region has weak governance and less political feasibility compared with the EU, especially for directing and implementing regional GHG mitigation activities, which will need to be further improved in the future.

6.2 Opportunities

There is a clear opportunity for the ASEAN region to take regional climate leadership by addressing a clear direction and designing a stronger political feasibility towards the Paris Agreement. As the EU has historically initiated the global leadership and many climate actions, ASEAN has many future opportunities for mitigation activities including fast economic growth, political initiatives, multi-national corporations and developing and trading potential low carbon technologies and products including CCUS (e.g. CO2) and renewable energy sources. For the future market, low carbon technologies and products as well as energy supply will be a strong part of ASEAN's market opportunities with the rest of the world. In the EU, a number of CCUS projects have been funded, coordinated and implemented (e.g. the ALIGN-CCUS). CCS transport grid and cluster projects (e.g. CO2 SAPLING Transport Infrastructure Project, and Rotterdam Nucleus) are also being planned (GCCSI, 2018). These opportunities will also be potentially available in the ASEAN region as well as the other countries within the APR.

It is also crucial to increase the political power of the ASEAN countries. Compared to the political form in the EU, the form in ASEAN is weak. It needs more political discussions and debates towards a stricter form in the region. As a potential approach, building more trading and financial mechanisms incorporated with developed countries such as the EU members, Canada, the US, Japan, and South Korea, through the UN framework, may provide opportunities for creating bilateral and multilateral alignments and incentivising potential markets for these regions and countries to incorporate their climate mitigation activities, in response to the Paris Agreement. Otherwise, the region will need to strengthen its own political alignment and corporation by itself.

In terms of generating internal financial sources for promoting and developing low and/or zero carbon technologies, especially for CCUS, market-based instruments for climate change such as ETS and Carbon Tax and other economic instruments (e.g. ALIGN-CCUS, HORIZON 2020 and NER 300 in the EU) can be considered for the ASEAN region. Potential external funding opportunities may also be generated through CDM and JCM and/or other countries such as Japan, China and the ADB (Government of Japan, 2019). The Japan Fund for the Joint Crediting Mechanism (JFJCM) is one of ADB's trust funds, which could also assist in another opportunity for grants and technical assistance for CCUS. This provides financial incentives for expanding opportunities for adopting advanced low-carbon technology to projects financed by the ADB. The JFJCM also potentially helps by providing the form of grant and technical assistance to projects in ADB's developing member countries which have signed bilateral agreements for the JCM with Japan (ADB, 2016). Thus, this mechanism could potentially be further scaled up for supporting CCS technologies and their deployment. Given this, as business, market and funding opportunities grow in the region with a large volume of external investment from developed countries, the energy and market demands are being significantly generated internally and externally.

To the extent of CCS opportunities in the ASEAN region, CCS associated with high CO2 gas production has proven a lower cost for the early stage of CCS development (Irlam, 2017). In fact, there are significant opportunities in the region with high demanding CO2 gas fields (Minh and Hoang 2017). It should be noted that CCS implementation associated with CO2 gas fields could be beneficial especially for the early stage of the development.

The potential and future investment for The CCUS products and technologies from those countries will not only achieve the reduction of GHG emissions, but will also develop the technologies and their related products, as well as developing other low and/or zero carbon technologies such as renewable energy. Thus, the region's considering and initiating the policy action to the right balance of low and/or zero carbon technologies at the domestic, regional and international levels will potentially assist in achieving these opportunities.

6.3 Challenges

Firstly, there is a need for the ASEAN region to share a clear direction for the regional activities, including climate change action, trading and marketing. Secondly, the current status may require that the region needs to maximise its future opportunities for developing low carbon technologies and development including CCUS. In this regard, the region may require further improvement of the institutional arrangement within the region for generating a financial mechanism for CCUS. The region could institutionalise the funding mechanism to generate financial sources for a future ETS such as the EU-ETS. This can be used for encouraging CCUS projects and their implementation as well as renewable energy, and for environmental liabilities for CCUS implementation and long-term management. However, this fact reveals that the recent situation for the EU has shown some difficulties such as the failure of carbon pricing and funding opportunities through the EU-ETS. A significant drop in the oil price affects the carbon price unit based on the EU-ETS funding mechanism. As a consequence, there is limited availability of funding opportunities via the NER300 for low carbon technologies such as CCUS. Thus, any future introduction of economic and market-based instruments will need to be carefully considered for the ASEAN region.

It is also important to note that potential financial mechanisms (i.e. ETS and Carbon Tax) in the ASEAN region should also be considered within the APR. This will need a further study and analysis, however, it is essential to examine what other countries are taking action on the issue, such as Japan, China, South Korea, Australia and New Zealand. China has recently introduced an ETS at the sub-national level. Australia used to have a carbon pricing mechanism. New Zealand has its own ETS. Thus, there is a need for such a significant study for potentially establishing a harmonised regional framework at the APR.

Furthermore, it is important to note that the recent trend of Japan, China and South Korea's investing in coal fired projects in the ASEAN region has significantly grown. This may, in turn, further require the region to urgently discuss introducing CCS readiness and CCU technologies. Thirdly, as mentioned previously, in order to establish the climate change activities and financial mechanisms within the region, it is important for the region to make an institutional arrangement to assist in realising the activities in practice, by developing and/or synthesising the EU form, including the EU's Court of Justice, a supranational organisation and the role of the EC. Fourthly, the ASEAN region and/or its countries will need to clarify the applicability of the relevant international treaties relevant to CCUS technologies such as offshore CO2 disposal, liabilities for leaking CO2 and environmental and health damage in onshore and offshore areas, and trading and transporting

protocols for CO2 (e.g. the London Protocol). Such treaties will allow the ASEAN countries to create a basic form of their legal requirements and standards such as monitoring process, standards and techniques, transfer of responsibility, and long-term liabilities.

Lastly, the ASEAN region will urgently need to prepare for designing a policy and legal framework for CCS at the regional level. This may be incorporated within the APR. There have been a few CCS pilot projects implemented in Indonesia associated with the ADB and some legal and regulatory analyses have been undertaken. However, the progress has been limited due to the major focus of the projects being technological deployment. The ADB's report (2013) concluded that there have yet to be dedicated CCS regulations in Southeast Asia (i.e. Indonesia, Philippines, Thailand, and Viet Nam) with the lack of incentives or legislative requirements to promote future investment in CCS. Furthermore, a study for policy and legal development will be crucial for such fast economic growth countries and the existing regulations could be used and potential funding mechanism should be developed among multilateral and bilateral agreements.

It is essential for the region to address a clear vision and policy goals for climate change as well as the role of CCUS. A number of legal barriers will also need to be overcome at the regional and domestic levels. Each country will then consider how it could take responsibility from the regional framework for CCUS.

8. Conclusions

This study aimed at comprising an analytical method and applying it to address any relevant policy for and legal barriers to developing the future opportunities for CCUS technologies in the APR. The demand for CCS deployment has been further expected to be higher in the region, especially in the ASEAN countries (as the specific case study of this study), due to becoming a region of the major economic sources and the major GHG emitters.

The study has shown that the roles of policy and law regarding the further development of CCUS deployment within the ASEAN countries are commonly matched to the purpose of regional framework in the EU, except for the different position of global responsibility and form of regionalisation. In terms of barriers to policy and legal framework, there are still high uncertainties about global and regional action to the targets of climate change including the non-mandatory based Paris Agreement and non-existing partnerships toward a low carbon society at the regional level. There are a number of key challenges for the future CCUS policy development within the region, comprising: the establishment of specific emission targets (i.e. key actions) at the regional level under the Paris Agreement; the enhancement of building regional partnerships relevant to the CCUS's technological development and trading (i.e. bilateral and multilateral agreements); the introduction of carbon credit mechanisms similar to the Kyoto Protocol in the Paris Agreement; the demand for encouraging the developing countries to coordinate a CDM and JCM applicable not only to the global but also to the regional levels, especially within the region; and the establishment of a regional commission such as the EC to institutionalise more opportunities for sharing information and creating a market pool and/or financial sources in the region such as an application of EU-ETS and NER300 in the EU, although the future application of these funding mechanisms in the region will need to be carefully considered. Conducting future studies on social acceptability will be essential at the regional, domestic and/or local levels.

In terms of the challenges in the legal framework, this study has specifically suggested that there will be an urgent need for: clarifying the issues, scope and applicability of the existing international laws to the APR and ASEAN (e.g. the London Protocol) such as the issues of territories and transboundary; establishing technological standards and practice codes; and seeking the ways of building potential infrastructure for the technologies across the region, such as shared storage sites, pipelines and grid-networks. The overall findings also suggest the ASEAN region has a great potential to lead the climate action in reducing GHG emissions at the domestic, regional and global levels and CCUS could play one of the significant technological roles. However, the current regional governance and its political feasibility will need to be further enhanced and improved in order to make it possible and there is a need for this governance to guide its countries to their clear direction of the regional approach to GHG mitigation activities.

Given this, beginning with addressing the circumstances of the ASEAN countries throughout our study, as the most urgent group within the APR, it will contribute to introducing a novel exploration for the future CCUS studies in the region. Our future studies on exploring the policy and legal development in more detail regarding CCUS technologies especially in the APR (i.e. ASEAN) will be crucial to maximise the technological options and solutions (i.e. CCUS and renewable energy technologies) towards a future global low and/or zero carbon society.

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Paper

Crowdfunding: aspects of private autonomy and market development.

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Abstract

Crowdfunding is a relatively recent phenomenon which consists of promoting or supporting an initiative by raising the necessary funds over the internet. Originating in America as a social phenomenon, on the basis of guidelines issued by the European union, it was adopted by almost all the Member States which, to this end, introduced policies of incentives for innovative start-ups and approved measures to facilitate access to credit for businesses. Italy's first intervention was the Decreto Crescita 2.0 (lit. '*Growth Decree*') which, by modifying the economic framework law, introduced regulations for the collection of risk capital by innovative start-ups with the help of online platforms. The crowdfunding tool was subsequently transposed into the Italian system under the repeatedly revised Consob Regulations of 2013. This dual regulatory approach makes it possible to clearly define the rights and obligations of the interested parties (investor, portal manager and issuer).

Keywords: crowdfunding, web portal, investor, manager, issuer.

Introduction

Crowdfunding is a relatively recent phenomenon which consists of promoting or supporting an initiative by raising the necessary funds over the internet. Originating in America as a social phenomenon, its economic benefit is the possibility of collecting large sums of money from a very large audience of small investors willing to commit modest sums of money for the realization of a given project. There are four known forms of crowdfunding: the *donation model*, aimed at financing non-profit initiatives, in which donors obviously have no right to reimbursement; the *rewards model*, in which investors receive a symbolic prize for their financial commitment; the *pre-purchase model*, used by start-ups, which envisages preferential treatment for donors when taking advantage of the services provided by the company or purchasing its products, provided of course the initiative is successful; and the *equity model*, in which the investment entitles investors to a capital stake in the issuing company and the attribution of shareholder status (AGRAWAL A.K.-CATALINI C.- GOLDFARB A., 2011, 61; BRADFORD C.S., 2012; HAZEN T.L., 2012; SUMNERS P.C. 2012). The latter is the model that has most required legislative intervention, based on the belief

that while the opportunities offered by technology should be exploited to the full, we may not however neglect wider issues concerning the interests at stake of the parties involved (issuer, intermediary and investor) and the principles that govern financial markets. On the basis of what happened in America, the European Commission, as part of the Europe 2020 growth strategy, first recommended member states to implement incentive policies for launching innovative start-ups as a tool to combat youth unemployment and to pass measures aimed at facilitating access to credit for companies investing in innovation (MACCHI F, 2017). In following this recommendation, Italy passed the Decreto Crescita 2.0 (Legislative Decree No. 179 of 18 October 2012 converted into Law No. 221 of 17 December 2012), which amended the Financial Framework Law (TUF) to introduce regulations for the collection of risk capital by innovative start-ups with the help of online platforms. Subsequently, the Italian government extended investment collection by means of crowdfunding portals to include innovative small and medium-sized enterprises (SMEs). This approach was implemented in the detailed Consob regulation (Consob Regulation no. 18592 of 26 June 2013 and subsequent amendments), aimed at protecting investors from the risk of opportunistic behaviour resulting from the lack of information provided relating to the investment. also in the period following conclusion of the offer (PIANTAVIGNA P. 2014).

Method

Once we have identified the regulations operating in this sector, if we aim to interpret them, we first of all need to provide a legal definition of the type of contract we are dealing with. In this regard, while some scholars have compared it to a mandate for the placement of securities (EROLI M. 1989; SCORZA G. 1978), the majority see the relationship between the issuer and the portal manager as constituting a service contract (MOSCARINI L.V. 2007; CAGNASSO O. 1987). The next step must then be to determine the rights and obligations of the issuer and those of the crowdfunding portal manager vis-à-vis the investor.

Results

Crowdfunding represents an important development opportunity for the domestic and international market. However, it must be conducted according to pre-established rules based primarily on the duty of fair practice and good faith, which must apply to all the parties involved in the relationship, even more so when the intermediary is a bank. Other problematic aspects such rules must clarify regard the importance of information flows managed by the portal operator, and the management of risks associated with crowdfunding operations.

Conclusions

After years of immobilism, the introduction of legislation aimed at regulating equity-based crowdfunding represents an important opportunity for the development of Italy's domestic market (TROISI A. 2014). Economic scholarship however suggests that this legislation needs to be implemented if our model is to compete with those of other advanced economies and ensure that any deviations from the classic crowdfunding model (such as disintermediated crowdfunding) are specifically regulated (HEMINWAY J. 2013; THOMPSON R.B.-LANGEVOORT D.C. 2013). Because while it is true that the highlighting of new interests is a matter for private autonomy, the control of their merit is always the responsibility of legislators.

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Special Theme: Sustainability and Africa

Sustainable development of South Africa

An in-country perspective

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Abstract

Globally, most governments have come to accept the need for less exploitative forms of development and have undertaken developmental goals and projects that aim to provide a conducive living environment for future generations. Model projections indicate that the majority of population growth and development will occur on the African continent in the next century. There are progressive factors indicating that sustainable development on the continent requires urgent focus. As such, African governments recognised this urgency and, together, developed the African Union's (AU) Agenda 2063: The Africa We Want, which details developmental goals for the entire continent for the next 43 years. Furthermore, a global collaborative effort resulted in the Sustainable Development Goals (SDGs), set out by the United Nations General Assembly, to prioritise developmental goals for creating and maintaining a sustainable future for current and future generations. Sustainable development plays an important role in supporting South Africa's growing population, contributing to the country's economy and conserving natural resources. The AU's aspirations, together with the SDGs, have partly been incorporated into the government's National Development Plan (NDP), and the country's public and private sector actively supports sustainability measures. Even so, high poverty rates, economic contraction and untenable use of natural resources persist in South Africa. A qualitative review of South Africa's addressment and fulfilment of specific SDGs was conducted, namely SDG 4: Quality Education, SDG 8: Decent Work and Economic Growth, SDG 11: Sustainable Cities and Communities, SDG 13: Climate Action, SDG 15: Life on Land and SDG 16: Peace, Justice and Strong Institutions. This was done in relation to government actions, private and public sector involvement and societal engagement. Published literature and current news were reviewed to explore country-specific issues within these SDGs, to reflect on the measured impact, summarise indices and evaluate the county's commitment to these SDGs. Possible solutions to system challenges are highlighted and research needs are outlined for consideration. In conclusion, addressing the needs of the many, while managing the state of the economy and natural environment, is within the capabilities of South Africa and is thus a realisable goal. Sustainable development within environmental limits has never before been as important to focus on as it currently is. To do so, better prioritisation of development goals and future scenario planning is needed, in conjunction with increased research addressing the core developmental needs. South Africa should not only be investing in development initiatives but should actively be developing normative scenarios for the most favourable future that could realistically be achieved. The development of such scenarios is able to guide as well as frame development initiatives so as to ensure that they effectively work towards a common goal. Proper research-based planning and cross-platform collaboration will enable future generations to benefit from a functioning economy with abundant resources which will allow them to support their needs.

Keywords: Sustainable development, South Africa, Research needs, SDGs

1. Introduction

In 2000, the African Union developed Agenda 2063: The Africa We Want, which details developmental goals for the entire continent for the next 43 years. The Agenda explores climate policies in Africa and discusses opportunities to concurrently address climate change and development challenges on the continent (AU Commission, 2015). South Africa's National Development Plan (NDP) Vision 2030 was introduced in 2012, which aims to reduce inequality, eliminate poverty, create jobs and grow an inclusive economy by 2030 for the 59,308,690 strong population (National Planning Commission, 2011).

Shortly afterwards, the country joined others in committing to the Sustainable Development Goals (SDGs) set out by the United Nations General Assembly in 2015. The SDGs programme has helped South Africa to prioritise developmental goals, access funding, and build learning networks to better situate policy mechanisms (Stats SA, 2017c). The AU's aspirations, together with the SDGs, are partly incorporated into the government's NDP, and the country's public and private sector

actively supports sustainability measures. These three programmes have mutually reinforcing agendas speaking to the common heritage, values and ethics of African cultural identity (Figure 1).

***Figure 1**. Main objectives of the NDP Vision 2030, African Union Agenda 2063 and SDGs 2030 (Presidency, 2019).*

Public organisations choose to fulfil SDGs through their work while private businesses are integrating SDGs into their corporate strategies to become more socially responsible and explore growth opportunities in new markets. Their actions include reducing environmental impact, reducing carbon emissions, generating jobs in the green economy and developing nature-based solutions (GCNSA, 2019). However, despite these engagements, South Africa faces serious developmental challenges such as high poverty rates, economic contraction and untenable use of natural resources.

The Sustainable Development Goals Centre for Africa states that 'Africa is partly on track for three goals: Equality, Climate and Life on Land.' Their 2019 report shows that available data with which to keep track of progress versus indicators are woefully inadequate and huge gaps exist in the information used to identify the continent's fulfilment of all SDG's (SDGCA, 2019). In 2019, the South African government instigated an inter-ministerial structure to set up the National Coordination Mechanism to strengthen implementation of and review progress on the fulfilment of the goals of the SDGs, AU Agenda and NDP. This allows for strategic oversight in accurate indicator selection, data collection, knowledge gaps and challenges within every SDG. The stakeholders involved include national government, provincial and local governments, parliament, civil society, the private sector, academia, development partners as well as the United Nations, AU and SADC (Presidency, 2019).

In this paper a qualitative review of South Africa's addressment and fulfilment of specific SDGs was conducted, namely SDG 4: Quality Education, SDG 8: Decent Work and Economic Growth, SDG 11: Sustainable Cities and Communities, SDG 13: Climate Action, SDG 15: Life on Land and SDG 16: Peace, Justice and Strong Institutions. This was done in relation to government actions, private and public sector involvement and societal engagement. Published literature and current news were reviewed to explore country-specific issues within these SDGs, reflect on the measured impact, summarise indices and evaluate the county's commitment to these SDGs.

2. SDGs Overview

2.1. SDG 4: Quality Education

The Quality Education SDG aims to 'ensure inclusive and equitable quality education and promote lifelong learning opportunities for all by 2030.' Several indicators monitor access to equitable and quality education, quality early childhood development, technical and vocational skills, gender disparities, literacy and numeracy, building and upgrading educational facilities, scholarships, and qualified teachers and trainers (UNESCO UIS, 2017).

The South African education sector is administered by two national government departments, the Department of Basic Education (DBE) and the Department of Higher Education and Training (DHET). The DBE oversees compulsory primary and secondary education in 23,796 public schools with 12,490,132 learners and 1,966 private or independent schools with 402,141 learners, in 2019 (SAMI, 2020). The DHET oversees tertiary, vocational and 21 Sector Education and Training Authorities. The country has 26 public universities, 123 private universities and 50 technical education and vocational training (TVET) colleges. In 2017 there were 1,036,984 university students, 688,028 TVET students and 258,199 community education and training students (DHET, 2019).

Basic education is heavily subsidised, allowing greater access to primary and secondary education, and the government has made strides in reducing the levels of inequality in the education system. Nonetheless, South Africa has one of the most unequal demographic schooling results in the world (Spaul, 2019). Quality of basic education varies greatly across the country, with troubling obstacles to schooling (The Economist, 2019).

Policies and programmes aimed at addressing education needs support learner transport, nutrition, health services, mathematics literacy, reading improvement and vacation schooling. All basic education learning materials and student workbooks are provided by the DBE to all schools for free (DBE, 2015).

The amount of learners in Grade 10 (±17 years old) in 2017 (1,052,080), compared to the amount of learners who wrote their matriculation (National Senior Certificate) exam for all subjects in 2019 (504,303 full-time and 106,385 part-time) indicates that, potentially, 41% (441,392) dropped out of school during that time or took longer to complete secondary education (Chothia, 2020). Similar statistics were reported in 2010 (The Economist, 2010). Information on the current status of these 41%, and those from previous years, including why they did not graduate is unavailable. These numbers may have been the catalyst of the DBE's newest proposal of introducing a General Education Certificate after completion of Grade 9 (±15 years old) which opens a pathway to technical colleges before Grade 12. Education specialists advise the government that priority should be given to improving early grade literacy (Ngqakamba, 2019).

Youth illiteracy levels vary across the country, and troubling data indicates that in some provinces 75% of 9-year-old learners cannot read for meaning, and this statistic is as high as 91% in Limpopo and 85% in the Eastern Cape (Amnesty Int., 2020). Although UN data shows youth (15–24 years) literacy rates as high as 98% (UNICEF, 2013). In 2018, data indicated that the adult illiteracy rate (here defined as 'adult above 20 years with Grade 7 as their highest level of education') was 13.8% nationally, and provincially up to 20.5% in the Eastern Cape, 19.7% in Limpopo, and 19.1% in the Northern Cape (SAMI, 2020). Additionally, other data indicates that 'adults 15 to 34 years' have a 78 to 96% functional adult literacy rate (Stats SA, 2017a). These contrasting data are indicative of confusing and inconsistent data, wording of definitions and a great need for a well-developed, standardised education indicator evaluation system.

Of the total 504,303 full-time learners who wrote the matric exam in 2019, 81.3% (409 906) passed by attaining a mark of at least 40%. Of these, 36.9% achieved a Bachelor's pass (a 10.3% increase from 2016) for entrance to university level study, and 28.7% achieved a Diploma pass to continue TVET education (DBE, 2020). For the remaining 15.7%, those who want to continue their studies must either enter the saturated job market and after six to eight years' work experience (recognition of prior learning) may apply for further studies, or be selected to attend learnership programmes. In terms of gender balance, data indicates a roughly equal ratio in national school learner numbers, where males (82.8%) achieved a slightly higher matric pass rate than females (80.1%) in 2019 (DBE, 2020).

In 2011, 37% of public schools had computers for teaching and learning, though fewer had internet access, while 9% were largely without electricity and about 13% did not have sanitation facilities (DBE, 2011).

The amount of people with degrees has grown between 2008 to 2016 at 76% per year (DHET, 2019). Tertiary and vocational training became more accessible in 2017 when the government initiated widespread grants to students from financially needy backgrounds, catalysed by student protests throughout the country (#Feesmustfall protests) (Fihlani, 2019).

Despite the progress made, there are still serious challenges within the basic education system (Mohamed and Byrne, 2020; Mthethwa, 2020). A 2020 report by Amnesty International states that the DBE is not only in violation of the Minimum Norms and Standards for School Infrastructure regulations, but it is also not on track to achieve its stated aims (Amnesty Int., 2020). This sector desperately needs research to advise how many new schools must be built (supply vs. demand) and where (population density hotspots), fast track teacher output, determine what the varying education needs of all learners are and how they can best be met with limited resources. Post-school education has increased enrolment and promotes equitable access but will face developmental challenges due to slow economic growth and youth unemployment (DHET, 2019).

2.2. SDG 8: Decent Work and Economic Growth

The Decent Work and Economic Growth SDG aims to end poverty, eradicate forced labour and ensure that people have decent work, productive employment and encourage entrepreneurship by 2030. The Decent Work Profile for South Africa analyses the progress and challenges across the thematic areas of decent work. South Africa's current economic conditions need to be read against the background of the first democratic elections in 1994 where legal, political and social policies were introduced to address the imbalances of the past and promote an inclusive society that shares equitably in economic prosperity. Since the first democratic elections (GDP $139 billion in 1994) the economy has expanded ($278 billion in 2019) (Presidency, 2014).

South Africa is the most developed country in Africa and up to 2014 was the largest economy on the continent with an annual GDP of $350 billion (Naidoo, 2020). However, in recent years economic growth has declined from 2.5% in 2013 to 0.8% in 2018 (Stats SA, 2020). The 2019 outbreak of the global coronavirus pandemic and Moody's investment downgrade to junk status in 2020 weakened the South African economy, which was already in recession, with a projected GDP growth contraction of -2.7% y/y in 2020 (Bishop, 2020; Gernetzky, 2019). Additionally, the South African government had an exorbitant debt of $70.8 billion in 2019 (SARB, 2019). Foreign investment has decreased due to rising political tensions, global economic slowdown and decreased electricity availability (Hogg, 2020).

The country has excessively high levels of poverty at 50% of the population (Stats SA, 2018). This figure may rise further due to the global economic recession and current developmental challenges (Nel, 2020). The unemployment rate has been increasing yearly and currently sits at 29% (Stoddard, 2020). Many South Africans, particularly youth, are disconnected from the formal economy through not finding employment. Between 2008 and 2017, up to 40% of unemployed citizens were new labour market entrants (Stats SA, 2017b). Medium-term data showed a general increase in employment levels by 1.5 million, from 14.9 million in 2013 to 16.4 million in 2018 (Stats SA, 2020).

Basic conditions of employment legislation set minimum wages for some sectors, normal work hours (45 hours), maternity and paternity leave, and minimum age requirements (no child under 15 may work). Health and safety laws promote the safety of workers in the workplace (ILO, 2012).

It is suggested that the best way to overcome slow economic growth are interventions that promote entrepreneurship and job creation. It is well understood that decent work and economic growth forms the means to the attainment of equitable, inclusive and sustainable development (ILO, 2012). However, many business start-ups require tremendous venture capital which is not easily accessible due to the risks of failure. It is estimated that 71% of start-ups in South Africa fail. These failures are attributed to poor financial literacy, lack of basic skills and an inadequate market (Ngalonkulu, 2018). A plausible solution is for well established businesses and organisations to support entrepreneurial development and create a need in the market by purchasing from and supplying the local market (Francke and Alexander, 2019).

In summarising current challenges, Business Unity South Africa has stated that 'this downgrade is largely as a result of the government's own making over an extended period. The inability to implement a comprehensive package of economic structural reforms (such as quickly enabling private sector investment in power generation), to cut the extensive and wasteful umbilical cord of state ownership and support to non-strategic disastrously run state-owned organisations like South African

Airways, and the fiscal crisis caused by nine years of corruption and state capture have placed South Africa in this situation' (Haffajee, 2020).

2.3. SDG 11: Sustainable Cities and Communities

The Sustainable Cities and Communities SDG aims to make cities and human settlements inclusive, safe, resilient and sustainable. The indicators cover housing, transport systems, sustainable urbanisation and the environmental impact of cities. Just under five years since the adoption of this SDG, South Africa has had a 47% indicator coverage (Goal Tracker, 2019).

South Africa has increasingly developed more policies and interventions to address the more than 2,700 informal settlements throughout the country which house an estimated 13.1% of all households (which includes approximately 1,967,000 children) (Hall, 2016; Stats SA, 2019a). Information on the amount of people that live in informal settlements is lacking. Many poor and low-income households have to live in informal settlements due to a critical lack of affordable housing. Residents of such informal housing experience inadequate living situations, face the threat of evictions and often lack access to basic services. Of the total households, 81.1% live in formal housing and 5.8% in traditional and other housing (Stats SA, 2019a). The middle-to-high income group can access formal housing through mortgage-secured financing systems.

Through several national housing policies between 1994 and 2018, the government has built 3.3 million housing units (Africa Check, 2019). However, a housing backlog continues to be a major problem, caused by slow and inefficient housing delivery and a higher than expected demand, estimated at 2.1 million homes (BBC News, 2019).

Policy has been introduced to promote spatially integrated sustainable human settlements and quality housing, focusing on building multicultural and non-racial communities that offer a mixed housing typology: free basic houses, social housing, finance linked individual subsidised housing and an open market. Nonetheless, this has achieved little impact. Metropoles and local municipalities now develop Integrated Development Plans (IDP) for their regions, which aim to determine optimal sustainable development for inclusive socio-economic growth (Harrison, 2001).

In 2013, of the more than 80% citizens who regularly use transport, use was split between 41.6% minibus taxis (making about 15 million trips daily), 23.4% private and shared cars, 10.2% buses, 4.4% trains, 8.5% walked and 1.9% used other means. Travel cost and time, distance to transport, flexibility, reliability, safety and inefficient transport availability were cited as serious challenges (Stats SA, 2014). This data may be outdated and Stats SA is collecting information from the public in 2020 to update this data. Industry players describe the transport industry as 'highly fragmented,' where the middle-class benefit from 99% of transport subsidies (using trains and buses, mostly only in Cape Town and Johannesburg), while the poor working class spend up to 50% of their income on public transport (compared to only 10% in developed countries) (Gedye, 2020). For instance, the eThekwini Municipality launched the People Mover bus project where buses run across the city at an affordable price. However, those living in the peripheries of the city do not have access to the bus routes (Dawood, 2017).

Solving public transport issues in the country is, at this moment, one of the most crucial and challenging goals, and more effort has to be made to achieve realistic short-term successes.

Challenges include the lack of efficient coordination between policies that results in the counter-treatment effect of the policies' goals, incoherent area-based planning strategies, poor planning, insufficient capacity, inadequate monitoring, lack of political will and limited public-private partnerships and community engagement (SERI, 2018). Therefore, immediate future research on the progress of this SDG should largely focus on practical improvements in housing delivery and improving living conditions, and on implementing useful successes for public transport for a larger portion of citizens.

2.4. SDG 13: Climate Action

The Climate Action SDG aims to reduce global greenhouse gas emissions (GHG), adapt to climate change and foster investment in low-carbon development. South Africa is also signatory to the Paris Climate Agreement Accord, which details a significant decrease in the country's GHG, as compared to 1985. According to the Copenhagen Accord, this would mean a

34% reduction in emissions as compared to a business-as-usual scenario by 2020. South Africa's long-term goal is to maintain stable emissions by 2050 of 212–428 MtCO2e (Climate Action Tracker, 2019). In a wider sense of this goal, South Africa seeks to further mitigate the impact of climate change by adopting climate smart technologies and fostering investment and adaptive citizen behaviour into more environmental-conscious solutions. All this is to be done within the socio-economic context of the country, supporting economic development and alleviating the worst impacts on the poor (DEA, 2019).

Indices include the total projected carbon emissions for a specific time period, as well as the number of national and local disaster risk reduction strategies adopted (Stats SA, 2017c). Other informal indicators may include the implementation of government policy mechanisms, private sector declarations of environmental responsibility, total amount of research funding into climate-smart solutions and further research and development investment, engagement events hosted for multi-sector involvement with a focus on climate adaptation, national proclamations of disaster zones and finally investment into nature-based solutions and climate-smart technologies (DEA, 2019).

The diverse impacts of future climate change consequences, continued environmental degradation and environmental pressures (i.e. drought, alien invasive plants and pollution) will manifest on different scales, differently impacting a variety of stakeholders. The solutions to these effects are variable and context-specific, requiring unique applications and responses from government and the private sector. Future climate projections show a decrease in water availability overall, particularly in the Northern Cape, Western Cape and Gauteng provinces, as well as increased frequency of sporadic heavy rains and storms, causing structural damage and soil erosion (DEA, 2013).

Climate Action Tracker rates South Africa's efforts as 'highly inefficient,' which indicates that the country's commitment falls outside of the fair share range and is not consistent with halting global warming to below 2 degrees Celsius (Climate Action Tracker, 2019). Challenges include policy misalignment and action coordination and collaboration throughout various government levels and the private sector, as well as timely implementation of proper solutions, as there seems to be a more reactive than proactive management of situations (Stoddard, 2019). Climate change mitigation commitments pose a considerable challenge to South Africa, with 80% of the country's emissions originating from the energy sector (DEA, 2019).

***Table 1**. Net CO_2 emissions for South Africa per category, in 2015 (DEA, 2019).*

IPCC 2006 Broad Categories	Net CO_2 emissions in 2015 ($MtCO_2e$)
1. Energy: fuel combustion activities, fugitive emissions from fuels, carbon dioxide transport and storage	423.18
2. Industrial Process and Product Use: mineral, chemical and metal industries, non-energy products	35.78
3. Agriculture, Forestry and Other Land Use: livestock, land, aggregate sources, harvested wood	-27.52
4. Waste: waste disposal, treatment, incineration	0.04
5. Other: international aviation, water-borne transport	11.49
Total	442.97

Government action has included developing legislation that decreases the nation's dependence on coal energy and increasing the adoption of renewables and gas (South Africa, 2019). A carbon tax was introduced in 2019 to act as a disincentive, however as electricity generation is the biggest GHG emitter (with little alternative options), few firms will avoid this tax in the short-term. National policy is being developed through the climate response strategy and will focus on building an effective climate change response and ensure 'the long-term, just transition to a climate-resilient and lower carbon economy and society' (South Africa, 2018). The bill is at an advanced stage and is expected to be passed into law in the near future (Gerber, 2018).

Priority actions to achieve SDG goals should include multi-sector collaboration of coordinated actions aligned to changing people's behaviours to adapt to future climate challenges (i.e. using less water and electricity, reducing carbon negative

activities); investment into and support of nature-based solutions and long-term sustainable solutions; further development of nature protection by expanding nature parks and marine protected areas; controlling water-thirsty invasive alien plants in important water catchments; upgrading water infrastructure and investing in structures for growing water needs; supporting renewable energy production through expanding the mandate of the Independent Power Production Programme and increasing domestic use of decentralised power generation; and setting sectoral environmental targets for an overall decrease in water and electricity usage, carbon emissions and pollution (Kuramochi et al., 2018). It should be kept in line with future needs through a climate-smart approach, global emissions limits and biodiversity conservation targets (Cumming et al., 2017).

The 2016/2017 drought experienced in the Western Cape provides a case-study of South Africa's readiness to address climate change impacts and environmental pressures, and its ability to plan ahead (Githahu, 2020). The drought had little head warning and was exacerbated by climate change effects and an increase in water demand (Western Cape Government, 2018). Water use efficiency interventions were driven and supported by the provincial government and the uptake of water-wise technologies and management resulted in the lower water use per area unit (WWF South Africa, 2018). A drought-related disaster was largely averted. For this to have happened, many stakeholders had to come together to strategize, compromise and implement the most impactful actions and programmes. Clearly, South Africa has what it takes to ensure successful adoption of resource-wise behaviours and implementation of climate smart solutions given adequate planning and cross-sector collaboration.

Significant research has been done on the potential climate change impacts and simulated scenarios for South Africa. The Council for Scientific and Industrial Research (CSIR) developed the Green Book, an 'online planning support tool that provides quantitative scientific evidence on the likely impacts that climate change and urbanisation will have on South Africa's cities and towns.' A major focus is to profile local community levels to predict vulnerability and potential adaptive solutions (GreenBook, 2019).

2.5. SDG 15: Life on Land

The Life on Land SDG is steered by several stakeholders including government departments (the Department of Agriculture, Land Reform and Rural Development as well as the Department of Environment, Forestry and Fisheries), private companies and non-governmental organisations (NGOs) focusing on environment and nature conservation. All involved stakeholders work independently towards achieving the goals of protecting, restoring and promoting sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation and biodiversity loss, as well as the NDP goals of environmental sustainability and resilience (Cumming et al., 2017).

Indicators include total land area percentage of natural ecosystem types, sustainable management, IUCN Red List Index, traded wildlife (poached and trafficked), environmental rehabilitation programmes (such as Working for Water) and official development assistance on conservation and sustainable use of biodiversity and ecosystems (Stats SA, 2017c).

South Africa (with an area of 1.22 million km²) is considered one of the most biodiverse countries in the world due to its species diversity and endemic fauna and flora, as well as its diversity of ecosystems (Ntshane and Gambiza, 2016). More than 8% of inland area and 5% of the country's waters fall within a protected area network (SANBI, 2019). In 2014, the protected areas network extended 143,336 km2 for inland terrestrial areas and 1,069,252 km2 for inshore and offshore marine areas. This includes 17 National Parks, 10 Trans frontier National Parks, 42 Marine Protected Areas and 16 Botanical Gardens (DEA, 2016).

According to the 2017 SDG Indicator Baseline Report, the percentage of terrestrial and freshwater ecosystems that were well protected in South Africa increased by 1% between 2010 and 2016. However, in terms of terrestrial ecosystems, natural forests occupy less than 1% of the total land area, whereas Albany thickets and savannas occupy approximately 28% of the total terrestrial land. As of 2016, South Africa had 35% of its natural forest biome, 13% of its savanna biome and 10% of its Albany thicket biome under protection. The percentage of mountain ecosystem types that are well-represented in protected areas increased by 1% (to 42%) between 2010 and 2016 (Stats SA, 2017c). Towards development assistance on conservation and

sustainable use of biodiversity and ecosystems, the government's financial investment increased from the 2013/14 financial year to 2014/15 and then dropped in 2015/16, where it amounted to approximately $88,000 (Stats SA, 2017c).

South Africa is currently working towards the implementation of the Protected Areas Expansion Strategy and promoting the Biodiversity Stewardship Programme to build conservation partnerships around privately owned land and introduce incentives to protect and rehabilitate ecosystems, such as tax rebates and reductions (Balfour et al., 2016).

In 2011, South Africa joined other nations in undertaking the UN's Advancing Natural Capital Accounting project. Key findings indicated nationwide deterioration of fresh water quality which informed the development of the government's National Water and Sanitation Master Plan. Thereafter, in 2018, the country joined the UN's Natural Capital Accounting and Valuation of Ecosystem Services project. Results are expected soon, which will inform environmental management decision-making (through statistical and institutional mechanisms) and help to advance theory and practice of ecosystem accounting (SANBI and Stats SA, 2018).

The country's rich biodiversity assets provide immense opportunities to support its development path, especially as the knowledge base of the value of ecosystems and management strategies effectively expand. The current focus on ecological infrastructure is aiding to unlock investment in South Africa's ecosystems, with multiple social, environmental and economic benefits (Anderson et al., 2017).

South Africa's biodiversity is under pressure due to extreme environmental pressures and loss and degradation of natural habitats, which include land conversion to intensive agriculture, mining and urban sprawl (Brownlie et al., 2017; Holmes et al., 2012). Therefore, a long-term plan to promote biodiversity and the conservation and rehabilitation of natural assets is critical, and should be complemented by a strategy for mitigating the environmental impact of all developments.

2.6. SDG 16: Peace, Justice and Strong Institutions

The Peace, Justice and Strong Institutions SDG aims to promote just, peaceful and inclusive societies. The South African government has clustered this goal into safe communities, a just society and effective governance. Sub-targets include reduction of violence, promotion of the rule of law to ensure equal access to justice for all, reduction of corruption and bribery, developing effective, accountable and transparent institutions and ensuring responsive, inclusive, participatory and representative decision-making at all levels (Stats SA, 2017c).

Important indicators include the murder rate, rate of robberies, rape and sexual assault statistics, safety rates, assault rates, bribery rates and proportion of positions (by age, sex, disabilities and population group) in public institutions (Stats SA, 2019b). Despite not explicitly mentioned in the SDG, South Africa makes use of specific indicators for gender-based violence (GBV). South Africa has one of the highest global rates of GBV (Cohen and Vecchiatto, 2019).

South Africa is struggling to maintain previous improvement in all three clusters. The national murder rate increased from 35.8 per 100,000 people in 2018 to 36.4 in 2019, while the rate of sexual offences increased from 88.3 per 100,000 people in 2018 to 90.9 in 2019 (SAPS, 2019). Moreover, 0.18% of individuals reported being asked for a bribe by a government official in 2017, while in 2018 this increased to 0.31%. Public polls support these statistics: in 2017, 39.4% of heads of households reported that they felt crime was increasing, while this figure rose to 42.1% in 2018 (Stats SA). One notable improvement, however, is the proportional representation of female, black and coloured judges in South Africa, all of which have been increasing since 2010 (Stats SA, 2019b).

Undoubtedly, the single largest challenge for this goal is corruption. The phenomenon of state capture is estimated to have cost South Africa a third of its GDP, or approximately $96 billion (Merten, 2019). This is almost as large as the 2019 National Budget. The direct financial impact of this has been detrimental to the safe communities cluster. It has inhibited increased expenditure on the police force and thus impedes its ability to discharge its duty of ensuring peace and safety. Compounding the challenge, there is a direct association between poverty and crime in South Africa (Cheteni et al., 2018), and state capture

has both directly and indirectly led to heightened levels of poverty. The Zondo Commission (or State Capture Inquiry) is currently underway, tasked with investigating state capture and recouping some of the stolen money. This is proving to be a complex and arduous task, with no known results at this time (Davis, 2020). Until April 2020, no person has been tried or convicted for state capture related crimes although some media reports that it may happen (Wiener, 2020). State capture is the most prominent example of corruption, though it is not the only instance. South Africa has very robust and effective anti-corruption legislation, though enforcement is insufficient and accountability is relatively low.

Regarding the just society cluster, South Africa's judiciary fares well. It has generally proven itself to be independent, free of state capture and corruption. Moreover, only 23% of South Africans responded with 'most of them' or 'all of them' when asked whether judges and magistrates are corrupt (Logan, 2017), which is down from 27% in 2013; 80% believe that court decisions are binding. Importantly, of individuals who had some form of contact with courts in the previous year, 77% found it 'easy' or 'very easy' to access the assistance they needed from the courts. This indicates that access to justice is healthy in South Africa.

Effective governance has been hampered by the erosion of government institutions, though has recently started improving. Since President Ramaphosa was elected, he has continued to work towards the strengthening of government institutions (Guest et al., 2019). The task is complex, though there has been notable improvement in, for example, the National Prosecuting Authority. NGOs in South Africa are relatively strong, particularly human rights and faith-based organisations, and have achieved success with increasing government accountability, as well as undertaking some of the roles which the eroded government institutions are unable to fulfil (Matthews, 2017). South Africa's constitution also enshrines a robust framework of human rights.

In April 2016, the Safety and Security White Paper was adopted to emphasise pre-emptive, rather than reactionary, safety interventions, outlining a strategy for addressing the causes of crime and the promotion of safety (Civilian Secretariat, 2016). However, in order to improve progress regarding this SDG, the government will have to work closer with NGOs and ombudsman agencies, to co-develop strategic guidelines and priority development areas.

3. Conclusions

The consideration given to each SDG in this paper shows widely varying achievements, addressment and existing challenges within South Africa. Through the country's efforts it is clear that widespread recognition is given to the environmental and social limits within which sustainable development has to happen. Recently, major actions have been taken by the South African government and the private sector, which show a willingness and commitment to the goals of the AU's Agenda and UN SDGs.

In attempting to address key knowledge gaps, the United Nations Development Programme (UNDP) in South Africa has partnered with the Department of Science and Innovation to launch an Accelerator Lab in South Africa in 2020 for research-based planning and cross-platform collaboration. Its goal is to implement programmes and projects and to invest funds into core developmental needs (UNDP, 2019).

To this Lab, we suggest the co-creation of normative and business-as-usual scenarios with the collaboration multiple key stakeholders. The normative scenarios ('the future we want') contrasted to a business-as-usual scenario would help to identify crucial pressure-points in decision-making towards a common goal. These narrative models are built by co-developing future scenarios with key stakeholders in the South African economy, which address challenges and solutions in every sector. This endeavour would enable the country to not be reactionary, but to be proactively precautionary and develop contingency plans, as well as to understand where synergies lie between government, public and private sector stakeholders. Thereafter, a broad review of current South African economic, social, agricultural and environmental policies should be undertaken in order to see whether it is in line with a projected future outlined by the normative scenario, thus ensuring appropriate implementation and removing adverse incentives.

The limited scope of this review did not consider other SDGs that impact the Goals focused on in this paper. A comprehensive review of every SDG is necessary to truly understand the full picture of the developmental needs and challenges South Africa faces, which we believe the Accelerator Lab is able to address.

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Assessing the Effects of Households' Lifestyle on Carbon Footprint in Ibadan Metropolis

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Abstract

Households' consumption patterns have been identified to contribute 75% of total global greenhouse gas emissions. Nigeria is recognised as one of the most vulnerable nations to the adverse effect of climate change. Under a business-as-usual growth scenario, consistent with strong economic growth of 5% per annum, Nigeria's emissions are expected to grow to around 900 million tonnes per year in 2030, which translates to around 3.4 tonnes per person. The objectives of the study are to profile the components of the lifestyle that describe household's carbon emission; estimate the carbon footprints of the components of households; and determine the factors that influence the carbon footprint in Ibadan, Nigeria.

A multistage sampling technique was conducted in the seven Local Government Areas.319 respondents were selected randomly from the clusters. A structured questionnaires and Key Informant interview were used to gather information from the study groups. The eligible participants are the household heads. Evidence of correlations between the components of the household profiles and carbon emission was measured using Analysis of variance. Stepwise linear regression model were used to further explore the predictors of carbon emission.

The study revealed that the respondents' mean family size was 4.85 and mean monthly income was N 90,075 ($250). Most household heads (70.2%) are civil servant with at least secondary education. Electricity remains the main source of lighting. Only 24.5% of the respondents complement their lighting with generators powered with fossil fuel and 1.5% complement their lighting with solar/inverter. Only 50.8% respondents commute to work with public transport, 20.1% by personal car; 38% by carpooling; 2.8% on foot; and 0.9% by motorcycle. Only 77.1% never travelled by air; 3.1% travelled 2-4 times per month by air; 2.5% travelled per month by air; and 17.4% travelled less than once per month by air. Income, place of residence, age, numbers of cars available for household use, distance travelled to work, family size, accommodation type and commute time to work are the key variables that show significant association with households' carbon footprint ($p < 0.05$).

The carbon emission in the study area is lower as compared to the level of carbon emission in other cities in the industrialized nations. However, the determinant factors influencing the contribution of carbon emission are mainly income, commute time, accommodation type and family size. This can serve as a policy guide for household carbon mitigation in Ibadan, Nigeria.

Keywords: Households' lifestyle, Carbon Footprint, Climate Change, Ibadan

1. Introduction

The contending issues of our time are eradicating poverty in all its forms and tackling climate change. The pattern of energy utilization in the Nigeria economy can be divided into industry, transport, agriculture and household consumption. Household consumption presently dominates energy use within the economy, accounting for about a total of 65% (Oyedepo, 2012). The United Nation Framework on Climate Change (UNFCC) aims to keep the warming below 2^oC while recognising the development right of the developing nations to eradicate extreme poverty.

Achieving the target of limiting climate change to well below 2^oC would require aggressive decarbonisation and limit on greenhouse gas emission produced by each countries. However, this can limit the options of poor countries towards achieving their energy sector growth and poverty reduction targets (Benthem, 2015; Steckel *et al.,* (2013). It goes without saying that energy plays a vital role in economic growth and development especially as it concerns poverty eradication and issues of national security. The standard of living of a given nation can be directly related to its per capita energy consumption. The per capital energy consumption is a measure of the per capita income and consequently a measure of the prosperity of a nation (Oyedepo, 2012).

Households directly or indirectly contribute to the rise of carbon emission from the consumption of various goods and services and therefore exert an important influence in the total greenhouse gas emission, however with making better choices, we can structure our daily lives in ways that enhance economic productivity and wellbeing while limiting emission.

Carbon footprint has become a widespread term now used across the society, media, cooperate organisations and governments. It refers to the total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life cycle of a product. This includes activities of individuals, populations, governments, companies, organizations, processes, industry sectors etc. Products include goods and services. There are other substances that contribute to greenhouse warming effect but with dearth of data it is difficult to quantify it (Wiedmann & Minx, 2007). However, for the case of this work, only carbon dioxide (CO_2) was considered.

Carbon footprint is useful in the management and evaluation of carbon emission mitigation. This is now gaining relevance at the household level due to the impact of lifestyle of citizen of a country on the emission of carbon dioxide and other GHGs which are responsible for the global warming. In a bit to mitigate climate change, individuals are taking responsibility to offset their carbon emissions such as tree planting, supporting forestation and renewable energy (Murry & Day, 2009). In order to manage the GHG emission effectively, Pandey & Agrawal, (2011) proposed that: the quantity of emission is determined; the major sources are identified; and the areas of emission reductions and increased efficiencies are prioritized.

Africa's response to climate change is tilted towards adaptation than mitigation. This may be to the fact that the countries contribute little to the global GHG and policies specifically addressing carbon mitigation are not available (Eluwa & Siong, 2014). Households have been identified as one of the major contributors of greenhouse gas with significant impact on the environment. Zhang & Wang (2017) considered the relevance of energy policy in carbon emission reduction. They reviewed the policies of 144 countries based on the demand-side and supply-side and found that income, location and social equity affected choice of policy on carbon emission mitigation. They recommended that government should not only set carbon target but also provide incentives for the reduction of carbon emission. Tukker et al. (2010) analysed the potential for carbon footprint mitigation through behavioural change and innovation strategies. They noted that incentives, awareness campaign, provision of high quality and convenient alternatives can provide a shift towards a low carbon lifestyle. Gilg *et al.,* (2005) examined green consumption versus a sustainable lifestyle around the home. The results show that different demographic groups with different behavioural qualities and attitudes. Hence, there was need for policy makers to make policies to target specific age groups towards a sustainable lifestyle.

Haines *et al.,* (2009) assessed the health implication of policies targeted at tackling Climate Change. They examined mitigation strategies in four domain namely: household energy, transportation, food and Agriculture, electricity generation. They found that there was need for policies toward GHG abatement to be cost effective and socially friendly. Likewise there will be need for policy implementation, development and technology improvement especially in the developing nations. Also, Herrmann *et al.,* (2017) considered measures to reduce GHG and the health co-benefit such as walking, cycling, eating less meat etc. in urban households in part of Europe using a mixed-method approach (simulation and qualitative in-depth interviews).

Gill & Moeller (2018) considered the households in Germany vis-à-vis their income and expenditure pattern in the reduction of their carbon footprint. Their investigation revealed that density effect of cities saves some GHG compared to sparse households, with higher incomes and greater consumption opportunities. Hussein *et al.,* (2013) assessed the impact of climate mitigation policies required to limit GHG emission. They observed that the mitigation policies affected the welfare of the poor in developing nations since the majority of the households relied primarily on their own labour for income and owned small size farmland. They concluded that the only promising option is to avoid deforestation- which aid forest carbon sequestration. Mills & Jacobson (2011) investigated the improvement of lighting service in the developing nation for GHG mitigation.

This study examined the components of households' lifestyle that describe the carbon emission in the study area, estimated the size of the carbon footprint in the study area and identified the factors that contributed significantly to the carbon footprint in the study area. The profile of the households served as the sources of data gathered, using a semi structured questionnaire and analysed by a carbon footprint calculator and regression model. The findings revealed the components of households' lifestyle that characterized the carbon emission in the study area.

2. Materials and Methods

The study was conducted in Ibadan, the capital of Oyo State. Ibadan is a city located between longitude 70 20" and 70 40" East of the Greenwich meridian and between latitude 30 55" and 4010" North of the equator. The city is in the equatorial rain forest belt and has a land area of between 445km^2 and 455km^2 with an estimated population of 3,070,000 (Demograhia World Urban Area, 2018). It is composed of eleven Local government areas, six at the outskirts (peri-urban) and five at the centre (urban). The latter are: Ibadan South East, Ibadan North East, Ibadan North West, Ibadan South West, Ibadan North Local Government Areas while the formal are: Akinyele, Egbeda, Ido, Ona Ara, Lagelu, Oluyole Local Government Areas. Ibadan metropolis is an important commercial centre and it comprises of people of different cultural and socio-economic backgrounds. However, the predominant ethnic group in the city is Yoruba. The main economic activities engaged in by the dwellers include Agriculture, trade, Civil service employment and others.

This was a household-based cross-sectional study. The study used a multistage sampling technique in selecting the representative households. The first stage involved the selection of work places within the local governments' areas. In the second stage, a simple random sampling was employed to select the respondents. 25 households were randomly selected from each cluster.

Household profiles were presented with appropriate Charts and Tables. Continuous variables were presented as means and standard deviations while categorical variables were expressed as percentages. Households' carbon footprints calculated from the direct energy consumptions (electricity and transportation) are the main outcome (dependent) variables while the households' socioeconomic and related factors were the independent variables. A multiple linear regression analysis was used to determine the independent predictors of carbon footprint in this study. The 95 per cent confident interval (CI) for these predictors was calculated. The level of significance was set at p-value of 0.05.

2.1 Analytical Tools and Tools

The greenhouse gas emission model for developing nations proposed by the Energy Research Centre, South Africa was adopted. All the unit costs are expressed in Naira (N) equivalent

I. Emission from electricity consumption (means)

$$GHGem = \frac{12\text{-month} \times \text{Cost/month} \times \text{Emission factor/tariff}}{\text{Number of household occupancy}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

$$= \frac{12 \times N/\text{month} \times \text{kWh}/ N \times \text{ton } CO_{2e} / \text{kWh}}{\text{Number of household occupancy}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

II. Emission from transportation

For a private car, using average volume of fuel per month.

$$GHGem = \frac{12\text{-month} \times \text{Litre / month} \times \text{Emission factor}}{\text{Average occupancy of vehicle}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

$$= \frac{12\text{- month} \times N/\text{month} \times L / N \times \text{ton } CO_{2e} / L}{\text{Average occupancy of vehicle}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

For public transportation

$$GHGem = \frac{12\text{-month} \times \text{distance / month} \times \text{Emission factor/distance}}{\text{Average occupancy}} \quad \ldots\ldots\ldots\ldots\ldots\ldots 5$$

$$GHGem = \frac{12\text{-month} \times \text{km /month} \times \text{ton CO2e / km}}{\text{Average occupancy}} \quad \ldots\ldots\ldots\ldots\ldots\ldots 6$$

Where

Petrol emission factor = 0.43963132Kg CO_{2e} /Kwh

3. Results and Discussion

Socio-demographic Characteristics of the Respondents

In all, a total of 319 respondents were used. Table 1 presents the socioeconomic characteristics of the households. The mean age of the respondents was 40.49 with a range of 21 to 73 years. The modal age of the respondents was 40-49 (n=102, 32 %) and followed by 31-34 (n=100, 31.4 %). This revealed that most of the household stakeholders were in their active stage. One hundred and seventy eight respondents (55.8 %) lived in rented apartment while 44.2 % owned their houses. The type of houses they occupied mostly is block of flats (n=149, 46.7 %), while the least was duplex (n = 7, 2.2%) and the period that most householders had resided in the area was between 1-3 years. This suggest that many people are moving away from the metropolitan centre to the peri-urban area where it is believed that the cost of living is cheaper such as cheaper house rent or owning a personal house compared to the urban area.

The occupation of the most respondents within the study area are civil service and this still remains the occupation of the highest income earners in the households (n= 187, 58 %). This implies that they were educated with at least secondary education. Their mean monthly income was N90075 ($250), median income is N65000 ($180.55) and modal income is N50000 ($138.9). The income level revealed that most of the respondents were in the lower middle class as recently released by the World Bank (Sarosh S. 2018). The new standards are set as $3.20 per day for the lower middle class and $5.50 per day for the higher middle class. The new classification means that the poverty line for Nigeria is living on less than $3.2 per day. This shows that 90 % of Nigerians are living below the poverty line. The predominant lower middle income group can be said to be vulnerable because they share the same borderline with the poor and also share similar characteristics with them. The implication is that any slightest shock brought about by climate change could easily force them down to poverty line and then back to poverty. (See Table 1)

Table 1 Socio-demographic Characteristics of the Respondents

Variable	Category	Frequency (%) SD	Mean
Age (in years)	20-29	45(14.1)	
	30-39	100 (31.4)	
	40-49	102 (32.0)	41.18
	50-59	4.83	
	60 and above	61 (19.1)	
		11 (3.4)	
Gender	Male	170 (53.3)	
	Female	149 (46.7)	
Time lived in area (in years)	Less than 1	22 (6.9)	
	Between 1-3	109 (34.2)	
	Between 4 - 6	63 (19.7)	4.83
	Between 7- 10	1.7	
	Above 10	54 (16.9)	
		71 (22.3)	
Types of accommodation	Duplex	7 (2.2)	
	Boyz quarter	59 (18.5)	
	Flat	149 (46.7)	
	Bungalow	45 (14.7)	
	Tenement building	59 (18.5)	
Home ownership	Rented	178 (55.8)	
	Owned	141 (44.2)	
Occupation of largest households' income earner	Civil Servants	187 (58)	
	Artisans	11 (3.4)	
	Traders	35 (11.0)	
	SMEs	23 (7.2)	
	Retirees	3 (0.9)	
	Others	60 (18.8)	
Occupation of respondent	Civil servants	224(70.2)	
	Artisans	4(1.3)	
	Traders	32(10)	
	SMEs	15(4.7)	
	Retirees	3(0.9)	
	Others	41(12.9)	

Source: Author's Computation from the Field Survey (2018)

Households Energy Sources

Electricity remains the main sources of household lighting of the households (91.5 %) as shown in Table 2. Twenty four per cent (24%) of the respondents use generator either as main or complementary source of lighting while only five per cent (5%) households made use of clean

sources of energy such as solar panels and inverters as complementary to electricity supply from the national grid. As the electricity supply from the national grid continues to dwindle, the people continue to provide alternative sources of electricity in order to meet their energy demand at home. The complementary sources that are affordable by most householders such as generators are run on fossil fuels and only few people can afford the cost of procuring an inverter or solar panel. Likewise, as the population increases, people continue to move to new sites where they are not connected to the national grid and many householders run on generator that make use of fossil fuel, which leads to carbon emission. (See Table 2)

Table 2 Sources of lightening of the Respondents

Variables	Categories	Frequency (%)
Electricity (National grid)	Yes	91.5
Generator	Yes	24.5
Inverter/Solar	Yes	1.5

Source: Author's Computation from the Field Survey

Households Mode of Commuting to Workplace

Most of the respondents, 50.8 %, commute to work with public transport, 20.1 % commute to work in their personal cars, 11.9 % commute to work by carpool and 0.9% on their personal motorbike as shown in table 3. The reasons why most of the householders make use of the public transport were because they do not own a car and this can be attributed to the fact that they earn less income. Most respondents (77.1 %) have never travel by air or have not travel by air within the year. Only 3.1 % of the respondents travelled frequently in aircraft as shown in fig 1. Most of the air travellers did so by the reason of official engagement. This shows that household members in Ibadan contribute less carbon emission due to air travel. This is evidence that the prevalent mode of travel by households in the city is by road (see Table 3).

Table 3 Mode of commuting to workplace by Respondents

Mode of Transportation	Transportation means/frequency	Percentage (%)
	Work mainly at home	13.5
	On foot/ Bicycle	2.8
	Motorcycle	0.9
Road	Public transportation	50.9

	Car Personal	20.1
	Car pool	11.9
	None	77.1
	Less than once per month	17.4
Air	Once per month	2.5%
	2-4 times per month	3.1%

Source: Author's Computation from the Field Survey (2018)

Estimation of Ibadan Metropolis Carbon Footprint

The estimated mean carbon dioxide emission of the respondents due to direct electricity consumption in this study was calculated to be 132.21 kg CO_2e per person per year while the estimated mean car carbon emission obtained was 118.75 kg CO_2e per person per year. Hence the total mean carbon emission was 250.96kg CO_2e per person per year. The carbon emission of households due to electricity was higher than the carbon emission generated by car mobility. This shows the level at which households consume the available electricity supplied. This study revealed that public transportation and carpooling help in the reduction of carbon footprint and this agrees with the studies conducted by (Bhoyar et al. 2014; Druckman & Jackson, 2009; Markaki et al. 2017; Vavra 2013). This should be a motivation for government and policy makers to entrench a better public transport services as a mitigation strategy for carbon emission at both the state and national level (see Table 4).

Table 4 Estimated Carbon Footprint of Respondents in the Study Area

Category	Minimum Carbon Emission	Maximum Carbon Emission($KgCO_{2e}$)	Mean Carbon Emission ($kgCO_{2e}$)	Standard Deviation
Mobility	0.0	763.64	118.75	150.32
Direct Energy (Lighting)	0.0	1207.29	132.21	132.65
Total	0.0	1970.93	250.96	

Source: Author's Computation from the Field Survey

Using the stepwise linear regression on the factors associated with carbon emissions due to mobility, the results in Table 5 shows that there is a significant association between the two predictors (time to commute to work and household income) and the carbon emissions. The model was able to explain 35.7 % of the total variables in the carbon emission using two predictors. The association is revealed as follows: Time to commute work (β= 0.304, p= 0.000)

and (β= 0.146, p= 0.006). Relatively, the association between the carbon emission and time to commute to work almost triple the strength of the household income variable ((β= 0.304 and β= 0.146).

Table 5: Stepwise linear regression of carbon emission (due to mobility) against Respondents' lifestyle Profile

Step	Variables	Beta	t-value	R	p-value	Decision
1	Time to work	0.304	6.138	0.326	0.000	Significant
2	Average income	0.146	2.751	0.357	0.006	Significant

N = 319 $p < 0.05$
Source: Author's Computation from the Field Survey (2018)

The time the respondents took to commute to and from work is statistically significant. The regression is linear and the association between the carbon emission and time spent to commute to work is very strong. For an additional household who commutes to work, there is an increase of 32.6 % carbon emission. Most households commute to work using vehicles driven by fossil fuel and largely these cars used for commercial transport services are old and poorly maintain. This has a negative environmental impact as a result of increasing release of carbon emissions from their exhaust. This study support the research carried out by (Agarana & Bishop, 2017; Godson et al., 2015). The poor infrastructural development of the system in which the life of the households are embedded, is a major contributing factor to carbon emission. The roads connecting the peri-urban and the metropolitan centre, where most of the business activities are located are in very bad conditions and these are common features in the developing nations. Within the urban centres, the roads tend to be better but they are narrow thereby leading to traffic congestion. A serious drive towards infrastructural development and provision of good road network in Ibadan can help reduce the time commuters spend on the road to get to their work places and to return back to their houses, as this can mitigate against carbon emission.

Income also has a strong link with carbon contribution and the relationship is linear. It is evident that as the income of the household increases, there is desire for the stakeholder in the house to want to own a personal car as a means of commuting to work. This is seen in most cases as a show of status and also individual perceives it to be faster. This calls for the attention of government to improve and provide a decent public transport services within the state as incentive for private car owners. Other modern transport facilities can be provided such as intra city trains thereby reducing the carbon footprint per person. (See Table 5)

Stepwise linear regression of carbon emission (due to electricity consumption) against Respondents' lifestyle Profile

The result of the fitted stepwise linear regression model using the estimated quantity of carbon emissions due to electricity consumption in the residence as the dependent variable and the households' profile as the independent variables appear in Table 6. The beta values from the model as indicated in the table revealed the strength of the statistical association between the variables. The relative strength of each of the predictors was directly compared. The beta values with negative signs indicated an opposite relationship between the three predictors (independent variables) and as their values move away from zero, the strength of the relationship improved. Also, the t-test values and their significant are revealed to show the level of potency of each variable in the fitted model. The stepwise linear regression results indicated that three of the socioeconomic variables (family size, income and accommodation type) are significantly associated with carbon emission due to electricity consumption at the household level. The fitted regression model was able to explain 48.1 % of the association of the three independent variables and the carbon emission. The association between the carbon emission and family size (β= -0.357, p= 0.000) ranked highest. Household income (β= 0.341, p= 0.000) and accommodation type (β= -0.113, p= 0.025) followed respectively. (See Table 6)

Table 6: Stepwise linear regression of carbon emission (due to electricity consumption) against Respondents' lifestyle Profile

Step	Variables	Beta	t-value	R	p-value	Decision
1	Family size	-.357	-6.048	0.322	0.000	Significant
2	Household income	.341	6.833	0.468	0.000	Significant
3	Accommodation type	-.113	-2.256	0.481	0.025	Significant

Source: Author's Computation from the Field Survey (2018)
P < 0.005 N= 319

The findings in the study areas, confirmed that household size, income and housing type were factors that contributed significantly to carbon emission resulting from the use of electricity in homes. The regression shows that household size had a statistically negative impact on the household carbon footprint. This implies that carbon emission level is a decreasing function of

the family size and assuming all other socioeconomic factors are kept constant, increase in one person in a house will cause 35.7 % decrease in the household. There exists a reduction in the households' carbon footprint as household members tend to share appliance within the house. Households with large family size benefit from economic of scale (Ala-mantila et al., 2014; Gill & Moeller, 2018; Tukker et al., 2010; Wiedenhofer et al., 2018) .

Also, there was a linear relationship between income and direct carbon emission. The relationship is statistically highly significant. For every increase in naira, there is a corresponding addition of carbon emission (34.1%), this is similar with the findings of (Seriño, 2017; Vavra, 2013). The reason is that households with higher income tend to have more disposable income and adopting a carbon intensive lifestyle. The implication is that as the household affluence increases, there will be increase in negative environmental impact due to over consumption of materials. The result also shows that the kind of accommodation occupied by households is statistically significant. The relationship revealed a nonlinear model. The type of house owned or rented in the study area was observed to be closely related to the size of the family. The mean and modal household size was 4.85 and 5 respectively. This may necessitate why most people owned or rented a block of flat with three rooms. Also most urban dwellers with higher income tend to attract relatives from poorer homes. The household members share resources together, limiting carbon emission. (See Table 6)

5.0 Conclusion

This research assessed the effects of household lifestyles to on carbon footprint in Ibadan Metropolis, Nigeria. It profiled the components of the lifestyle that described household's carbon emission; it estimated the carbon footprints of the components of households; determined the factors that influence the carbon footprint; and whether there is a significant relationship between the components of the households and the carbon footprint. Structured questionnaires, Key Informant Interview and the Carbon footprint calculator were employed to determine components that influenced the variation of carbon footprint in Ibadan metropolis.

The profile of household components was matched to households' consumption to obtain household carbon emission. The estimation of carbon emission revealed that households mean emission in Ibadan, Nigeria was 250.96 CO_2e kg/person/annum. When disaggregated by major consumption categories, results showed that direct energy utilization was relatively higher than

mobility. Income, family size, accommodation type and commute time to work are the key variables that explained the relative contribution of carbon emission to households' carbon footprint. The household carbon footprint in Ibadan is not worrisome and does not pose a serious threat as compared to the level of emission in industrialized nations. However, it is essential to investigate this issue because as population increases and incomes improve, households tend to increase their carbon footprint.

The results have shown, with empirical evidence that households income, households size, accommodation type and mobility appear to be the key quantitative factors that influence household carbon footprint in Ibadan metropolis. The carbon footprint of Ibadan was estimated to be minimal compared with some other metropolitan centres around the globe. However, if the current carbon emission at the household level is not controlled, the potential ecological disasters associated with climate change may sabotage the sustainable development mission of the state and the nation at large. Household consumption is a matter of private choice however, alternative options that are capable of reducing household carbon emissions should be considered.

Most households depend on fossil fuels (generator) as a sure means of energy supply. Therefore it is imperative for policy makers to look into clean and efficient lighting technologies such as energy saving bulbs as a feasible approach in limiting household emissions. This should be provided at a subsidized cost. As new residential sites continue to open up, the government might consider advocating off-grid solutions for households in these areas. Also, there should be National intensive campaigns on energy conservation at the households' level. The commute time to work is higher as revealed in the study. This is attributed to the fact that there are deficiencies in the infrastructural development in the state such as poor road networks and bad roads connecting to the metropolis from the peri-urban areas. This increases fuel consumption of vehicles, thus resulting to higher volumes of carbon emitted. The government should not treat this with kid gloves but earnestly drive towards rehabilitating and constructing these roads. This will not only reduce the carbon footprint of the state but also improve commerce, which will in-turn lead to rising incomes hence reducing the level of vulnerability among citizens. Also, government or corporate organizations could leverage on the current situation that majority of the household dwellers in the study area commute by commercial vehicles. They should consider providing efficient and decent urban transit buses and light rail, this will significantly reduce carbon emissions in Ibadan.

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Posters

Assessing Water Sustainability in Cyprus

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Abstract
The complexity for a sustainable, adequate supply of water in Cyprus, while ensuring the enhancement and protection of quality and quantity of aquatic ecosystems, continued to raise concerns in Europe and around the globe. This research's purpose was to find out which solutions are the best practices for sustainable water resource management. Overconsumption of water resources can have dramatic impacts on ecosystems. Cyprus has a semi-arid climate which means that conventional water supply is limited by several factors, and water overconsumption is an additional stressor to the environment. Environmental scientists have been proposing that sustainable management of water use can be achieved through the protection and preservation of aquatic ecosystems, by climate change, and behavioural adaptation and pollution reduction. A water balance for Cyprus was set up. The politically unstable situation due to national jurisdiction causes problems regarding contradictory data because different land areas were included in different data sets. To meet the demand groundwater abstraction was the easy solution since groundwater aquifer supply surpassed the availability of all other sources. Treated water supply in irrigation increased as the available treated water increased throughout the years. The domestic sector was supplied with desalinated water during dry periods because surface water was not enough to meet the demand. Regarding the possible future development for water supply in Cyprus three scenarios were produced. To reduce the water from evapotranspiration so that more water remains in storages, the first scenario focused on climate change adaptation. The outcome from the second scenario which focused on the demand of water in the four sectors was that by including the consumption of the northern area of Cyprus total demand increased and by reducing overconsumption total demand decreased. The sector with the highest water demand was in agriculture. The focus of the third scenario was on water availability from different sources. The most viable solution that follows the sustainable abstraction levels was the combination of all sources.

Keywords: hydrological balance, hidden water, sustainable development

1. Introduction

Water is essential in conserving stability and structure of species diversity and ecosystems'. The uncontrollable use of water can lead societies to conflict and collapse since without water it is impossible for living organisms to survive. In this investigation, 1) Cyprus water balance is assessed and 2) three scenarios are produced to show what-if climate change adaptation, water demand in sectors and available water supply from different sources could change. Cyprus is chosen for this assessment as a continuation of a previous study on the problems arising from national statistics of hydrological research. The scope of the research was initially chosen because of the ability of the authors to explain such a complex system, and the implications arising from water overconsumption. How does the water supply meet the water demand and what could be done to be considered sustainable? Sustainable water is defined as a nation that can self-supply adequate water for multiple human needs without hindering the health of the ecosystem and its ability to maintain further sustenance of the water cycle for future generations. Correct quantification and management of the available water resources are relevant for the sustenance of society's valuable resource and the proper decision of policy makers. Concentrating more on the four R's and the protection and preservation of water bodies the consumption of water resources can be more sustainable. Water resources benefit the society and their overconsumption can result in the tragedy of the commons, this is a major concern and why further knowledge on this matter is required.

2. Method

The data used for the assessment of Cyprus water balance are according to the national water agency; the Water Development Department's (WDD) annual water resource study of 2018 and the average levels of the water balance for the years 2010-

2017 found in WDD website (WDD, 2017). The unit used for the water balance is cubic kilometers (km^3). Primary data collection has been conducted by experts using telemeters from the main water bodies of the river basin (under governmental control). The department extrapolated the findings to estimate missing data from water bodies where no telemetry exists. The national statistics exclude the northern area of Cyprus due to political complexity. "Sankeymatic"[1] was used to create the Sankey diagram (see Figure 1) based on the latest data of the Food and Agriculture Organisation of the United Nations, AQUASTAT to compare and show the implications of different statistical sources (FAO, 2016). In addition, the confusion created due to the semantic choices of different statistics is shown in the Sankey diagram.

The annual water balance study and the literature review of hydrological studies assisted in finding key solutions used for the representation of sustainable water management scenarios (Miller, 2007; WDD,2017). The relevant technologies used and the department's technical, socio-economical, legal and environmental aspects are retrieved from the annual water report (WDD, 2018).

Scenario modelling is used to represent the outlined pathways for adaptation and future water management. The scenarios are based on water balance statistics, northern studies and UN population estimates (WDD, 2017; Elkiran & Ergil 2006; Elkiran et. al., 2019; UN, 2020). Scenarios allow for hypothetical assumptions formulated by what-if questions to show how the changes, in reality, could affect the water sector. To represent the basic scenarios in tables 2, 3 and 4 data from the Water Development Department's statistics of 2017 were used.

Table 2 and 4 is solely based on the eastern area of Cyprus and excludes the northern area. In table 2 precipitation is kept constant to give emphasis on evapotranspiration, infiltration and surface runoff changes that could be achieved under climate change adaptation measures. Distribution losses are kept constant assuming that some progress would be made to reduce the losses from the Water Development Department's facilities to customers. In scenario 1 evapotranspiration is reduced by half (from 1.82 km^3 to 0.92 km^3), so that surface storage capacity would be filled and groundwater would increase compared to the basic scenario. The same is assumed for groundwater storage in scenario 2. In scenario 2 evapotranspiration is reduced by three times (from 1.82 km^3 to 0.61 km^3) so that surface storage capacity would overfill and water would flow in river beds. We assume that increased surface water will decrease soil salinity, and desertification risks and the regional climate will change.

Table 3 is a representation of the water demand of the four sectors that use water. In scenario 1 a reduction in agricultural demand by 0.060 km^3 and 0.021 km^3 in the domestic sector is assumed to show a possible reduction from most consuming sectors compared to the basic scenario. This reduction could be achieved assuming the reduction of losses from old pipes, the changing of water consuming crops, irrigation methods, switching to compost toilets and reducing water consumption in tourism. The industrial and environmental sector in scenario 1 is kept constant assuming that no reductions could be done. Scenario 2 includes the whole area of Cyprus by using aggregates of the estimated demand in agriculture of 2017 for the eastern area and estimates from the northern area of 2012 from WDD, 2018 and Elkiran et. al., 2019 respectively. The domestic demand is calculated by using the total population for the island estimated by the UN for 2020 and the water use per capita as estimated by Georgiou & Dörflinger (2002) multiplied by 365 days. The domestic sector includes tourism so the estimated demand of tourism from both areas is added to the per capita estimations (WDD, 2017; Elkiran et. al., 2019). The estimated demand for public buildings such as municipalities, schools, similar buildings and private business are not included in the calculations of the domestic sector. There are no estimates for the environmental and industrial sectors in the northern area so we assume that demand for those sectors is doubled compared to the basic scenario.

Table 4 is done to suggest what-if water availability from different sources changed to apply to sustainable abstraction and use of water from different sources. In the basic scenario, water is produced from unconventional resources and is driven by fossil fuel energy, whereas in scenarios 1 and 2 we assume that production from unconventional resources is produced by using

[1] SankeyMATIC. Sankey diagrams, online webpage. http://sankeymatic.com/

renewable energy sources. The renewable energy sources are required so that water production would be sustainable. In scenarios 1 and 2 surface water available is found in dams which have an overall capacity of 0.330 km^3 and we assume that if the climate change adaptation measures are taken they would be filled up. In scenario 1 water available is only from surface water and treated sources. This means that desalinated water and groundwater would not be required so availability from those sources is zero. In addition, no more dam construction will be made to increase surface water capacity. By not abstracting water from groundwater sources we assume that groundwater aquifers would stabilise their water quantities and improve their quality. The recycled water available is estimated by multiplying the basic scenario's treated water by 3 times, that would mean that it could potentially cover all water demand (and even more) of the domestic sector as seen in the basic scenario in table 3. Assuming that is necessary to comply with the European regulations of water treatment so that it can be used further. Assuming that the water demand is the total value assigned is the basic scenario in table 3, water remaining in surface water dams will be 0.015 km^3. Although since it is unsure if that would be enough in quantity for the dams to maintain healthy quality of water levels we suggest scenario 2 as a more efficient solution. In scenario 2 surface water sources are equal to scenario 1. The difference is in the maximum amount of sustainable water level abstracted from groundwater made available to decrease the abstraction of surface water and protect the dams' water levels and quality. The amount of treated water is subtracted by the total amount of water available which is an assumption.

3. Management actions to reduce water use

This section describes the key solutions for sustainable water management actions retrieved from the Water Development Department (WDD 2018) and Miller (2007) to outline the pathways for adaptation and future water management actions. Three main paths have been identified in hydrological studies that can result in sustainable methods for supporting the water balance of a water-scarce region like Cyprus. The three paths are discussed further on and are i) the protection and prevention of ecosystems from pollutants, ii) climate change adaptation measures and iii) behavioural adaptation.

i) Protecting and preventing the ecosystem from pollution can have positive results. Pollution in ecosystems acts as a pressure on living organisms' health, on the ecosystem by reducing its capacity to remediate pollutants and on the overall quality of living. Food yield decreases when the environment is destructed by pressures. Examples of pollutants are point, nonpoint pollutants, solid wastes due to human activities and by-products sometimes carried by floods, wind and rain or flushed in drains leading to water bodies. More specifically phosphates and nitrates in fertilisers, pesticides, harmful chemicals, microplastics and gaseous pollutants in high levels pose a threat on the ecosystem and its habitats. Pressures on the economic sphere arise due to the reduction of resources because of pollution. According to certain international agreements, Cyprus and European countries are being fined for the excess levels of pollution emitted, this results in the waste of economic resources which could be used otherwise.

ii) Climate change adaptation captures broadly several measures that are taken into consideration by each nation. Specifically, in the water sector, climate change adaptation is directed in decreasing evaporation and increasing water capture via environmentally friendly methods such as forest restoration, watershed protection, and decreasing chances of abrupt weather events like floods. Besides, sea-level rise measures like the protection of coastal infrastructure, private property and the environment along with the decrease in temperatures by reforestation and reduction of CO2 equivalents (especially in the energy and transport sector) are suggested by the scientific community and national advisors to combat climate change impacts. Reforestation assists additionally in flooding, landslide erosion and pollution runoff. Drought and desertification measures for the protection of crops, soil dampness, the decrease in evaporation, and erosion are included in the climate change adaptation framework. If temperature levels are decreased, evaporation levels and electricity demand decreases, crops can be protected. The snow cover period will then increase so that it can assist in saving water in the form of snow during winter that will later melt. Part of the snow will infiltrate underground into groundwater aquifers. Water saved in the form of snow becomes an

additional volume in the water balance and can theoretically reduce infrastructure costs of storage units and water production units.

iii) Behavioural adaptation can accommodate measures for securing quality and quantity of water resources. Human behaviour can be adapted by following the four 'R' which are to a) refuse, b) reduce, c) recycle and d) reuse water resources. The different sectors can apply the four 'R' when possible.

a) For instance, farmers could refuse water-intensive crops, the use of pesticides and fertilisers, the irrigation during high evaporation hours, fossil fuel generators and groundwater use. The domestic sector including tourism could refuse the use of water-based toilets, the frequent washing of linen and towels, flashing medicines or other harmful chemicals in toilets and drains, and more. The industrial sector could refuse the use of harmful chemicals so that water can be reused. The behavioural adaptation of refusal could reduce the point and nonpoint pollutants from different activities, salinization, nutrient loss, eutrophication, allow recovery of aquifers and protect water resources.
b) Reduction of water use could be applied in agriculture by upgrading to efficient irrigation systems, irrigating during low evaporation hours, changing rusty or broken pipes, vegetating the area to decrease evaporation from the soil, use water resistance and native species of crops. Also farmers could create buffer strips to protect the water bodies from any potential run-off, reduce nutrient loss, grazing and tilting can reduce erosion, and increase soil humidity. The domestic sector could reduce water use by having shorter showers instead of long baths, use compost toilets, follow the agricultural sector's methods, and reduce groundwater abstraction. The industrial sector could reduce the pollutants entering sewage waters for easier water treatment, the quantities of water used, and the reduction of harmful by-products in the life cycle of a product or service.
c) Recycling of water resources in the agricultural sector from treatment plants, sludge, manure from livestock, compost from housing for fertilisers and vegetation byproducts for soil production could be good practices for increasing resource supply. The domestic sector could use the practices suggested in the agricultural sector for irrigation and outdoor cleaning activities. Moreover, the recycling of solid wastes could help in the reduction of pollution. The industrial sector could use recycled water to increase water supply and reduce resource demand and pollution. Recycled water could be used in the environment to restore soil quality, and increase water quantities in water bodies.
d) Reuse of recycled water in all sectors could increase water supply and reduce the need for abstracting groundwater. The reduction of groundwater abstraction would allow aquifers to recover and decrease salinisation risks. The reuse of water could reduce the need for desalination water considering that the previous 'R' are implemented. The costs of water production from desalination plants could, therefore, be reduced. Furthermore, nutrients found in treated water will be upcycled by farmers reducing the resources needed for making new ones.

4. Results

This chapter includes section 4.a with the presentation of Cyprus water balance and its main flows, the estimates of water demand, the water produced from unconventional sources and the storage capacity of surface water. Through the water balance, the technologies used for supplying water are revealed. Section 4.b presents the three main scenarios based on management actions.

a. Water balance

In this section the water balance of Cyprus for years 2010-2017 is presented, the unit used is cubic kilometers (km^3).

Precipitation average for the eight-year period was estimated at 2.78 km^3 with the highest precipitation period in 2012 and the lowest in 2013. Precipitation levels increased by almost an estimation of 1.13 km^3 in 2015 and dropped to similar levels of 2013 in 2017. The variation in precipitation is not constant over the years and even if the trend represents a decrease in

precipitation we can not say that this will be the case for the following years. In 2017, the estimated precipitation levels amounted for 1.96 km^3 .

The estimated levels of available water quantity are related to the levels of precipitation. The available water increases during high precipitation levels (2012) and decreases during low precipitation levels (2013 and 2017). The average available water for the eight-year period (2010-2017) was estimated at 0.215 km^3. In 2017, available water quantities amounted for an estimate of 0.136 km^3.

Since evapotranspiration quantities are not shown in the water balance we calculated the evapotranspiration average for the eight-year period (2010-2017) to be 92% (WDD, 2017). The Water Development Department (WDD) notes that around 90% is "lost'' due to evapotranspiration and 0.02% is "lost" during runoff which ends up in the sea. It is not clear through the WDD water balance if distribution losses through pipelines are included in this estimate.

The water demand as estimated by the Water Development Department (WDD) increases every year during the eight-year period. The water demand estimates showed an increase of almost 0.4% each year. Water demand estimations are heavily based on the water needed for the area, and crop types for irrigation purposes in agriculture, green areas, the domestic water use estimated that includes tourism needs, industrial water use and environmental purposes. Although the domestic water demand was not coupled with the population and the per capita use of water throughout the years. In 2017, water demand estimates amounted for 0.264 km^3. Furthermore, water from rainfall alone was only adequate to cover water demand in 2011 and 2012, whereas the rest of the years demand exceeded water availability from rainfall. The least water available year was 2013 (dry year) where demand was estimated to be 0.143 km^3 higher than the available water from precipitation. Even with the additional water from non-conventional methods the water availability for years 2013, 2014 and 2017 was not adequate to cover the demand. That meant that decision-makers had to reduce the water supply for agriculture and the rest sectors.

To cover water demand the Water Development Department (WDD) introduces water from non-conventional methods such as desalination plants for domestic use and recycled water from tertiary treatment plants for irrigation use. Water from desalination plants complements the water needed for potable use and in rare occasions water for irrigation. Thus water produced in desalination plants is correlated with the lack of adequate water from precipitation. Other than that, the agreements made with desalination plants are required to produce a minimum amount so that the infrastructure costs are depreciated within the agreement period. The average desalinated water produced during the eight-year period (2010-2017) was 0.042 km^3. During 2012 and 2013 with minimum levels of production of 0.018 km^3 and 0.011 km^3 respectively. In 2017, desalinated water production was equal to the production of 2016 amounted to 0.069 km^3.

The average water produced in tertiary treatment plants for the eight-year period was 0.016 km^3. There was an increase in treated water throughout the years from 0.012 km^3 in 2010 to 0.020 km^3 in 2017. Although not all treated water has been used because of the lack of infrastructure to store recycled water and the unpopularity for its use from farmers. Recycled water has not only been used for irrigation purposes but was also used for the enrichment of aquifers and river beds by the Water Development Department (WDD) and in some cases, it was discharged into the sea because of the lack of storage facilities.

The total capacity of dams has been increasing throughout the years. In 2017, the total capacity of dams was at 0.332 km^3 of water. Two new dams will be built for the supply of areas where water availability is low, transferred water is used to meet the demand gap. The tenders for the infrastructure are now cancelled due to several reasons such as disagreements with the contractors. Thus there has been a delay in the implementation of the new dams.

The following figure Figure 1 shows the basic estimated flows in the water balance for Cyprus based on the Aquastat database. Assumptions are listed in Table 1.

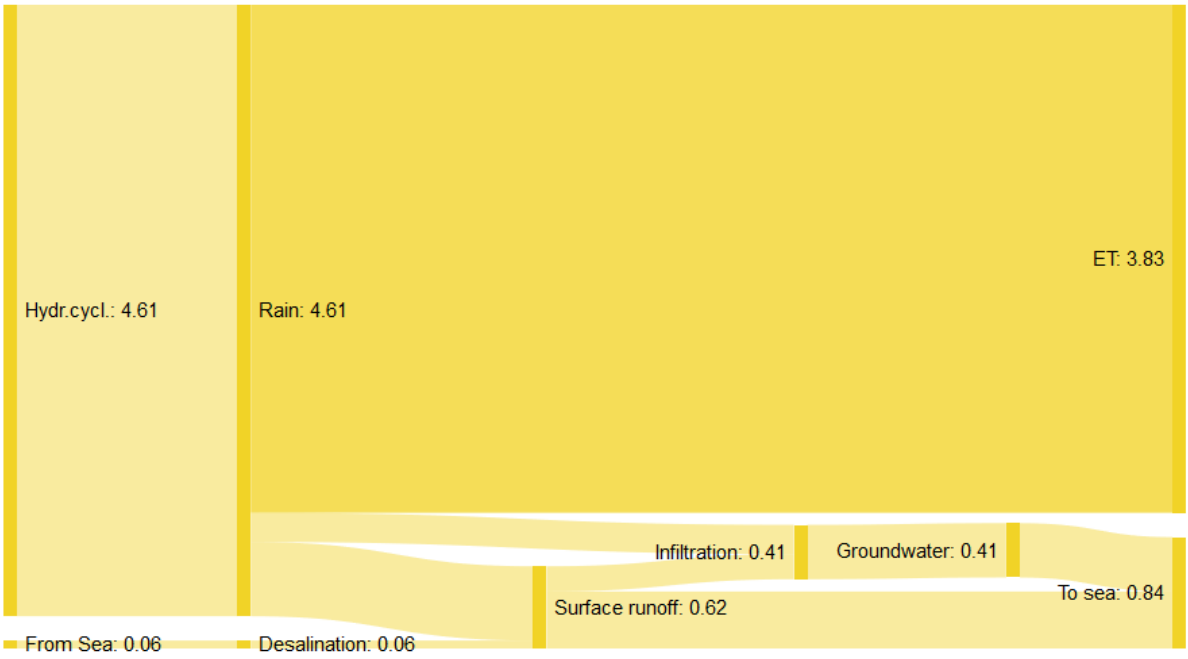

***Figure 1**. Water balance, Cyprus, in km³. Mainly based on data from Aquastat (2020) from 2017. Hydr.cycl.=hydrological cycle, ET=Evapotranspiration.*

***Table 1.** Assumptions made for the water balance diagram in Figure 1.*

Item	Explanation	Comment
ET (Evapotranspiration)	Rain minus Surface runoff, infiltration, imports, and exports	
To Sea	Surface runoff minus infiltration and export	
Land area	CY= 925 kha	CY: whole island
Desalination	everything allocated to surface water	
Groundwater	assumed that excess goes to the sea	

b. Scenarios for sustainable water use

In Table 2 climate change adaptations are presented, which includes information only for the eastern area of Cyprus. The basic scenario is based on the water balance of Cypriot Water Department statistics of 2017. All scenarios have constant precipitation levels based on the basic scenario estimates. Scenario 1 (Sc. 1) assuming that ET is reduced (-) by a half and maintains the percentage of distribution losses by assuming that climate change adaptation measures are in place giving the chance of filling up the surface storage capacity. Scenario 2 (Sc. 2) is based on decreasing (-) ET by 3 times and maintaining the distribution losses constant and doubling the surface storage capacity. Scenario 2 assumes maximum additional water retained assuming that the regional climate is reversed from semi-arid to a tropical climate.

Table 2. *Climate change adaptation.*

Scenarios/ Water Sources	Basic scenario (km^3)	Basic scenario (%)	Sc. 1: (km^3)	Sc. 1: (%)	Sc. 2: (km^3)	Sc. 2: (%)
Precipitation	1.96	100	1.96	100	1.96	100
ET	1.82	93	0.92	47	0.61	31
Infiltration	0.04	2	0.67	34	0.65	33
Surface Runoff	0.06	3	0.33	17	0.66	34
Dist. Losses	0.04	2	0.04	2	0.04	2

In table 3 the basic scenario is based on the estimated demand of the eastern area of Cyprus of 2017. All scenarios exclude distribution losses. Scenario 1 (Sc. 1) is based on reducing the total water demand by reducing the agricultural water demand by 0.060 km^3, reducing domestic demand by 0.021 km^3, while keeping the industrial and environmental sector's demand constant. In Scenario 2 (Sc. 2) the agricultural estimate is based on the whole area of Cyprus from estimates of 2017 from the eastern area and from 2012 from the northern area (Georgiou & Dörflinger, 2002; WDD, 2017; Elkiran et al., 2019). The domestic sector is based on population estimates of the UN of 2017 for the whole area of Cyprus, from calculations of the average estimates of per capita water consumption from the Water Development Department's study in 2002 and the aggregation of the whole island's tourism consumption (Georgiou & Dörflinger, 2002; WDD, 2017; Elkiran et. al., 2019). For the environment and industrial area since there are no estimates from the northern area we assume it is double the amount required in the eastern area.

Table 4 includes information only from the eastern area of Cyprus. The basic scenario is based on the total available supply from different sources in 2017. Scenarios 1 & 2's surface water available is covering full dam capacity as of 2017. If all surface water dams are filled they can cover all sectors' demand of 2017 and there will be an excess of 0.07 km^3 + 0.08 km^3 from recycled water assuming that currently treated water is tripled, to fulfil the European regulations, for maintaining water quality in dams. Without any abstraction of groundwater or production of desalinated water will the existing sources in scenario 1 (Sc.1) be enough to maintain the healthy quantity and quality levels in the dams? Probably not, that's why if we assume the sustainable abstraction levels of groundwater as calculated in Georgiou & Dörflinger in 2002 and the sustainable production of desalinated water (with renewable energy) would further assist in the protection of dam levels, soil quality etc. In scenario 2 (Sc.2) there is a slight increase in recycled water.

Table 3. *What if water demand in sectors changed.*

Demand Sc./ Sectors	Base Sc. (km^3)	Base Sc. (%)	Sc.1 (km^3)	Sc.1 (%)	Sc.2 (km^3)	Sc.2 (%)
Agriculture	0.180	69	0.120	65	0.255	53
Domestic	0.070	25	0.049	26	0.198a.	41
Industry	0.003	1	0.003	2	0.006	1
Environ.	0.013	5	0.013	7	0.026	5
Total	0.260	100	0.185	100	0.485	100

a. The domestic sector in scenario 2 does not include water demand from public buildings.

Table 4. *What if water available from different sources changed.*

Available supply Sc./Sources	Base sc. (km^3)	Base sc. (%)	Sc. 1 (km^3)	Sc. 1 (%)	Sc.2 (km^3)	Sc.2 (%)
Surface water	0.071	24	0.330	80	0.330	59
Groundwater	0.157	53	-a.	0	0.080	15
Desalinated	0.041	14	-b.	0	0.062	11
Recycled	0.027	9	0.081	20	0.083	15
Total	0.296	100	0.411	100	0.555	100

a. Assumed that groundwater is not abstracted.
b. Assumed that desalinated water is not produced.

5. Discussion

The methodology used for the assessment of sustainable water management in national and international context assisted in determining the water balance and the best practices for the common resource. The European policies for water management are the basis for the results' content and have clearly shown the abilities of the national measures.

There is a correlation with the amount of surface water availability and use, groundwater used and desalinated water. When surface water availability is high and can meet the domestic demand, desalinated water production and groundwater abstraction are lowered. Although, water availability is subject to the increase in temperature due to climatic changes speeded up by human activities, thus better ways are required to secure water supply especially in semi-arid climates. As water demand increases so must water supply increase.

Reducing pollution can increase the quality of life for all ages, protect and preserve the environment and increase economic activity, water supply and potential profit. Measures related to climate change and behavioural adaptation can have a positive impact on evaporation reduction, water resource availability, ecological health and the socio-economic aspects. Increasing surface water capture and reducing water use from groundwater aquifers that are salinised get the chance to recover. Reducing water use in the domestic sector allows the water to either be used in agriculture where demand is higher than supply or to be used in the environment and remediate soils, while at the same time reduce the need for desalinating water. Countries with similar backgrounds can learn from this study's examples from the methods and solutions available to sustain water supply.

Some of the limitations in assessing water sustainability are related to the reliability of the data used. For instance, when using national data the absence of illegal and unbilled groundwater quantities withdrawn for private use could be misleading policy maker's decisions. The Sankey diagram shows how complicated it is to include all factors in one model and that assumptions are required to supplement the data. In addition, there is complexity when trying to represent the physical aspects of the hydrological cycle when the semantics used in previous studies are defined differently. The data differ from each statistical dataset. This made it even harder to produce Sankey diagrams for the comparison of other statistical sources since it would become more confusing to deliver the outcome to the reader.

Scenarios were found useful in the assessment of the management actions because they showed the strengths and weaknesses of such methods during the implementation phase. In addition, the scenarios gave an overview of the state of water resources which is important in the planning stage and could be useful in the decision phase. The what-if approach allowed flexibility that can not be achieved easily outside this investigation. Assumptions helped to fill in blanks that are not easily accessible from other studies. Limitations in the scenarios are that they do not necessarily represent reality and realistically the water system is more complicated than the simplified scenarios made. That weakens the scenarios and model's reliability.

For instance, in table 2 we assumed that precipitation is constant for all three scenarios which is not realistic. Instead, precipitation varies from year to year. Another assumption made was that in scenarios 1 and 2 distribution losses remain constant. Realistically, distribution losses would be more than the basic scenarios if no repairs were done. Assuming that maximum additional water retained would change the regional climate from semi-arid to a tropical climate is a weak assumption since for a climate to change it takes decades.

In table 3 we did not include the consumption in public buildings and businesses because no data could be found, this shows a weakness in the scenario. In reality, the total water demand would be higher if we would include those flows. Another limitation in table 3 is that we used a constant value to calculate the domestic consumption for the whole population. Whereas in reality water consumption varies between areas and it could be as low as 150L/day to as high as 650L/day. The assumption made for the environment and industry that would double if we were to include the northern area because data weren't available is another weakness in the scenario. The area covered in the northern area is ⅓ of the whole island so environmental water demand should be definitely lower.

In table 4 we assumed that the available recycled water would be tripled to fulfil the European regulations. Although, not all water used in domestic will be treated and not all will be reused. Furthermore, we assumed that desalinated production would be zero, realistically at the moment desalination can't be hauled because of the depreciation expenses. Another assumption made which is not true is that the unconventional sources of water would produce water with renewable energy supply. Currently, the first water treatment plant built working with renewable energy has only just started water treatment. Finally, due to the limitations and implications, we came across the proposed scenarios might not be useful. Many factors that affect the implementation are not considered in this investigation and many assumptions were needed to fill in data. Other management practices might be preferred especially since there are no binding agreements for implementing all proposed practices.

6. Conclusions

A water balance for Cyprus was set up. Problems were encountered regarding contradictory data, and also that different land areas were included in different data sets, due to the politically unstable situation regarding national jurisdiction. Groundwater surpassed the availability of all other sources making the groundwater aquifers the easy solution for supplying water to meet demand. Available treated water increased throughout the years along with its use for irrigation purposes. Desalinated water has been increased during dry periods to supply domestic use because surface water was not enough to meet the demand.

Three scenarios were produced regarding possible future development for water supply in Cyprus. The first scenario focused on climate change adaptation to reduce the water from evapotranspiration so that more water remains in storages. The second scenario focused on the demand for water in the four sectors. The outcome was that with the reduction of overconsumption total demand decreased and by including the northern area of Cyprus demand increased. The agricultural sector had the highest water demand. The third scenario focused on water available from different sources. The combination of all sources turned out to be the most viable solution and follow the sustainable abstraction levels.

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Assessment of ecosystem services in adaptive orchard meadows in Visnyeszéplak

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Abstract

The concept of ecosystem services has become an important element of scientific research and policy on biodiversity and landscape conservation. Ecosystem services are the material and the non-material assets that ecosystems provide to society. It is important to emphasize that these services are only realized if the entire ecosystem operates appropriately. Recently, there has been an increasing focus on the ecosystem services of agroecosystems as well. Adaptive orchard meadows are complex agroecosystems, which rely on old traditional farming and combine fruit trees with meadows. Farming in adaptive orchard meadows is a complex activity that requires a holistic approach by farmers but, in return, it provides several benefits to the farmer and the local community. Our aim was to prove that these adaptive orchard meadows can provide a wide range of ecosystem services in an area characterized by a good ecosystem condition. In our study, we assessed the ecosystem condition and the ecosystem services of adaptive orchard meadows in an eco-village, Visnyeszéplak, situated in the south-western part of Hungary. In this village, inhabitants attempt to live in harmony with nature. Therefore, all farming activities are nature-friendly. The assessment of ecosystem condition was based on the qualitative content analysis of interviews, the results of a survey of nesting bird populations and scientific data. The following criteria were used for the evaluation: intensity of use, presence of invasive species, habitat and species diversity, soil fertility, water retention capacity and risk of erosion. Ecosystem services were selected and characterized based on the interviews and available scientific data. Only provisioning and regulation and maintenance services were selected. Cultural services were not within the scope of our assessment. Our results show that the village has a mosaic spatial structure and the orchard meadows are comprised of different habitats as well. The bird survey revealed a high biodiversity of bird species. Invasive species are not widespread, indicating a good ecosystem condition. The water retention capacity of the area is extremely poor. The soil fertility is also low and there is a high risk of erosion but, with nature-friendly farming, these conditions have been improved. Ten ecosystem services were identified in these adaptive orchard meadows. Seven provisioning services were found, such as products from bred animals (meat, milk, egg and honey), plant-based services (e.g. fuel wood, fodder and herbs), genetic material from local fruit, domestic animal breeds and others. Three regulation and maintenance services were identified, such as control of soil erosion, pollination and micro climate regulation. Our main conclusion is that nature-friendly farming helps to maintain the good ecosystem condition and it is a good basis for the provision of ecosystem services.

Keywords: nature-friendly farming, eco-village, adaptive orchard meadow, ecosystem condition, services

1. Introduction

The concept of ecosystem services has become an important element of scientific research and policy on nature and landscape conservation (Gómez-Baggethun et al., 2010; Diaz et al., 2015). Ecosystem services are the material and non-material benefits which ecosystems provide to society (MA, 2005). It is important to emphasize that these services are only realized if the entire ecosystem functions properly (Haines-Young and Potschin, 2010). The Common International Classification of Ecosystem Services (CICES) distinguishes three main categories of services: provisioning services (material outputs of ecosystems), regulating and maintenance services (ecological regulatory processes) and cultural services (the non-material outputs of ecosystems) (Haines-Young and Potschin, 2013, 2018). The Cascade model explains the flow of services from nature to society through simple and well-understood steps (the ecosystem condition – the potential ecosystem services – the actual use of ecosystem services – the contribution of ecosystem services to human well-being) (Haines-

Young and Potschin, 2010). The ecosystem services concept provides a good opportunity to understand the cooperation between humans and the landscape. In areas where land-users are connected to and dependent on the rich natural heritage of an area, there is a particularly good opportunity to gather relevant data for designing long-term, sustainable systems that can be used in landscape planning (de Groot et al., 2010). Such areas like eco-villages, where people live and practice farming in harmony with nature and think in all four dimensions of sustainability (social, cultural, ecological and economic) (http1). There are many eco-villages in the world. Although they are very different, they have common goals and features. Inhabitants of eco-villages wish to live in harmony with nature and use nature-friendly technologies (in farming, waste management, sewage system, etc.). They do not want to poison their environment with chemicals and fertilizers. Their lifestyle and farming activities are restrained and therefore they can stay in the same area for a long time. These goals are always defined by the community (Farkas, 2014). The positive effects of the mosaic landscape on agriculture has recently been proven. The combination of multiple functions can be effective, economically and ecologically. Agroforestry systems, including orchard meadows, have the above-mentioned characteristics (Sanchez, 1995). José (2009) shows that agroforestry systems provide a wide range of ecosystem services. Farming in orchard meadows is a complex activity that requires farmers to follow a holistic approach. They must continuously adapt to the functioning of ecosystems in their orchards, although they can also shape some of the functions, depending on their needs (e.g. wind protection). Usually, these adaptive orchard meadows have a loose structure where the orchard is combined with meadows. Grass is grown around fruit trees where flowers, herbs and mushrooms can grow (Lantos, 2005). Farmers do not use chemicals and fertilizers, and avoid monoculture and the use of non-endemic and invasive species. They prefer to grow local fruit varieties that have adapted to the local natural circumstances. Therefore, after some time, the orchard does not need any external inputs and it is quite resistant to external environmental impacts (Lantos, 2018). This study is part of a research project on assessing ecosystem services provided by different habitats (forest, grassland, orchard and home gardens) in the eco-village of Visnyeszéplak, Hungary (Prohászka et al., 2019). In this paper we explore the ecosystem services of adaptive orchard meadows in detail. Our main aim was to conduct a preliminary assessment of the ecosystem condition of adaptive orchard meadows and the ecosystem services provided by this unique habitat, using mostly semi-structured interviews supplemented with a bird survey and data from GIS data sources.

2. Methods

The study area

Visnyeszéplak is located in Somogy county at the border of the Somogy and Baranya counties, in the south-western region of Hungary called Zselicség (Figure 1). Its total area extends 239 hectares. Visnyeszéplak was founded in the early 1990s and is among the first eco-villages established in Hungary. It is still operating with more than 150 inhabitants.

***Figure 1**. Location of the study area, Visnyeszéplak, Somogy county, Hungary.*

The settlement borders oak and beech forests of the Zselic Landscape Protection Area to the north and east (Bartha, 2015). Typical habitats include forest, grassland, orchard and home gardens (Figure 2). Orchard meadows are indicated in orange, below. Every family in this village owns orchard meadows, totalling 26 hectares (11% of the total area).

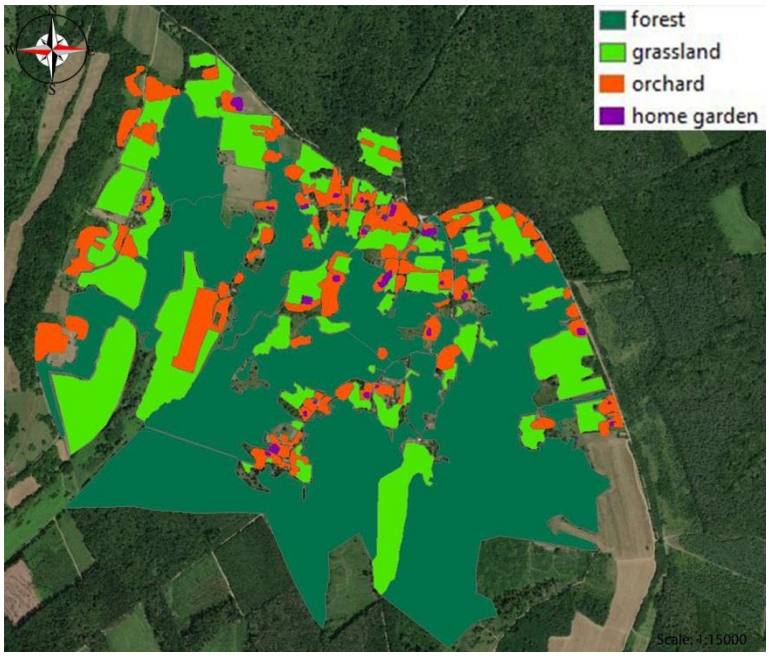

Figure 2. *Habitats in Visnyeszéplak.*

Methods of data gathering

There are very little published information and data available about the natural conditions and ecosystem services of the Visnyeszéplak village. Therefore, we predominantly base our study on the qualitative analysis of semi-structured interviews and a bird survey, supplemented by some databases and additional information gathered after the interviews. These activities can be considered to be the first steps to conduct a more in-depth quantitative data collection and analysis of ecosystem conditions and ecosystem services.

Four semi-structured interviews (Patton, 2002) were conducted with the two main representatives of Visnyeszéplak eco-village (László Máté and Péter Zaja, who are also the co-authors of this paper). The first round of interviews, conducted in February and March 2018, focused on the general characteristics of this eco-village and the livelihoods of their inhabitants. The second round of interviews, carried out in January 2019, concentrated on ecosystem services provided by the main habitats (forest, grassland, orchard and home gardens). Notes were taken during all interviews, which were supplemented with audio recording in the second round of interviews. The first interviews lasted 2.5 hours and 3.5 hours, while the duration of the second interviews were 6 and 4 hours, respectively. Summaries of the interviews were used for the qualitative content analysis.

In addition, a CES (Constant Effort Sites) survey was carried out in one of the orchard meadows (marked in Figure 2). The goal of this method is the monitoring of the population changes of passerine and near-passerine species during nesting periods. The first continuous bird-ringing programme was developed by the British and Irish Ringing Scheme in the early 1980s. This protocol was followed by the majority of countries, such as Hungary. In Hungary, the annual bird monitoring period takes place between April 15th and July 13th. Every year the same number and placement of nets are implemented. The purpose of the method is to provide a unique sign (bird ring) for the birds caught in the nets, 9 times in a standard location, with 8-12 bird nets. According to the protocol, the bird ringing must be executed in 10-day periods, with a minimum of 3 hours and a maximum of 6 hours at a time (Balmer et al., 2004; Karcza and Halmos, 2004). At the CES point selected for the orchard meadows in Visnyeszéplak, a total of 10 Polish-type bird nets (12 meters, 5 pockets) were recorded

8 times in spring and summer in 2019. Due to the rainy weather, one monitoring event was missed in June, but this is allowed according to the protocol.

Some GIS databases were used for the analysis: MePAR, the Hungarian agricultural parcel identification database (http3), MBFSZ (Mining and Geological Survey of Hungary) maps (geological atlas of Hungary) (http4), ENFO maps (soil maps: genetic soil type, water management soil type, chemical soil properties, soil organic matter stock) (http 5), and DOSoReMI (Digital, Optimized, Soil Related Maps and Information in Hungary) maps (digital soil maps: pH (0-30 cm), lime content (0-30cm)) (http 6) for determination of the soil character of the study area.

Methods of analysis

Ecosystem state is important for the provisioning of ecosystem services. Therefore, we started our analysis with this first cascade level. Ecosystem condition of the adaptive orchard meadows was assessed, based on the qualitative content analysis of interviews, results of the CES surveys, and databases of MePAR, MBFSZ, ENFO and DOSoReMI. In the interviews' summaries, we focussed on information on the naturalness of the area (intensity of land use and presence of invasive species), habitat and species diversity, soil fertility, water retention capacity and risk of soil erosion. The CES survey provided information on the diversity of bird species. Data from the GIS databases of MePAR, MBFSZ, ENFO and DOSoReMI were used for the assessment of the soil type and quality.

The next step was the selection and assessment of ecosystem services (second and third level of the cascade), which was also based on the qualitative content analysis of the interviews. Selected services were categorized according to a combination of CICES 4.3 and 5.1 classification (Haines-Young and Potschin, 2013, 2018; http2) to facilitate assessment and interpretation. Thereafter, information about the selected ecosystem services was collected from the interviews' summaries to describe their state and characteristics.

3. Results and Discussion

Ecosystem condition

Creating an adaptive orchard meadow is not an easy task as it can take years and decades before fruit trees will carry fruit. Although, for the good quality and long-term sustainability, it is well worth the wait. The interviewees said that their own adaptive orchard meadows needed 15 years to become a self-sustaining system. Since then, they had not needed to look after this habitat so much. Originally, Visnyeszéplak was characterised by vineyards, but in the period of socialism a large part of it was converted into arable land. During this period a lot of inhabitants moved to other settlements and nature recaptured the area. Therefore, when the current inhabitants moved to Visnyeszéplak in the early 1990s, they had to make the field suitable for farming again. Instead of starting a large-scale arable farm, they adapted to the mosaic landscape and used a lot of fruit trees that grew there to create adaptive orchard meadows. The aim of the residents was to keep and evolve the mosaic and grove-like structure typical of the area with local fruit tree species and sustain the other habitats (forests and grasslands). The orchard meadows provide habitat for several species. The CES results indicate a high biodiversity of bird species. 112 individuals, from 18 bird species, were caught without a natural watering or other water sources. Among others, sparrows (20 Eurasian Tree Sparrows, 8 House Sparrows), woodpeckers (7 Great Spotted Woodpeckers, 4 European Green Woodpeckers), tits (18 Great Tits, 1 Marsh Tits) and thrushes (19 Common Blackbirds, 4 Song Thrushes) were captured. During the interviews, it became clear that keeping these species in place (by providing hiding and nesting place and feeding the birds in the winter) is also an explicit goal, as they have a substantial role in natural pest control. The interviews revealed that the water retention capacity of the area is extremely poor. This statement was also partially proven by the water management soil type map of ENFO. According to this map, the soil in Visnyeszéplak is characterised with medium water absorption and medium drainage capacity. To compensate for this, small lakes are created by the locals and, in addition, barrels and cisterns are used to collect rainwater. The MePAR database shows that the area is at risk of erosion, but it does not occur in the settlement due to optimal vegetation and good natural management. Typically, there is Luvisol soil in the

loess hills of Zselic (Káldi, 2010), including Visnyeszéplak (http4, http5). The soil pH is slightly acidic as lime content is low (http6) and organic matter content is also low (http5). Locals find it difficult to cultivate the soil and it is poor in nutrients. The low intensity farming adapts to the characteristics and carrying capacity of the area, so invasive species, such as Japanese knotweed (*Fallopia japonica*) and Goldenrods species (*Solidago sp.*), are not widespread.

Ecosystem services

Many ecosystem services were designated as important for the orchard meadows by our interviewees, clustered into 10 main ecosystem service groups, according to CICES. Among the selected ecosystem service groups, 7 belonged to the provisioning and 3 to the regulation and maintenance services. Cultural services were not assessed in this study. Below, the selected ecosystem services and examples are listed under the two main types.

Provisioning services:

- Cultivated terrestrial plants grown for nutritional purposes (fruits)
- Bred animals reared for nutritional purposes (meat, milk, egg and honey)
- Wild plants used for nutrition (gathering wild plants, fruits and mushrooms)
- Fibres and other materials from plants and bred animals for direct use or processing (bones, skins, carved wood and building materials)
- Materials from plants and animals for agricultural use (forage and manure)
- Plant-based resources (fuel wood)
- Genetic material from cultivated plants and bred animals (preservation of native plants and animals of local breeds)

Regulating and maintenance services:

- Pollination (pollination of fruit trees and other plants)
- Regulation of temperature and humidity, including ventilation and transpiration (micro and regional climate regulation)
- Control of erosion rates (protection against water-leaching in sloping areas)

Provisioning services

In Visnyeszéplak, adaptive orchard meadows provide a wide range of provisioning services. There are nearly 100 fruit varieties in these orchards, most of which are sourced locally. Some examples are shown in Figure 3 and Figure 4. One of the apple varieties is called the summer giant, yielding half a kilogram of fruit. The delicious batul apple or strawberry apple can be stored for more than a year after harvesting.

***Figure 3**. Apple varieties from Visnyeszéplak (batul alma (batul apple), vas alma (iron apple), szív alma (heart apple), eper alma (strawberry apple), tuboly féle alma (tuboly apple), and nyári fontos alma (Rambour Franc apple (photos by Péter Zaja).*

***Figure 4**. Other fruit species and varieties from Visnyeszéplak (ageni szilva (ageni plum), öreghegyi korai kajszi (apricot from the old hill), hébér körte (hébér pear), sárga cseresznye (yellow cherry), and érdi bőtermő meggy (high yield sour cherry from Érd), pacséri óriás meggy "the ancient sour cherry") (photos by Péter Zaja).*

One of the sour cherry varieties is resistant to diseases (e.g. monilia, cherry flies). This sour cherry is called "the ancient sour cherry" by residents, because it was already in Visnyeszéplak when they moved there. Fruits are used in many different ways: raw, dried, in jams, syrups, juices and pálinka (Hungarian brandy). The flesh and peel left over from the pressing, as well as the fruit that is not consumed by locals, are given to domestic animals as fodder and nothing is lost. Hay produced in orchard meadows is also an important ecosystem service. Some of the locals manage grazing in orchard meadows with old Hungarian breeds of cattle, horses and sheep (see Figure 5), e.g. Carpathian brown cattle, Angus cattle, Hungarian gray cattle, Hungarian Tarka cattle, Racka sheep (Hungarian sheep), Cigája sheep, and several horse species (e.g. Furioso-north star, Hucul, Brabant horse). Old Hungarian breeds of poultry (e.g. domestic guineafowl, Transylvanian naked-necked flow, (Yellow) Hungarian chicken) are also kept in these orchard meadows.

Figure 5*. Grazing animal species from Visnyeszéplak (Carpathian brown cattle, Angus cattle, Furioso-north star, and Carpathian brown cattle) (photos by Péter Zaja and László Máté).*

Grazing animals provide milk, meat and eggs. Again, it is important to mention that nothing is lost, so all parts of the animals (meat, milk, skin and bone) are utilised. Skin and bone are used to make carpets, sandals, bags, saddlery and other objects or decorations. Wood collected in the orchard is used as fuel, or as carving wood and building materials. Honey is also found in these orchard meadows. Seven beekeepers live and work in this area. Locals collect herbs (thyme, yarrow, ribwort plantain, etc.), which they use as both fresh and dried and prepare syrup, tea or, in some cases, crème, soap or essential oil from them.

Regulating and maintenance services

Microclimate regulation provided by the orchards is of great importance according to the interviewees because it prevents extreme weather damage in the area. The interviews revealed that, in many cases, while frost damage in surrounding settlements can sometimes be significant, it is not in Visnyeszéplak. In addition, heat waves usually do not occur. Although, the greatest role in this protection is provided by the forest surrounding the settlement. These orchards are essential in this protection, possibly due to their special structure. In the orchard meadows, the leaf canopy of fruit trees is of different heights and these trees are planted at a distance of several meters (5-15 meters) from each other. The interviews showed that the warm-loving fig never freezes, it grows particularly well in the area and, therefore, it is found in the adaptive orchards on several farms. Control of erosion rates is provided by this habitat because of continuous ground cover. There is grass growing between fruit trees, which is maintained by sectional grazing and mowing. According to the interviewees, there are many pollinators in Visnyeszéplak, including both wild bees and honey bees (because of beekeepers). Pollination is only problematic when the spring is colder than usual, especially in the case of early flowering species (like cherry and apricot). If the temperature is below 10 °C for a long period of time, pollination will not occur. According to our interviewees, to prevent this, the apricot tree is planted on a hilltop or on the northern hillside. Thus, delaying flowering as less sunlight reaches the tree. This delays the start of flowering by up to 4-5 days. However, there are some external effects that cannot be, or only partially be, prevented by the farmers. These include damage by wildlife, climate change and UV radiation.

4. Conclusions

In summary, the adaptive farming, suited to the landscape, enables the adaptive orchard meadows to function as a long-term agro-forestry system. Conscious adaptive farming, with control and feedback mechanisms, enable the locals to cultivate on poor soil conditions without degradation on slopes and with low water levels, providing livelihoods for the residents. By planting and cultivating resistant species in a mixed system, they help nature to balance processes, adapt to climate change

within certain limits, and increase resistance to pests and pathogens, eliminating the need for chemicals. Furthermore, our results show that the village has a mosaic spatial structure and the orchard meadows are comprised of different habitats as well. In this way, the orchard meadows provide a rich set of ecosystem services in the long-term with many benefits to the locals.

Although the interviews, supplemented with the CES bird survey and GIS-based data, helped us to obtain a brief picture of the ecosystem condition and ecosystem services of adaptive orchard meadows in our study area, more data and assessments are needed. Primary data collection and assessment related to soil and water quality and pollination is planned for the future. A questionnaire survey is also scheduled to obtain quantitative data on provisioning services.

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Framing the tourism industry into circular economy practices

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Abstract

Tourism is a fast-growing industry. It gives an important contribution to the economic development but, at the same time, it is also a significant contributor to environmental degradation and climate change. Considering that many of the tourist activities are based on the availability of natural ecosystems in good condition and accessible to tourists, it is crucial for the long-term success of the industry to develop strategies to mitigate its impact on the environment. Over the last years, Circular Economy (CE) has arisen as a tool to operationalize sustainable development principles and as a crucial guide of action for national and supranational policies. Considering the need of tourism industry to move toward a more sustainable approach, the main goal of the paper is to figure out how the CE may support the tourism supply chain into this transition. Starting from a literature review aimed to identify CE operationalization principles, the paper main goal is to evaluate how those principles may be applied into the tourism industry. Once identified CE operationalization principles, the paper offers a brief overview of literature analysing the potential of applying CE into the tourism industry. As circular tourism conceptualization and implementation is still under explored, this paper present a first attempt to frame circular tourism practices into the CE umbrella concept. To build the circular tourism implementation framework we first employ the 11R framework we have adapted for tourism sector CE implementation to identify CE practices applicable to this sector. Once the practices had been established, they will be framed to evaluate at which level it is possible to apply it, according to their potential implementation at destination level (decision-makers, local authorities, NGOs, industry associations), firms' level (hospitality, bar & restaurant, tourism facilities, tour operators, travel agencies), and consumers level (travellers). Next, it poses the base to the development of a circular tourism framework, which goal is to identify for each CE principle its potential implementation into the touristic supply chain. The recent proliferation of studies inherent the circular approach has stimulated academic research by opening new currents of research and leaving mostly unexplored others. The application of the CE concept in the tourism sector is still unexplored and more efforts should be done to understand the potentialities of Circular Tourism. The objective of the paper was to create a framework for circular tourism implementation, identifying the interrelations existing between the circular economy and the development of a more sustainable tourism. CE principles and related practices have a great potential to ensure a balanced development of the industry, actively contributing in the achievement of long-term sustainability goals. The proposed framework may represent a solid baseline to further investigate the potential impact of CE practices on a touristic destination. As this is a preliminary study, next step will be to identify for each of the 11 Rs the specific CE practices to be implemented by the touristic supply chain stakeholders. To give soundness to the project further development will include interviews with relevant tourism stakeholders to test the level of application of CE practices in tourism sector; the categorization of CE practices in hospitality industry into the framework proposed; and the application of the framework in our pilot project involving tourism firms in a coastal destination.

Keywords: circular economy; circular tourism; tourism industry; sustainable tourisms; literature review

1. Introduction

Tourism is a fast-growing industry, which is forecasted to grow at global level with a significant rate in the next decade. In recent years, tourism has experienced a continued expansion and diversification to become the second-fastest growing sector in the world (World Travel & Tourism Council, 2018), occupying a prominent role in the global and European economy. The travel and tourism sectors grew of 3.9% in 2018, accounting for the 10.4% of global GDP and contributing to the world economy with $8.8 trillion and 319 million jobs in 2018 (World Travel & Tourism Council, 2019). Europe has always been a very popular tourist destination and, according to the World Tourism Organization (WTO), five European States (France, Spain, Italy, Germany and the United Kingdom) fall into the top ten destinations preferred by travellers in the world ranking for the year 2017 (UNWTO, 2018). The tourism sector is also a significant contributor to environmental degradation and climate change (Budeanu et al., 2016; Gossling, 2002; Kucukusta et al., 2013). Estimates show that the industry is responsible for roughly 8% of global greenhouse gases (GHG) emissions (Lenzen et al., 2018). Additionally, tourism can produce negative impacts on biodiversity and cultural landscape, generating a negative effect on its ability to provide those amenities that generate its success (Gössling et al., 2012; Gössling and Buckley, 2016). Tourism activities strongly impacts on the environment, contributing not only to environmental degradation but also to the raising of GHG emissions associated with the sector (Pang et al., 2013). The study of Lenzen et al. (2018) found that, between 2009 and 2013, tourism's annual global carbon footprint increased from 3.9 to 4.5bn tons of CO2 equivalent. Additionally, forecasts indicate that the tourism industry is becoming more energy, freshwater, land and food intense, and within 25-45 years tourism resources use will double (Gossling and Peeters, 2015). Climate change and tourism are closely interrelated. While the tourism sector massively contributes to greenhouse gases emissions, mostly related to transportation, it also faces profound impacts from global warming, being one of the most vulnerable industries to environmental degradation and climate change (Gossling and Peeters, 2015; Smith, 1990). Considering this aspect, the success of the tourism industry in the long-term is strictly linked to its capacity to manage environmental sustainability issues (Bramwell and Lane, 2008). Therefore, addressing sustainability has become a major concern for the industry, policy makers and consumers (Lee et al., 2011). Estimates show that the industry is responsible for roughly 5% of global greenhouse gases emissions (World Tourims Organization and United Nations Environment Program, 2008). Additionally, tourism can produce negative impacts on biodiversity and cultural landscape, generating a negative effect on its ability to provide those amenities that generate its success (Gössling et al., 2012; Gössling and Buckley, 2016). Therefore, it arises the need to implement efficient policies and practices that my meet the twofold goals of reducing its negative impact on the environment while generating a positive impact on the economy (Fusco Girard and Nocca, 2017). The international community has widely recognized the importance to develop sustainable tourism as the "tourism that takes full account of its current and future economic, social and environmental impacts, addressing the needs of visitors, the industry, the environment and host communities" (United Nations World Tourism Organization and United Nations Environment programme, 2005 p.11-12). As from other industries, a significant contribution to the operationalization of sustainability is provided by the Circular Economy (CE). Being a pillar of National and International policies, CE may be defined as "*an industrial system that is restorative or regenerative by intention and design. It replaces the "end-of-life" concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models*" (Ellen McArthur Foundation, 2013). Starting from a literature review aimed to identify CE operationalization principles, the paper main goal is to evaluate how those principles may be applied into the tourism industry. Once identified CE operationalization principles, the paper offers a brief overview of literature analyzing the potential of applying CE into the tourism industry. Next, it poses the base to the development of a circular tourism framework, which goal is to identify for each CE principle its potential implementation into the touristic supply chain. The framework has the ambitious objective to provide a smart approach to support all stakeholders into a transition toward circular tourism.

2. Circular Economy principles

CE emerges as a concept to overcome the traditional "take-make-dispose" pattern of production and consumption. This concept has gained the attention of scholars and practitioners and, over the years, has evolved becoming an "umbrella concept" to foster the transition toward sustainability and cleaner production (Merli et al., 2018). In the next years, also European institutions and NGOs started to embrace CE as a guiding concept for a long-term plan of development (Ellen McArthur Foundation, 2013; European Commission, 2015). Therefore, this concept gathers a broader quantity of principles and related practices. Scholars have proposed R frameworks to systematize these principles. In its early stages formulation, CE was mainly associated with the 3Rs approach consisting in Reduce, Reuse and Recycle practices (Ghisellini et al., 2016). The 3R then evolved into the 4R, mainly in relation to the European directive for waste management, introducing also Recovery a way to valorize potential energy to be recovered from waste (European Parliament and of the Council, 2008; Kirchherr et al., 2017). Over the years other Rs have added to the more "traditional" 3 and 4Rs frameworks with the goal of enclose and differentiate the available CE strategies. Recently, the CE R framework has been enlarged to 9Rs, adding new principles: refuse, repair, refurbish and repurpose (van Buren et al., 2016). Reike et al. (2017), reviewing the Rs literature, have extended the framework to 10 R proposing to add re-mine, which aims to recover landfilled materials. Also Potting et al. (2017) have identified 10 R, introducing re-think as a CE principles. The 9 and 10 R frameworks, suggest that those practices aiming at slowing resource loops, should be part of CE principles as having a great potential to reduce resource usage rethinking the way product and services are delivered (Bocken et al., 2016). Generally, the Rs are not listed randomly, but their order reflects a hierarchy of principles' preferability. Starting from low circularity (e.g. re-mine), to high circularity potential (e.g. refuse). Thus, the Rs ranking reflect different of resource value retention, which should guide action for CE implementation (Reike et al., 2017). Table 1 summarizes the recent R frameworks that propose 9/10 R principles.

Table 1. *The CE 9 and 10 R frameworks.*

Circularly preference / ranking	Strategies (Potting et al., 2017)	Resource value retention options (Reike et al., 2017)	Gradation (van Buren et al., 2016)
1st	Refuse	Refuse	Refuse
2nd	Rethink	-	-
3rd	Reduce	Reduce	Reduce
4th	Re-use	Re-use / Re-sell	Reuse
5th	Repair	Repair	Repair
6th	Refurbish	Refurbish	Refurbish
7th	Remanufacture	Remanufacture	Remanufacture
8th	Re-purpose	Re-purpose (re-think)	Re-purpose
9th	Recycle	Recycle	Recycle
10th	Recover	Recover	Recover energy
11th	-	Re-mine	-

In order to classify CE principles through the R framework we have arranged that proposed by Potting et al. (2017), which is composed of 10 Rs. On this baseline, we propose a 11 Rs framework. This introduces the Regenerate principle retrieved from the Resolve framework of Ellen MacArthur Foundation, (2015) and the Rethink principle proposed by Potting et al. (2017) has been renamed into Re-servitization. Table 2 lists the R framework adopted in this paper, and for each R a brief description.

Table 2. *The 11R framework.*

CE principles	Description
Refuse	• buy less – use less (waste prevention); • preventing the use of raw materials; • preventing use of hazardous materials
Re-servitization	• pay per use • PSS / Performance economy • sharing economy • virtualization
Reduce	• reduce waste • reduce use of natural resources and energy
Regenerate	• return recovered biological resources to the biosphere (Ellen McArthur Foundation, 2013)
Re-use	• product reuse with the same purpose and without refurbishment (e.g. second-hand)
Repair	• maintenance • repair
Refurbish	• Returning a product to a good working condition (by replacing or repairing major components and/or cosmetic changes) maybe less than "as new" (Ellen MacArthur Foundation, 2015; Franklin-Johnson et al., 2016; Rizos et al., 2017)
Remanufacture	• creating new products from recovered components of old products which may equal or better than "as new" (Ellen MacArthur Foundation, 2015; Franklin-Johnson et al., 2016; Rizos et al., 2017)
Re-purpose	• product reuse for a different purpose or function
Recycle	• processing and reuse of materials
Recover	• recover energy or biomass from waste flows

3. Circular tourism

The circular economy aims at creating a virtuous circle that produces goods and services without wasting the limited resources of the planet as raw materials, water and energy, minimizing the production of waste (Ellen MacArthur Foundation and McKinsey Center for Business and Environment, 2015; European Commission, 2017; Macarthur, 2013). In the same way, circular tourism proposes a model in which every tourism actor (traveler, guest, tour operator and supplier) adopts an eco-compatible and resource-efficient approach. Opting for circular tourism allows travelers to take a responsible approach at all stages of their stay, from preparation for travel to local experience (Zhang and Tian, 2014). The steps to follow the circular tourism approach are: 1. Exploit the sustainable tourism opportunities offered by tourism agencies 2. Offer more sustainable tourism services 3. Choice of the most environmentally friendly transport option 4. Responsible management of selected services: use of local food products, crafts and eco-sustainable measures adopted 5. Waste management, energy and water conservation, etc. 6. Feedback between tourists and / or professionals to improve the sustainable tourist offer 7. Development of Sharing and Performance Economy (Green Ideas for Tourism, 2018) Fig.1). The development of a circular tourist economy may lead to the sustainable use of resources, improving the efficiency of the tourism industry and achieving the sustainable development of the sector. An adequate and sustainable management of resources is a key element of current and future touristic policies; it also requires the involvement of all component parts of the economy, and for them to be interconnected. Companies, consumers and governments need to work together towards a common goal: implementing a just, social, collaborative and sustainable economy.

Figure 1. The circular tourism loop. (Green Ideas for Tourism, 2018).

4. A framework for Circular Tourism Implementation

As circular tourism conceptualization and implementation is still under explored (Florido et al., 2019; Pattanaro and Gente, 2017), this paper present a first attempt to frame circular tourism practices into the CE umbrella concept. To build the circular tourism implementation framework we first employ the 11R framework we have adapted for tourism sector CE implementation to identify CE practices applicable to this sector. Once the practices had been established, they will be framed to evaluate at which level it is possible to apply it, according to their potential implementation at destination level (decision-makers, local authorities, NGOs, industry associations), firms' level (hospitality, bar & restaurant, tourism facilities, tour operators, travel agencies), and consumers level (travelers). The boundaries of the tourist sector supply chain are summarized in Figure 2, in order to set the different supply chain levels and the applicability of CE practices on each (European Commission - Joint Research Centre - Institute for Environment and Sustainability, 2012).

Figure 2. The tourism supply chain (European Commission - Joint Research Centre - Institute for Environment and Sustainability, 2012)

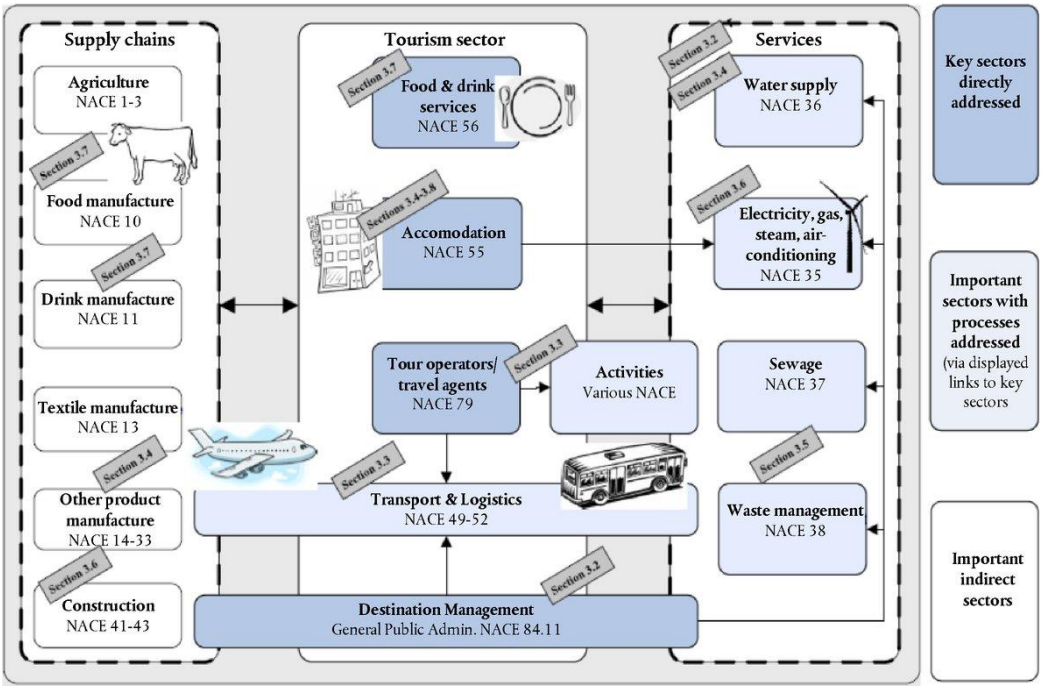

Table 3 shows the framework we propose for circular tourism development. The Rs are not listed randomly, but the order reflects their preferability, ranging from low circularity to high circularity. This framework which should guide action for CE implementation in tourism sector, can be used to frame circular activities already implemented in the hospitality industry. The project CIRTOINNO tried to identify the CE principles applicable to touristic firms in their operation (Manniche et al., 2017). For example, Berendsen is a supplier of linen and laundry-services in 16 European countries. Berendsen works to improve the lifetime and reduce environmental impacts of linen and laundry services for hotels and spas. They do so by various means, such as reusing greywater, using materials with a longer life and retaining wastewater heat. In this case in our framework these activities are framed as: Reuse, Regenerate, Recycle and as a B2B practices. Another example is Karma a platform that help reduce food waste from restaurants and cafés through allowing them to sell excess food to customers as take- away meals, thereby also party recover costs. In this case we can frame this activity as: Re.servitization, Reduce, Reuse and as a B2C practice. Form this preliminary analysis emerges that if Repair, Recycle and Reuse are common practices in tourism, Remanufacturing, Refurbishing, and Regenerate are less explored in the sector. They require specific knowledge, investments and founding boosting the research in circular tourism (Juli et al., 2019; Paulauskas, 2018).

Table 3. The framework for Circular Tourism implementation. Adapted from: (Kirchherr et al., 2017; Potting et al., 2017; Reike et al., 2017).

Circular	Value proposition	Destination (decision-makers)	Tour operators	Accommodation	Food	Place-based services (e.g. , beach club, spa)	Tourists	B2B – B2C

	Refuse							
	Re-servitization							
	Reduce							
	Regenerate							
	Re-use							
	Repair							
	Refurbish							
	Remanufacture							
	Re-purpose							
	Recycle							
	Recover							
Linear								

5. Conclusion

The recent proliferation of studies inherent the circular approach has stimulated academic research by opening new currents of research and leaving mostly unexplored others. The application of the CE concept in the tourism sector is still unexplored and more efforts should be done to understand the potentialities of Circular Tourism. The objective of the paper was to create a framework for circular tourism implementation, identifying the interrelations existing between the circular economy and the development of a more sustainable tourism. CE principles and related practices have a great potential to ensure a balanced development of the industry, actively contributing in the achievement of long-term sustainability goals. The proposed framework may represent a solid baseline to further investigate the potential impact of CE practices on a touristic destination. As this is a preliminary study, next step will be to identify for each of the 11 Rs the specific CE practices to be implemented by the touristic supply chain stakeholders. To give soundness to the project further development will include interviews with relevant tourism stakeholders to test the level of application of CE practices in tourism sector; the categorization of CE practices in hospitality industry into the framework proposed; and the application of the framework in our pilot project involving tourism firms in a coastal destination.

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The transition from linear to circular economy

The experience of SMEs in a Latin-America country

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Abstract

It is well known that the circular economy (CE) offers the possibility to build environmental, social, and economic prosperity by recirculating resources and energy through innovative materials, designs, processes, systems, business models, and technology. Nevertheless, the transition from the linear model to the circular model is a challenging goal for all the countries, particularly in economic terms. Thus, for instance, according to the Organization for Economic Co-operation and Development (OECD), the investment in environmental protection has steadily increased since 2000. Still, they varied significantly across OECD members in 2012, from under USD 50 per capita in countries like Turkey, Mexico, and Chile to over USD 200 per capita in countries like Italy, Netherlands, and United Kingdom (OECD, 2018).

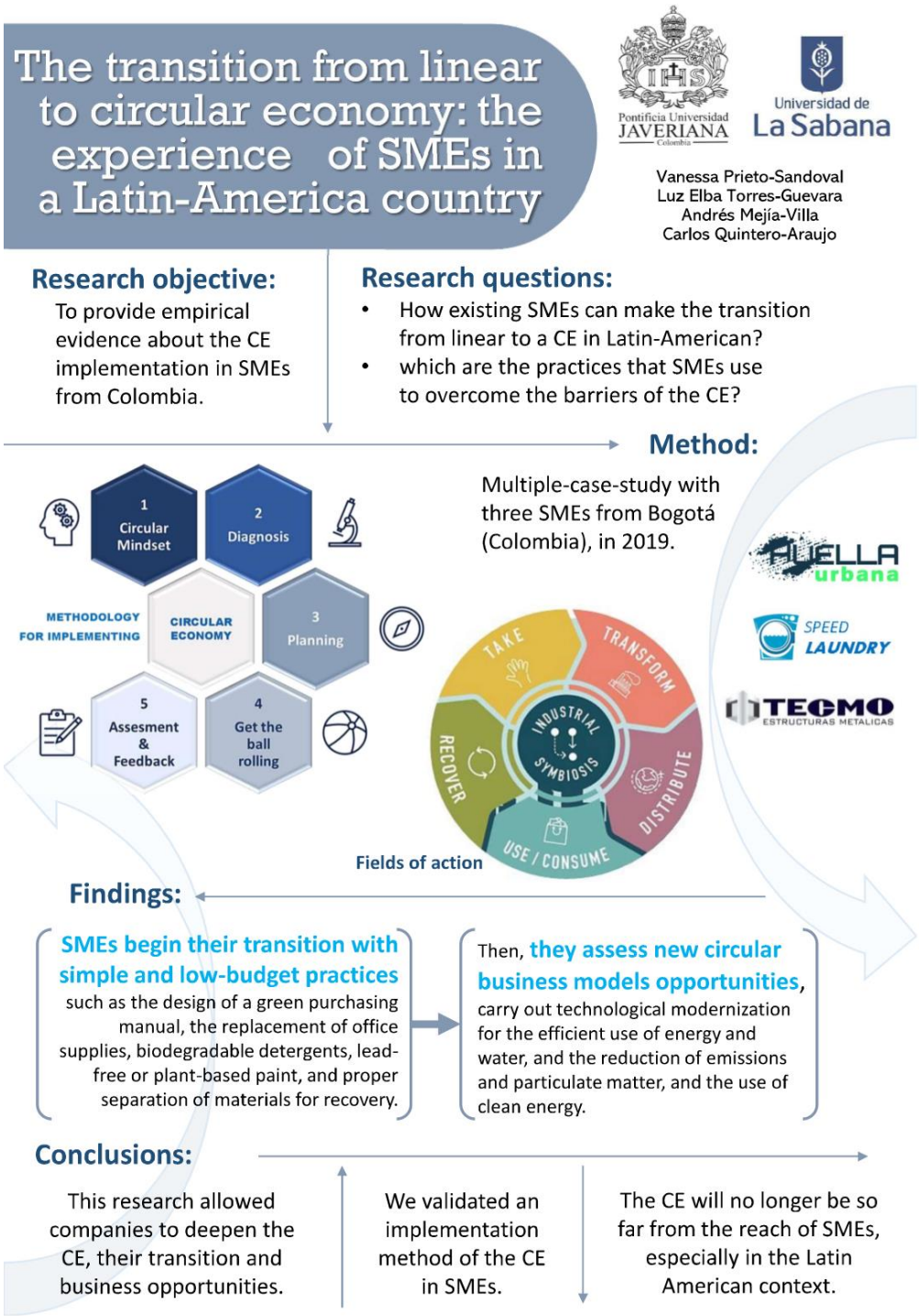
This challenge is even more acute for Latin American countries, given their complex social, economic, and political conditions. Moreover, about 95% of companies in the OECD member countries (OCDE, 2017) are SMEs, which implies they have limited financial resources despite they are the backbone of economic growth.

Nonetheless, most of the studies in the field of CE have focused on theoretical contributions and diagnostic studies of SMEs. Some studies have analyzed the opportunities and barriers for SMEs (Garcés-Ayerbe et al., 2019; Rizos et al., 2015); however, researchers have not treated the Latin-American SMEs transition to CE in much detail. To fill this gap in the literature, this study aims to provide empirical evidence about the CE implementation in SMEs of a Latin-American country that recently became an OECD member, Colombia. Thus, the research questions for this study are: How existing SMEs can make the transition from linear to a circular economy in Latin-American? And which are the practices that SMEs use to overcome the barriers of the circular economy?

With the aim to answer the research questions, this work presents a multiple-case-study with three SMEs from Bogotá (Colombia) and the surrounding region, in 2019. SMEs were selected through the “snowball” method because there is not a database to identify the SMEs interested in transforming their firms. Consequently, the SMEs are a manufacturer of recycled tire rubber floors, a manufacturer of metal building structures, and a laundry. They were selected through informative meetings about circular economy and postgraduate students attending the "Sustainable Development and Circular Economy" class.

The first findings show that SMEs can begin their transition with simple and low-budget practices such as the design of a green purchasing manual, the replacement of office supplies, biodegradable detergents, lead-free or plant-based paint, and proper separation of materials for recovery. Then, as they become proactive, they assess new circular business models opportunities, carry out technological modernization for the efficient use of energy and water, and the reduction of emissions and particulate matter, and the use of clean energy.

In conclusion, this research allowed companies to deepen the circular economy, carry out the transition processes, and identify business opportunities. Secondly, we validated a step-by-step implementation method of the CE in SMEs using three real cases that show how to identify, plan, and capitalize on the opportunities of the circular economy. Furthermore, as a result of this research, the circular economy will no longer be so far from the reach of SMEs, especially in the Latin American context, and these companies could begin to change from linear to circular business models.



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