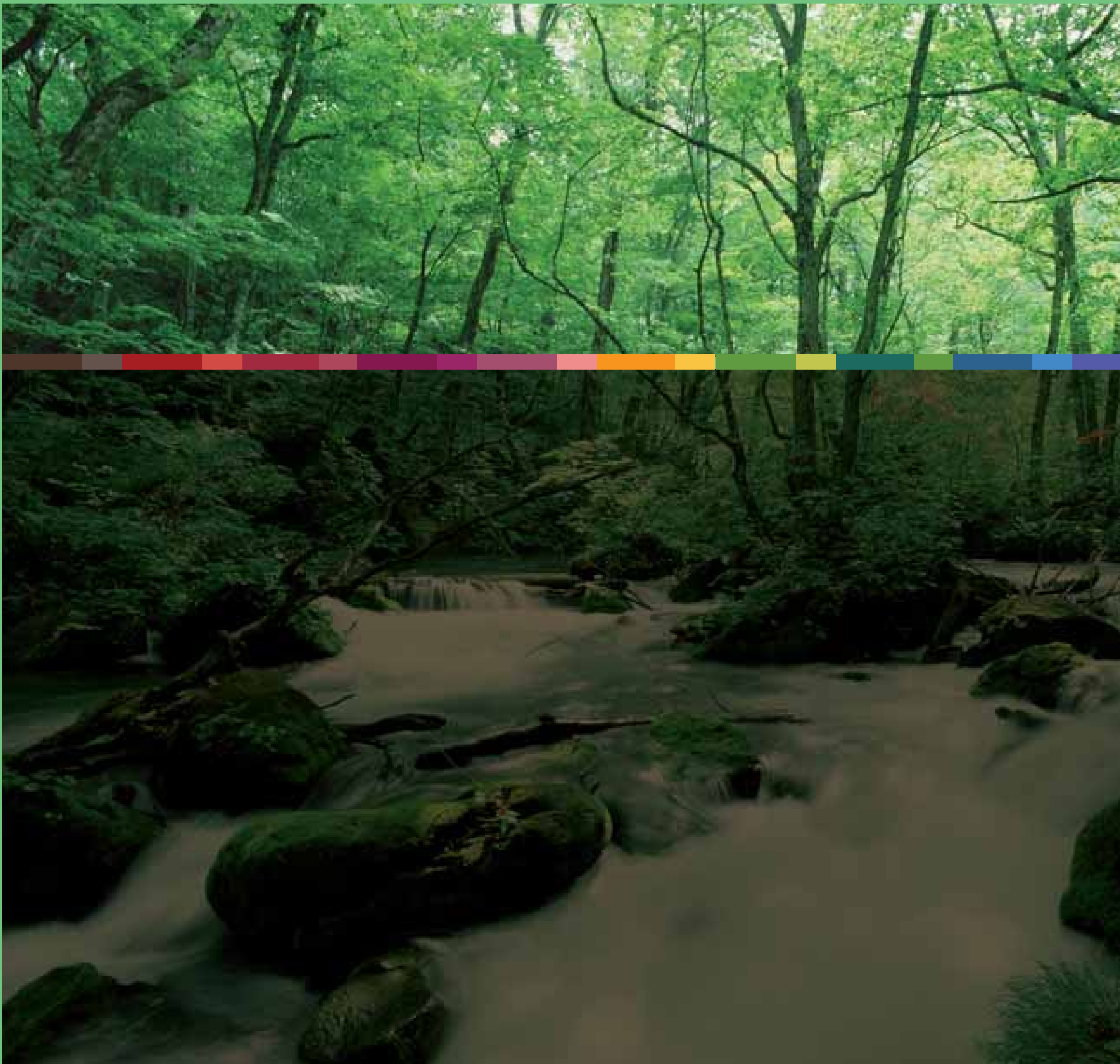
Borrowing services from nature

Methodologies to evaluate ecosystem services focusing on Hungarian case studies



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CONTENTS

AN INTERPRETER BETWEEN PEOPLE AND LANDSCAPES – Zsuzsanna Flachner (1965 – 2010)

Zsuzsanna Flachner was a senior research associate of the Research Institute for Soil Science and Agricultural Chemistry (RISSAC) at the Hungarian Academy of Sciences.She spoke not only English, Russian and Dutch, beside her native Hungarian language; but also the language of waters, living landscapes, the river Tisza and the local people. Everyone with whom she worked appreciated her professional knowledge. She understood also the language of scientists NGOs, politicians, business professionals, teachers and students. She translated for those who did not get along well with or misunderstood each other, helped man and man, man and landscape to find each other again.

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It is difficult even to list the fields she was familiar with. One of her most imported projects was mapping social, economic and environmental interactions. Economists had long advocated for the research of ecosystem services, which she carried out, but it was harder for scientists to accept it. However, she always had an idea how to use research findings to achieve our common goals for building a better world for man and nature.

In addition to all of these, Zsuzsanna Flachner was an activist and community organizer too. She was a woman who loved and made profit of knowledge and cognition, not only for themselves, but always for an additional good cause. She was among the founders of Alliance for the Living Tisza Association (ALT) and she was a member of the organization's advisory board. Moreover, until her death she was the president of CEEweb for Biodiversity as well as a member of other professional organizations. She was awarded Pro Natura Award posthumously in 2011 for coordinating NGOs in nature protection and for her activities in biodiversity conservation in the Tisza region.

She was full of vitality, cheerfulness, creativity, and possessed perfect organizational skills throughout her life. She managed to carry out five to six projects at a time with an incredible working capacity and enthusiasm. She never accepted the obstacles emerged along the way, and thus she made those around her solve seemingly impossible tasks as well. She lived with incredible energy and she was always ready to give greatest human or professional help.

Zsuzsa retained her cheerfulness, hope, vitality throughout her whole life. Until the last moments we never heard any complaints from her. On the contrary, she always talked about the way how she would recover from her long illness. She passed away with dignity, but her life does not remain unfinished. We all painfully miss her, but her thoughts, results, hope and dynamism keep living in us. Initiatives, organizations, and programs she started will continue, led by her fellow workers and friends. Her life remains a part of all of our lives.

Loving friends of her

INTRODUCTION

In the modern societies humans are largely managing the world's natural resources such as soil, fresh water, food, or timber, as limitless, never-ending resources, although once used, their renewal requires time. Over the past few decades, our demand for these resources has grown considerably due to exponential economic growth and population boom. This has put pressure on Earth's ecosystems on an unprecedented scale, including habitat loss and degradation, climate change, biological invasions, overexploitation and pollution. Humankind consumed the ecological resources available for the whole year during less than the first nine months of 2011. The balance of demand-supply collapsed more than one month earlier than it had in 2009.

This excessive demand for natural resources and land result in immense loss of biodiversity, one which is 100-1000 times higher than the background rate. Since all ecosystem services obtained from nature, such as food, fresh water, disaster prevention, soil formation, directly or indirectly depend on biodiversity, halting biodiversity loss has become a centrepiece of environmental policies at all levels. In 2001 the European Union set the target on halting biodiversity loss by 2010, which was translated into global commitment one year later to significantly reduce the rate of biodiversity loss by the same time. But these targets were not met and thus they were revised at global as well as at EU levels.

Reducing pressures that threaten natural systems requires a change in our approach. This change must take place simultaneously at all social and political levels, since it depends on communities of all sizes (settlement, regional, national, EU, UN) in order to protect and maintain biogeographic space in a harmonized way and in cooperation with one other.

Among the drivers behind biodiversity loss, values of society (being cultural drivers) are significant and largely determine the current unsustainable consumption and production patterns. Attitudes towards ecosystem services influence many of our actions, several of which are currently harm the environment directly or indirectly. Therefore, we must balance our values so that we appreciate services provided by nature more and put less emphasis on consumption and material wealth. In this vein, criticism of GDP has been emerging, since this indicator measures only economic growth and does not consider human well-being and the maintenance of natural conditions.

Attitudes towards ecosystems affect not only environmental, but also socio-economic decisions. The main challenge to develop proper policies is to dig down to the bottom of the problems and tackle the drivers behind them, instead of implementing end-of-pipe solutions. Policies should aim to reduce the total human pressure on ecosystems, including the unsustainable use of land and the overuse of natural resources and ecological space. In addition to changing the current harmful practices, political efforts should also aim at restoring degraded ecosystems to improve spatial structures and enhance ecosystem functions.

During formulating and implementing policies, it should be fully considered that natural and socio-economic systems work together inseparably. Each ecosystem on any scale is multifunctional; it provides numerous services to sustain nature as well as human society. Therefore, policies should aim to maintain and harmonize the diversity of ecosystem functions, especially in planning and management. Bearing cultural, institutional and structural drivers of biodiversity loss in mind, even the minor daily decisions of individuals may impact the state of the surrounding landscape, not to mention decisions arising from local and regional spatial planning and development decisions.

In environmental sciences, descriptive and analytical research is increasingly being replaced by systematic-approach, which concentrates rather on the analysis of interactions and cause-effect relationships. This publication aims to show good examples of proper measures and models to evaluate natural values and to integrate them properly into policies. Methods presented in the articles could play fundamental role in decision making, by presenting possible environmental and social consequences of particular policies.

CONCEPTUAL EVOLVEMENT OF THE LANDSCAPE FUNCTIONS ASSESSMENT

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1. Introduction

In environmental sciences, descriptive and analytical research is increasingly being replaced by the system-approach, concentrating on the analysis of interactions; and cause and effect relationships. That is especially true for studies focusing on spatial systems. Both natural units (habitats, ecosystems) and administrative units (land, region, county) have various functions. Every landscape, natural or transformed, provides many services for both nature and for human society. Research dealing with the assessment of the territorial functions and services focuses on the interactions of the natural and human systems. These studies could play a fundamental role in decision making, by representing the possible environmental and the social consequences of policies.

Based on a survey of the literature, this paper gives an overview of the evolution of the concept of landscape functions and proposes a new, coherent classification system for its assessment. This can offer a suitable base to survey multifunctionality and to measure each function and be used in landscape/regional impact assessments and planning.

2. The roots of the landscape function concept

The roots of the landscape function concept go back to the recognition of the multifunctionality of forests and green spaces. The idea of the positive environmental and social impacts and direct and indirect services of vegetated areas emerged in connection with the rapid expansion of built-up areas and the degradation and the endangerment of the natural systems. It became clear that beyond economic welfare, the physiological and psychological services that ecosystems provide are important for our well-being.

The first papers on the environmental role and the beneficial functions of forests are originated from the 1960s. They pointed out the medical and recreational benefits of forests and their positive impact on climate, air quality, water management and soil protection *(Héder and Mészöly 1969; Keresztesi 1968; Mészöly 1981)*. Hungarian foresters defined three basic functions (economic, environmental and recreational) of forests and proposed to acknowledge them as a basic concern in forest management planning. That proposal was accepted at the World Forestry Congress organized in Buenos Aires, in 1972 *(FAO 1972; Lett 2007).*

The description of the functions and services of green spaces can be found in the literature of landscape architecture *(Jámbor et al. 1982; Radó 1981; 2001)*, from the 1980s. Based on these sources, the multiple functions of green spaces was presented in an extended form in the book Environmental Planning *(Konkolyné-Gyuró 2003)* explaining the special ecological conditions of settlements and their various demands for use of green spaces.

The three main function groups of green spaces are: environmental regulation, recreation and provision of information, and aesthetic qualities.

- Environmental regulation: A vegetated surface positively affects the ecological conditions of all living creatures in the settlements (local climate, noise prevention, air and water quality, water management, prevention of qualitative and quantitative soil degradation). The extent of these benefits depends on the extent of the vegetated surface and the quantity of the photosynthesizing leaves.
- Recreation: Another important function of green areas is the provision of adequate space and facilities for outdoor recreation (playing, sports, hiking, relaxing, hunting, fishing, bathing, and healing) in parks, gardens and in urban forests. Nowadays ecotourism has an increasingly important role in providing natural, semi-natural areas away from human settlements.
- Information, aesthetics: Gardens, parks, cemeteries, arboretums, botanical and historical gardens, forests, greenways and study trails along waters and across different habitats play an important role in education, scientific research, dissemination, and perception of landscapes as well as in preservation of the cultural heritage and traditions. The aesthetic role is also significant in all of the green spaces. The aesthetic role is generally understood as an embellishment of the environment, although it has a much broader sense. Aesthetics means a cognitive process through the perception and understanding the place that results in getting information about the place and the whole landscape. It also refers to a positive psychological effect, provided by the pleasant scenery of the vegetation and water, the soft sounds, the climate comfort, and the spiritual associations *(Konkolyné-Gyuró 2003).*

The third precedent has been the concept of agricultural multifunctionality, originated from the first reform of the Common Agricultural Policy of the European Union in 1992 *(Ángyán et. al. 1999).* In this approach (similarly to the three basic functions of the forests) the production, the social/cultural and the landscape/nature-conservation role of agriculture was acknowledged *(EEC 1992).* The European Charter of Rural Areas is an important document, which emphasises the importance of multifunctionality in agriculture. Aside from food production, the document points out the significant role of agriculture in landscape management, in the preservation of rural traditions, heritage and cultural properties as well as in social cohesion *(Szakál 1996).*

A further series of papers has been recently published on this topic. Huylenbroeck's article, published in 2007, gives a comprehensive overview of them. It mentions two main approaches for interpreting and defining agricultural functions. One describes the opportunities and the services that agriculture provides and the other shows its functions from the point of view of social demand.

The author outlines four main function groups of opportunities and services.

- The first one is the „green function" including habitat and biodiversity preservation, the carbon- and nutrient cycle regulation and landscape management.
- The second is the "blue function" comprising the benefits related to waters and energy generation. The most important are: water retention, water quality control, and flood-prevention, as well as generation of hydropower and wind energy.
- The third group is the "yellow function", the cultivation, contributing to the rural areas vitality and cohesion, the utilization and maintenance of rural cultural heritage and traditions as well as the preservation of regional identity. The "yellow function" includes hunting, agro-tourism, and other forms of recreation.
- Finally several authors mention the "white function", which means food safety.

Looking at the multifunctionality of forests, green spaces and agriculture, their common ground becomes evident. All three are vegetated spatial units and ecosystems even if they are not all natural. Diversity within and between habitat types of a region plays an important role in multifunctionality. The more elements the system has, the more functions it can provide. Therefore attention should be turned towards ecosystem services and landscape functions.

3. Ecosystem services and functions of rural areas

Recommendations for the survey and evaluation of ecosystem functions and services were published in the Millennium Ecosystem Assessment *(MEA 2003).* The core idea of this report is the recognition of the strong connection between the condition of ecosystems and human well-being. Based on several previous studies, it summarizes the functions and services that ecosystems can provide for humans. These include the role of sustaining biophysical systems on Earth that create suitable living conditions for all living creatures and provide natural and social benefits for humanity. All these goods and services are called natural capital *(e.g. Costanza et al., 1997; de Groot et al. 2002).*

The existence of human society is inherently linked to landscapes or regions. Therefore, the investigation of ecosystem functions has to address all services provided by both natural and transformed ecosystems in a certain landscape or region. This idea led to the assessment of landscape functions. At the beginning, landscape multifunctionality studies focused on rural areas and applied unchanged function groups formerly used for assessing ecosystem services. In rural landscapes, where land cover is mostly semi-natural, ecosystem and landscape functions are highly similar to the services provided by natural areas.

A wide range of goods and services are reviewed in publications concerned with ecosystem and landscape functions *(de Groot 1992; 2000; Bastian 1996; Costanza et al. 1997; Daily et al. 2000; MEA 2003).* Despite some differences, the classifications distinguish three main function groups: regulation and conservation (environmental regulation, habitat protection); production and provision (primary biomass production and provision of territory for different human activities); and recreation, information (mental and physical recreation, aesthetic values and information about the cultural and natural heritage). Based on his former publications *(de Groot 1992; de Groot et al. 2002)* de Groot describes five function groups:

- Regulation functions: This group of functions relates to the capacity of natural and semi-natural ecosystems to regulate essential ecological processes and life support systems through biogeochemical cycles and other biospheric processes. Regulation functions maintain a 'healthy' ecosystem at different levels and, at the biosphere level, provide and maintain the conditions for life on Earth. In many ways, these regulation functions provide the necessary pre-conditions for all other functions. Thus, care should be taken not to double count their value in economic analysis. In theory, the number of regulation functions would be almost infinite. But for landscape planning, only those regulation functions, which have direct and indirect benefits to humans (such as maintenance of clean air, water and soil, prevention of soil erosion and biological control services) are considered to provide services,

- Habitat functions: Natural ecosystems provide refuge and reproduction-habitats for wild plants and animals and thereby contribute to the (in situ) conservation of biological and genetic diversity and evolutionary processes. As the term implies, habitat functions relate to the spatial conditions needed to maintain biological (and genetic) diversity and evolutionary processes. The availability, or condition, of this function is based on the physical aspects of the ecological niche within the biosphere. These requirements differ for different species groups, but can be described in terms of the carrying capacity and spatial needs (minimum critical ecosystem size) of the natural ecosystems.
- Production functions: Photosynthesis and nutrient uptake by autotrophs converts energy, carbon dioxide, water and nutrients into a wide variety of carbohydrate structures, which are then used by secondary producers to create an even larger variety of living biomass. That biomass provides many resources for human use, ranging from food and raw materials (fiber, timber, etc.) to energy resources and genetic material.
- Information functions: Because most of human evolution took place within the context of undomesticated habitat, natural ecosystems provide an essential 'reference function' and contribute to the maintenance of human health by providing opportunities for reflection, spiritual enrichment, cognitive development, re-creation and aesthetic experience.
- Carrier functions: Most human activities (e.g. cultivation, habitation, transportation) require space and a suitable substrate (soil) or medium (water, air) to support the associated infrastructure. The use of carrier functions usually involves permanent conversion of the original ecosystem. Thus, the capacity of natural systems to provide carrier functions on a sustainable basis is usually limited (exceptions are certain types of shifting cultivation and transportation on waterways, which, on a small scale, are possible without permanent damage to the ecosystem)" *(de Groot 2006).*

Although de Groot's concept of functions and services provided by rural landscape is becoming crystallized and many research projects have been carried out on this basis, there are still several methods for the assessment and valuation of landscape functions. One possibility is the participative function valuation controlled by experts. The other is the dynamically developing GIS assessment. A good example for the first one is the landscape function valuation in Ukraine in the delta of the Dniestr River. In this research the significance of each landscape function has been defined at a workshop with the participation of local people and stakeholders. The possible future changes in the functions has been also revealed and used for the presentation of land-use conflicts (Figure 1).

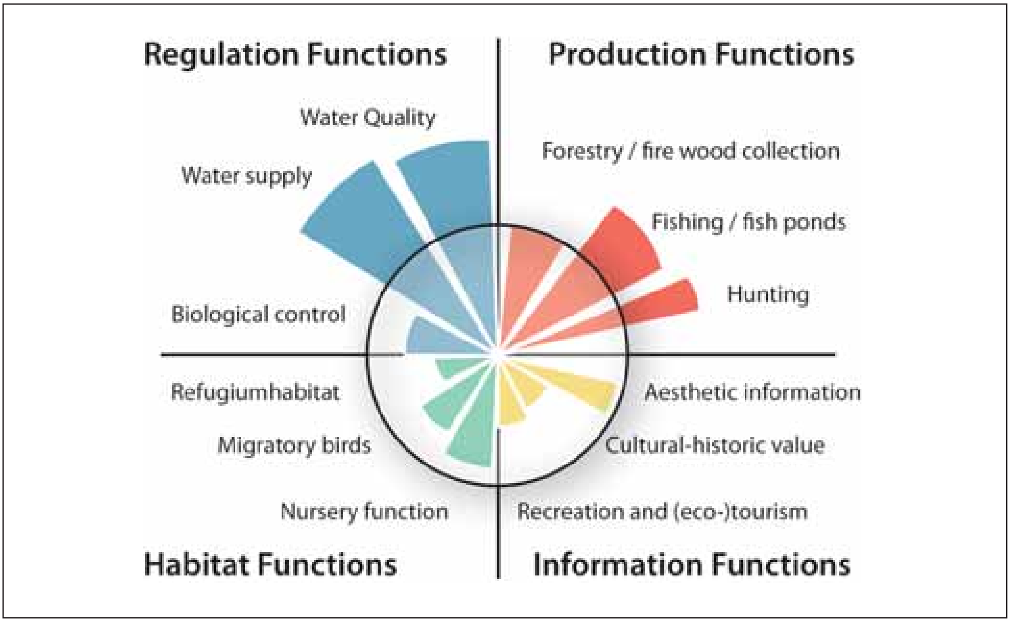

Figure 1: Main issues at stake in the Dniestr delta conflict analysis *(de Groot 2006).*

Some recent papers focus on GIS methods for assessing landscape functions. These studies do not take into account all functions but focus on some selected ones related to land use potentials and changes *(Willemen et al. 2008; Verbung et al. 2009).*

Knowledge about ecosystem services and landscape functions might effectively support decision making and planning because it provides transparent information about the changes and threats of the natural and cultural goods and services provided by living systems (Figure 2).

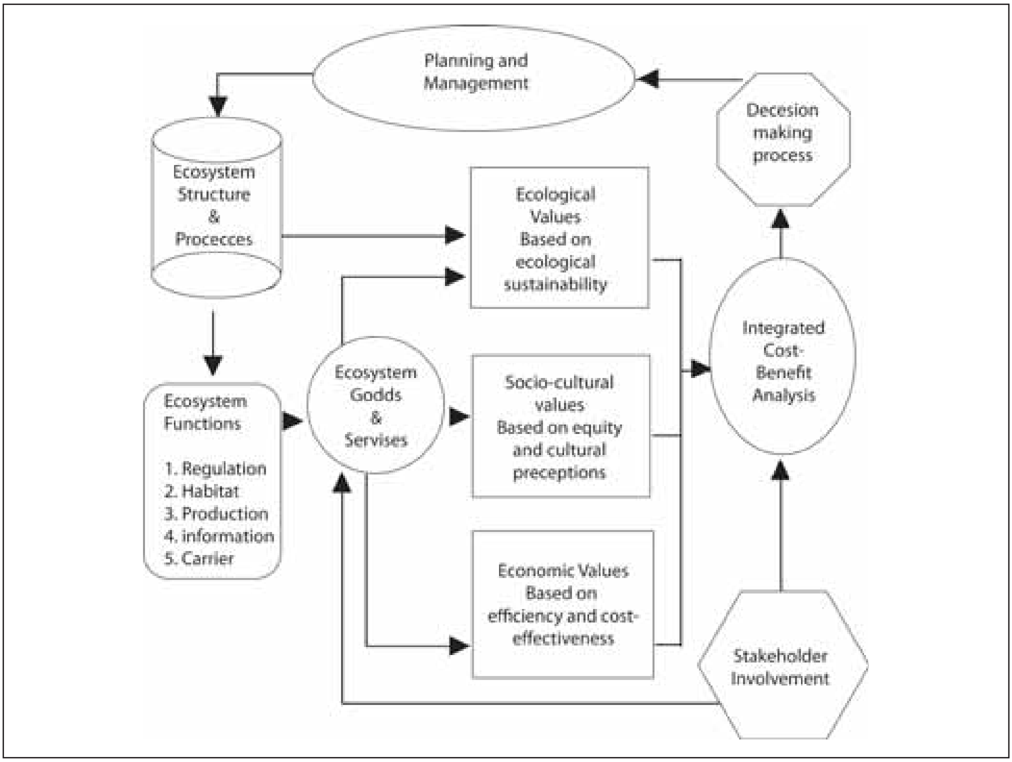

Figure 2: Role of function-analysis and valuation in environmental planning, management and in decision-making after de Groot 1992; de Groot et al 2002 *(de Groot 2006)*.

4. Land use functions

An overview of the presented functions makes it obvious that some of them, e.g. production provision of space and recreation, are inherently linked to the human use. Without human activities, they exist only as potentials. In the landscapes that are transformed by human activities, the role of different land uses and artificial surfaces have to be taken into account beyond the eco-system services. It is not only goods and services are present in the landscape, but also the driver functions of the land uses and the related land cover types. They are called "land use functions" in research reports and papers *(SENSOR 2009; Perez-Soba et al. 2008).* This concept has been established within the European integrated research project SENSOR, aiming to develop an ex-ante sustainability impact assessment tool. Nine land use functions (Table 1) have been chosen that refer to three function-classes: "mainly societal" "mainly economic" and "mainly environmental" land use functions.

Functions Mainly **SOCEITAL**	Functions Mainly **ECONOMICAL**	Function Mainly **ENVIRONMENTAL**
Provision if work	Residential and Land-Independent production	provision of abiotic resourses
Human health & recreation	Land-based production	Support and provision of biotic resourses
Cultural	Transport infrastructure	Maintenance of ecosystem processes

Table 1: The nine land-use functions, LUFs *(SENSOR 2009).*

"The definitions of the LUFs are as follows:

Mainly societal LUFs

- LUF 1 Provision of work: employment provision for all in activities based on natural resources, quality of jobs, job security and location of jobs (constraints e.g. daily commuting).
- LUF 2 Human health & recreation (spiritual & physical): access to health and recreational services, and factors that influence the quality of services.
- LUF 3 Cultural (landscape identity, scenery & cultural heritage): landscape aesthetics and quality and values associated with local culture.

Mainly economic LUFs

- LUF 4 Residential and land-independent production: provision of space where residential, social and productive human activity takes place in a concentrated mode. Utilisation of space is largely irreversible due to the nature of activities.
- LUF 5 Land-based production: provision of land for production activities that do not result in irreversible change, e.g. agriculture, forestry, renewable energy, land-based industries such as mining.
- LUF 6 Transport infrastructure: provision of space used for roads, railways and public transport services, involving development that is largely irreversible.

Mainly environmental LUFs

- LUF 7 Provision of abiotic resources: the role of land in regulating the supply and quality of air, water and minerals.
- LUF 8 Support and provision of biotic resources: factors affecting the capacity of the land to support biodiversity, in the form of genetic diversity of organisms and diversity of habitats.
- LUF 9 Maintenance of ecosystem processes: the role of land in the regulation of ecosystem processes related to the production of food and fibre, the regulation of natural processes related to the hydrological cycle and nutrient cycling, cultural services, and ecological supporting functions such as soil formation" *(SENSOR 2009)*.

Different indicators have been introduced to measure the performance of land use functions in the different land use change scenarios in each European region. The result of these valuations is presented in spiderweb diagrams. An example is shown in Figure 3.

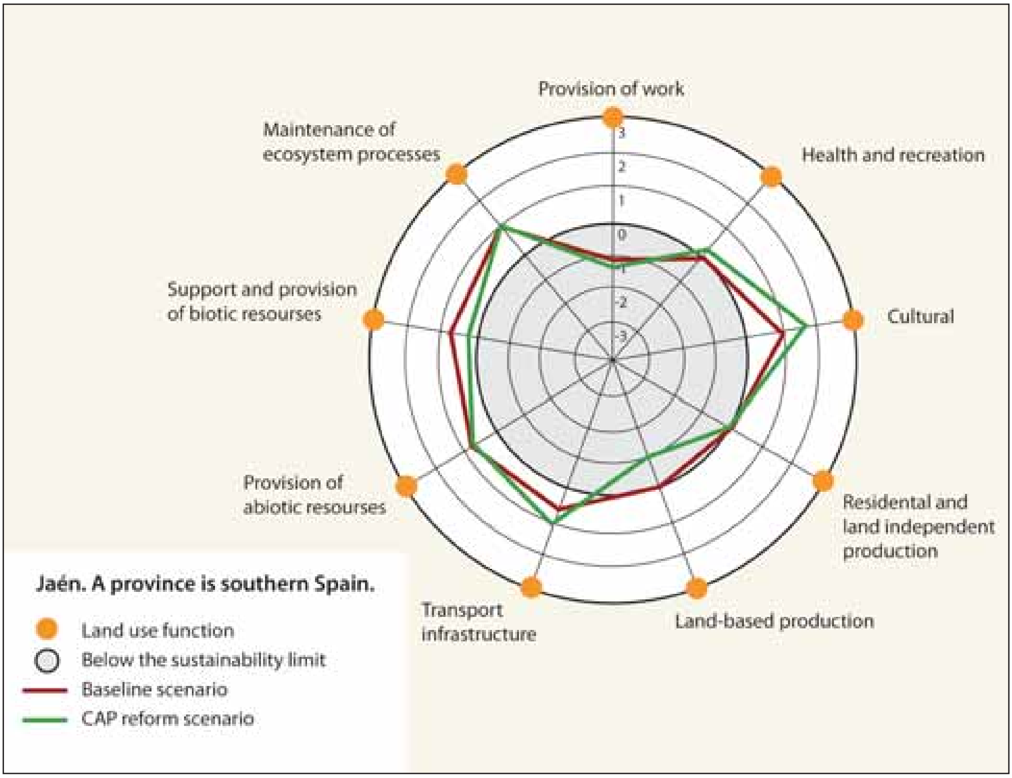

Figure 3: Sustainability assessment can be represented by a spiderweb diagram that shows the performance of the nine LUFs under different scenarios (SENSOR 2009).

5. Active and passive functions

Looking at the core idea of these approaches, an important aspect emerges, namely the existence of or lack of human contribution to these functions. Accordingly, we can distinguish between three types of roles. Firsts are the regulation and life sustaining functions of the natural systems (environmental regulation, habitat protection). Second are the potentials of the landscape (biomass, raw material production and opportunities for different land uses as well as provision of information and aesthetic qualities). They exist as goods or potential goods provided by the nature that have significance only due to human use. The third group of functions includes the services provided by human activities (settlements, infrastructure, recreational facilities and farm land etc). The basic difference between the first two and the third group is the human contribution. Natural systems are able to function independently from people. The potentials exist without any social utilization. Therefore functions of the first two groups are called passive functions, whereas functions in the third group, originating from the use of their potentials are called active functions.

In this chapter we recommend a system for the valuation of ecosystem services ("rural landscape functions"), land use and landscape functions by introducing the terms of active and passive functions. The passive and active functions exist together both in the cultural and natural landscapes.

5.1. Passive functions

Passive functions are potentials of nature, which can exist without human activity and act through the processes of natural systems. They are goods and services arisen from ecosystems.

5.2. Active functions

Active functions exist only through active human contributions. They are land-use functions of the transformed landscapes in artificial areas (settlements, agricultural areas and mines, recreation and infrastructural areas). In addition to the passive functions, these active landscape functions are equally important for human life.

I.1. Biophysical functions

I.1.1. Atmospheric regulation, air protection
- I.1.1.2. Gas, ozone regulation
- I.1.1.3. Climate regulation

I.1.2. Water regulation, protection
- I.1.2.1. Water protection and retention
- I.1.2.2. Provision of water supply
- I.1.2.3. Flood prevention

I.1.3. Soil protection
- I.1.3.1. Soil formation
- I.1.3.2. Soil water management regulation
- I.1.3.3. Erosion control
- I.1.3.4. Deflation control

I.1.4. Conservation of biological system and biodiversity
- I.1.4.1. Refugium
- I.1.4.1. Habitat
- I.1.4.2. Pollination
- I.1.4.3. Biological control

I.1.5. Production of biomass
- I.1.5.1. Food
- I.1.5.2. Raw materials for industry
- I.1.5.3. Medical materials
- I.1.5.4. Energy source

I.1.6. Complex functions
- I.1.6.1. Regulation of material flow
- I.1.6.2. Disturbance prevention
- I.1.6.3. Natural regeneration

I.2. Information, psychological functions

I.2.1. Information
- I.2.1.1. Scientific information, education
- I.2.1.2. Reference for functioning of biological systems
- I.2.1.3. Genetic information

I.2.2. Psychological conditioning
- I.2.2.1. Aesthetic experience (cognitive, artistic)
- I.2.2.2. Historical, spiritual information
- I.2.2.3. Human psychological recreation

Table 2: Passive landscape functions

II.1. Settlement

II.1.1. Living
- II.1.1.1. Urban living
- II.1.1.2. Rural living

II.1.2. Central, administrative
II.1.3. Defence
II.1.4. Human infrastructure/services
- II.1.4.1. Culture, heritage protection
- II.1.4.2. Education
- II.1.4.3. Science
- II.1.4.4. Health care

II.2. Production

II.2.1 Agricultural production
- II.2.1.1. Arable land cultivation
- II.2.1.2. Grassland pasturage
- II.2.1.3. Viticulture
- II.2.1.4. Horticulture
- II.2.1.5. Fishery, reed extraction
- II.2.1.6. Hunting

II.2.2. Forestry
II.2.3. Industry – mining
- II.2.3.1. Industrial production
- II.2.3.2. Energy production
- II.2.3.3. Raw material extracting

II.3. Infrastructure, communication

II.3.1.Transport
- II.3.1.1. Road transport
- II.3.1.2. Railway
- II.3.1.3. Navigation
- II.3.1.4. Aviation

II.3.2. Technical infrastructure
- II.3.2.1. Public utilities
- II.3.2.2. Waste management

II.4. Recreation, tourism

II.4.1. Water related recreation
- II.4.1.1. Recreation at lakes
- II.4.1.2. Recreation at rivers and streams
- II.4.1.3. Spa recreation
- II.4.1.4. Recreation at sea

II.4.2. Recreation in green areas
- II.4.2.1. Recreation in forest
- II.4.2.2. Recreation at agrarian and horticultural area
- II.4.2.3. Recreation in parks

II.4.3. Special recreation/ tourism forms
- II.4.3.1. Ecotourism
- II.4.3.2. Rural tourism
- II.4.3.3. Cultural tourism
- II.4.3.4. Cycling tourism
- II.4.3.5. Winter-sport/recreation
- II.4.3.6. Wine and gastro-tourism

Table 3: Active landscape functions

6. Conclusions

Natural and socio-economic systems work together inseparably. Every landscape, parish or region is multifunctional, providing numerous services to sustain nature as well as human society. The diversity of functions and their relative importance can greatly differ amongst landscapes with different bio-physical characteristics and land uses types. The diversity of the functions in different territories has to be maintained and harmonized in policies, especially in planning and management. We continuously seek to resolve conflicts, to generate beneficial co-existence of utilizations resulting in a cooperative prosperity. Landscape function analysis is a useful tool for balancing interests and provides important information for decision making and planning, mainly for sustainable development strategies.

According to these concepts, it is clear that till today the functions and services of natural, semi-natural ecosystems and areas transformed by human activities used to be analyzed and evaluated separately. Nevertheless in reality, they interact with each other. Application of the proposed classification of active and passive functions provides a logical framework for analyzing the landscape functions in a coherent system.

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THE INVENTORY STATE AND ASSESSMENT OF HUNGARY'S NATURAL HABITATS IN TERMS OF ECOSYSTEM SERVICES


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1. Introduction

In 2006 humanity's ecological footprint was 1.4 times larger than the current carrying capacity of Earth. Our footprint in the beginning of the 1960's was only the area of 0.6 Earth, but for the last 50 years it has been constantly rising, indicating the alarming trend of consumption. Hungary's index, like that of every other country in Europe, is also higher than 1; in 2006 it was 1.25 *(Ewing et al. 2009).* Humanity's living conditions and the production of world economy inseparably depend on the natural renewal capability (maintenance), and the functioning of ecosystems *(MEA 2005).* The overuse of the living natural environment's ecosystem services means an increasing threat to human well-being at both global and local scale. Their maintenance and the protection of their functioning capability is a vital question, and not only in terms of nature conservation.

The facilities of different regions, countries and lands are very diverse *(Kocsis and Schweitzer 2011; Pásztor et al. 2010)*. The pattern of ecosystems and their utilisation are not uniformly distributed. From this point of view the results of program MÉTA provide new and fundamental knowledge about the country's ecological state *(Molnár et al. 2009).*

The objectives of program MÉTA (Landscape Ecological Vegetation Mapping of Hungary) are:

- comprehensive assessment of the current state and patterns of natural, semi-natural vegetation of Hungary,
- understanding the land use and risk factors, which determine the state and survival of vegetation,
- scientific assessment of our heritage of natural, semi-natural vegetation,
- developing our landscape ecological approach and knowledge.

With this new, comprehensive information, the maintenance of ecosystems and optimal, more conscientious land use patterns becomes possible. We could also stand to gain protection of our natural heritage and its value. In this study, we provide views of the inventory of our vegetation, and we examine the possible use of ecological knowledge in landscapes by evaluating ecosystem services nation-wide. We broadly present local examples, illustrate the concept of relationships between land use, habitats, and ecosystem services and present two long-term research programmes that give a perspective on a more accurate evaluation of ecosystem services.

2. Land use and ecosystem services

The condition and functioning of ecosystems –the quality and quantity of services they provide – basically depends on the ecological characteristics of landscape, and on the extent and nature of land use. Figure 1. shows general trends of relations between land use and ecosystem services. Extensive use of the landscape changes the functioning of different services, what leads to higher total value for human population. Intensive land use (primarily market-farming) alters the general nature of the landscape to high-level supplying services, while other services of agro-ecosystems dramatically relapse *(Braat and Ten Brink 2008)*. Building-up an area, severely reduces the level of services, since maintaining cities, towns and human infrastructure is very costly, and usually at the expense of near-natural areas and rural services. Several different compromises and aspects of optimization are possible in land use: in space and/or time; private landowner and/or community point of view *(EASAC 2009).*

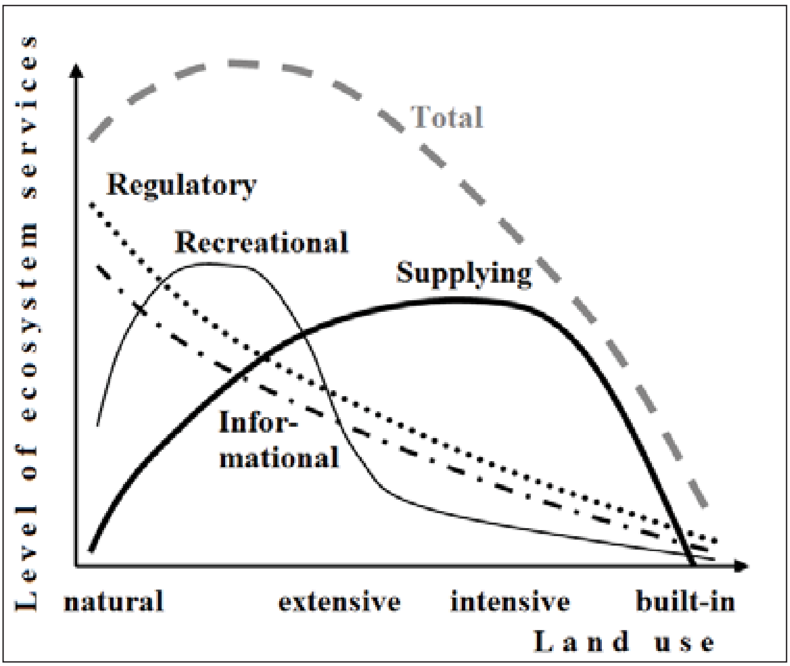

Figure 1: Rate and run of the main types of ecosystem services in the light of land use intensity (based on Braat and Ten Brink 2008).

3. The inventory of Hungary's natural habitats, their conditions and landscape patterns

Program MÉTA provides data primarily about natural, near-natural or extensively used lands, but since the landscape pattern and the pattern of land use are patchy and mosaic, a large area of the country is affected directly. 62% of the units covered by Program MÉTA *(Bölöni et al. 2007, Molnár et al. 2007)* still consists remnants of vegetation, while 38% of them are covered only by plantations, agricultural, industrial or urbanized lands. In their area with radius of 335 metres nothing has remained from original ecosystems *(Horváth et al. 2008).*

In terms of our vegetational heritage we distinguish 86 habitat types *(Bölöni et al. 2007)* that we classify into 18 habitat groups *(Molnár et al. 2008).* Since these groups can be interpreted easily as ecosystem-types, their nationally aggregated extents have been chosen as a basis of the inventory. For reviewing the status of the habitats we use naturalness and the Natural Capital Index (NCI*lin*), which is especially capable to be an universal, quantitative indicator of different regulatory ecosystem services (such as carbon sequestration, soil forming, micro-climate developing, or maintaining the populations of natural enemies, regulators of agricultural pests) *(Czúcz et al. 2008; Czúcz et al. 2011).* The landscape patterns are introduced on maps.

3.1. National inventory of habitat groups

In Hungary, based on the survey of program MÉTA, the total area of natural, near-natural and degraded vegetation is about 1 800 000 hectares, and it covers 19.4% of the country (www.novenyzetiterkep.hu – national data). Within that, 1 200 000 hectares show the characteristics of the near-natural vegetation, 600 000 hectares were degraded featureless by the recent changes. The present vegetational heritage of Hungary is seriously degraded in 17.3%, and 46.8% of the national territory is intermediately degraded, 32.6% is near-natural, only 3.3% of it is natural *(Bölöni et al. 2008).* Besides the loss of a part of habitats, and the deterioration of the remainings (loss in the stock of species, degradation in the composition of species and the structure of associations) contributed to the decay of natural heritage. Concerning all these effects on one stock, we express it by the vegetation-based Natural Capital Index (NCI-lin), which is currently 9.9%. It means that, only 1/10 of the natural ecosystems

Habitat groups (Á-NÉR 2003 codes)	**Extent in the country (hectare)**	**Natural Capital Index (%)**
Euhydrophyte habitats (A1 - A5)	9 730	0.07
Marshes (B1 – B6, BA)	117 170	0.74
Flushes, transition mires and raised bogs (C1, C23)	14	0.00
Rich fens, eu- and mesotrophic meadows & tall herb communi-ties (D1 – D6)	100 670	0.59
Colline and montane hay meadows, acid grasslands and heaths (E1 – E5)	29 330	0.16
Halophytic habitats (F1 – F5)	202 060	1.30
Dry open grasslands (G1 – G3)	11 970	0.07
Dry and semi-dry closed grasslands (H1 – H5)	95 820	0.52
Non-ruderal, pioneer habitats (I1 – I4)	380	0.00
Shrublands (J1a, J3, P2a-b, M6 – M8)	70 200	0.37
Riverine and swamp woodlands (J1b, J2, J4 – J6)	66 220	0.40
Mesic deciduous forests (K1a, K2, K5, K7a-b)	346 740	2.17
Closed deciduous woodlands (L1, L2a-b,x L4a-b, L5)	204 690	1.21
Rocky woodlands (LY1 – LY4)	8 600	0.06
Open steppe (oak) woodlands (M1 – M5)	6 050	0.04
Coniferous mixed woodlands (N13, N2)	1 320	0.01
Other, non-woody habitats (OA, OB, OC)	265 240	1.06
Other woodlands and woody habitats (RA, RB, RC, RD, P45, P7)	263 800	1.13
TOTAL	**1 800 000**	**9,9**

Table 1: Inventory of Hungary's habitat-groups, based on program MÉTA's results: their estimated extension in the country, and their percental contribution to the national Natural Capital Index (NCI*lin*)

once covered the country has remained. In a functional point of view, we lost 90% of the capacity of regulating ecosystem services (while the supply service of agricultural ecosystems is high). The total extent of habitat groups in Hungary and the value of Natural Capital Index (NCI*lin*) they represent are summarized in Table 1.

The numbers of Table 1 show that the highest Natural Capital values belong to the mesic deciduous forests (2.17%), the halophytic habitats (1.3%) and the light-rich, closed deciduous woodlands (1.21%) – because of their extent and their more natural status. We can find (about 529 000 hectares) degraded habitats (categories like: other, non-woody habitats; other woodlands and woody habitats) on very large areas, their average naturalness is lower, and because of this, they give an important, but still lower proportion of natural capital (1.06% and 1.13%).

3.2. Inventory and status of landscape vegetation

The landscape pattern is also an important feature of vegetation. For reviewing this, Király et al. (2008), partially based on the results of MÉTA database, compiled Hungary's vegetational landscape. However, MÉTA database is not only suitable for comparing a priori-defined landscapes, but also for separating independent landscapes, and for marking vegetation-based landscape borders. Csaba Molnár and his colleagues divided the country into 95 areas, in terms of natural vegetation, most uniform „vegetation-based landscape regions" *(Molnár Cs. et al. 2008)*. For introducing the vegetation heritage of these landscape regions, we made a summary, (in the form of a map) of near-natural vegetation and Natural Capital Index per landscape (Figure 2, 3).

As we can see in Figure 2, especially the forested parts of our mountains, and the larger grasslands and wetlands of Hortobágy are covered with vegetation, while the larger regions of Alföld and Kisalföld (and the foothill zone of the northern mountains) lost almost completely their near-natural character. The least vegetation cover (lower than 5%) can be found at Érmellék, Hegyalja, Győr – Tata terrace region and Igmánd – Kisbér plain, Mosoni plain, Felső-Bácska, Hajdúság and Mezőföld regions, where the value of NCI is only about 1-2% (Figure 3). Coverage exceeds 50% only in landscape units of summits, North-Börzsöny, Visegrád Hills, Vértes and Gerecse, South-Vértes and the South-Bakony. Natural Capital Index exceeds 30% in each of the case in these landscape units. Otherwise, that index was higher than 40% only in case of summits (51%) and North-Börzsöny (42%).
Figure 2: Average vegetation cover of our vegetation-based landscape regions.

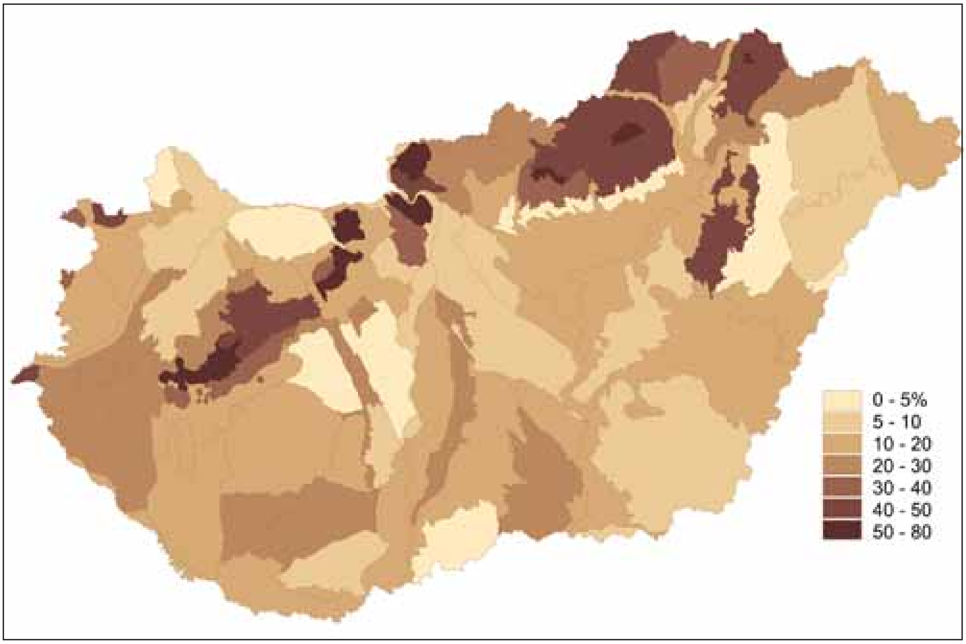

Figure 2: Average vegetation cover of our vegetation-based landscape regions.

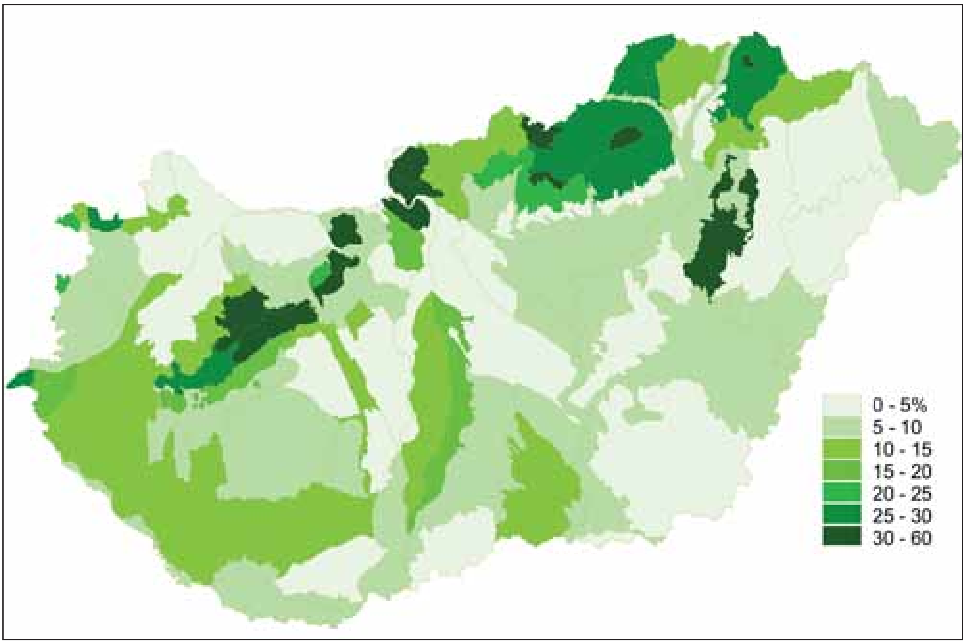

Figure 3: Natural Capital Index of our vegetation-based landscape regions.

3.3. Examples for the main types of land use

Below we list some typical examples of the main categories of land use from Figure 1.

- A near-natural landscape, Bükk-plateau – The vegetation is mainly dominated by mountain beech forests. Diverse rock forests have formed on the rocky ridges. On the southern rock formations open rocky grasslands and steppes are dominant. Planted coniferous woods are significant in scope (spruce mainly). As a result of century-old traditional land use and human activity (hay making) extensive, rare species-rich mountain meadows have been preserved. The number of plant species is between 1000-1200; the number of protected plants is more than 120; the number of invasive species is very low, and their role is not significant *(Vojtkó 2008).*

- An extensively used landscape, Bugac region – This is a cultivated sandy landscape, its level of modification is varying, and its farm culture is declining. Its vegetation cover is small or medium, natural or semi-natural. Poplar woods, oak woodlands, and sandy grasslands can be considered as the remains of the former forest steppe woodlands. Between the arable fields, orchards and abandoned areas, Molinia meadows, high reed beds, tussock sedge communities are lying in the low-lying parts mosaic of wet meadows with the occasional fragments of surviving willow swamps, swamp forests, salt lakes, dense and tall Puccinellia swards, salt marshes, and meadows. Many rare and unique species enrich the flora. The total number of plant species varies between 600-800; number of protected plants is between 80-100. Invasive weeds spread mostly in secondary sandy habitats and disturbed wetlands; their number is high and their effect on these ecosystems is significant *(Vidéki and Máté 2008).*

- An intensive agricultural farming utilized land, Bácska Loess Plain – Due to its excellent soil, this is a mostly plowed and intensively farmed landscape. On the sandy margins, significant areas are covered by species-poor fallows and plantation forests of mostly alien species. The remaining fragments of natural vegetation are determined by the transitions of different proportions of loess and sand. Many of the salt lakes have been drained, their basin is filled with salt meadows. The annual salt pioneer swards have mostly remained in their natural state. The previously dominant loess grasslands, except for one or two remnants, are pushed back to the basin-walls of former salt lakes and to the balks between the arable lands. Only a little stock of the forest-steppe meadows and the vegetation of loess-walls remained, continental deciduous steppe-thickets are almost completely gone. The original sand vegetation has been almost completely eliminated. Only little bits of Molinia marsh meadows have remained. The vegetation of brooks and the marsh meadows supporting them are generally in a favorable natural condition. Infections of invasive species are primarily significant in sandy areas; the regenerative capacity of the landscape is weak, except for the aquatic or halophytic habitats. In addition, the number of plant species is quite high, namely between 800 and 1000, however, the number of protected species is low varying between 20 and 40. The number of invasive species is high, and their impact is sometimes significant *(Csathó 2008).*

- A heavily built-up landscape, Vác–Pesti Duna plain – The largest part of the landscape is dominated by agricultural areas, plantations, planted forests, sand- and gravel mines, and towns or different buildings – primarily in Budapest and in its agglomeration zone. Natural or near-natural vegetation remains only in a small part (5-6%). A significant part of the landscape is floodplain, and although the pioneer vegetation of the reefs, and the entire river zonation (mostly willow, soft wood- and hardwood groves) are present, there are only fragments remaining of the latter. Willows and poplars are in a better state, but they are degraded in many places, and in other places they have been replaced by cultivated poplars. At the edges of the groves we find floodplain meadows, marsh meadows, and rarely moorlands. In the small branch of the Danube, islands with natural state have developed. In some areas, fragments of opened sand grasslands and closed steppe grasslands can be found. Sometimes sandy oak woodland inclusions can be detected between black locust, pine and poplar plantings. The estimated number of the remained plant species is between 400 and 600, number of protected plants varies between 40 and 60, the number of invasive species is high, and their effect is significant *(Csomós 2008).*

4. Habitats or ecosystems?

Both habitat and ecosystem approaches have their own justification. Although our approaches are different, usually we talk about the same things, from a different perspective. Habitats, according to Fekete et al. (1997) can only be interpreted in terms of organism or a group of organisms, and separate classification could be created for each organism. The National Habitat Classification System used in program MÉTA was formed according to plant associations appearing at similar or at same conditions *(Á-NÉR, Fekete et al. 1997; Bölöni et al. 2003; Bölöni et al. 2007)*. In the ecosystem-based approach, function of these systems (flow of mass and energy, production) is under consideration, but the diversity of species that build up and operate the system is pushed into the background. It is rather difficult to capture „natural entity", which has a temporary and undefinable nature. Operational units are used, like in habitat mapping *(Takács and Molnár 2009)*, or land cover mapping and classification *(Büttner et al. 2001)*. For determining of operational units, it is very beneficial if they can be „put together" by aggregating well-defined components. For example, the ecological footprint-calculations are linked to a very broad range of land use types (agricultural cultivated fields, pastures, fishing areas, forest management areas, built-up areas). To determine them, databases working with more detailed categories are used *(Ewing et al. 2009)*. In case of Hungary, for example, the CORINE Land Cover database *(Büttner et al. 2001)* or the Kreybig Soil Information System *(Szabó et al. 2007)* databases are used.

Well-documented and broadly applied habitat classification system, and the MÉTA database that appropriately describes the landscape conditions, provide sound bases for the development of an operational ecosystem-classification. Another advantage of this approach is that it establishes a connection between ecosystems, populations and habitats. As in case of each habitat categories we know well the flora and fauna communities building up them, and site requirements *(Babos 1954; Borhidi 2003; Bölöni et al. 2003; Fekete and Varga 2006).*

5. Case studies

If we would like to get a more accurate picture related of the functioning of ecosystems – and of ecosystem services – estimating and measuring basic operating parameters are needed. We are aware of many similar tests and their results *(Jakucs 1985; Précsényi 1970, 1975; Stefanovits et al. 1981).* Here we give a report about two currently running programs, which have results that can be integrated into the conception of understanding ecosystem services.

5.1. The relation between production and diversity of vegetation in a diverse area of Kiskunság

As part of Kiskun LTER *(Kovács-Láng et al. 2008)*, there is a 3x3 km research area, mostly belonging to Kiskunság National Park's Orgoványi Meadows. Here they run a monitoring process to follow the production and diversity, especially with regard to the relationship between weather and production *(Kertész and Ónodi 2008)*. The main challenge of the investigations is the diversity and mosaic pattern of the area. From poplar-juniper woodlands, through abandoned farm sites to marsh and reed beds almost every kind of habitat can be found at the site, which is typical in case of Kiskunság Sand Ridge. Therefore, a combination of different sampling methods is necessary to conduct landscape-level estimations.

The monitoring began in 1999, with the preparation of an overview map of the site, which was clarified in 2002. The field sampling began in 2000, and the complex sampling method had formulated by 2003. As a result of the monitoring, we can give an annual estimation of the underground and aboveground biomass of more important habitats, and of the Leaf Area Index (LAI). For the estimation, we create a calibrational database for each species with specific leaf area measurement, form yearly 30-35 cut turf samples. Besides, we estimate Normalized Difference Vegetation Index (NDVI) annually on about 120 points with multispectral measurements. In woodland habitats we measure leafage cover on about 60 points with LAI2000 instrument to estimate LAI directly. Based on the measurement data, we create annually an estimation for the underground and aboveground plant biomass and LAI of different land use types, and then assign them to the patches of the habitat map. In addition, in

2004, a representative sampling of plants was carried out in the area in 106 4x4 m quadrats, where we recorded the species, visually estimated the cover of different plant species, and measured leaf area with LAI2000 instrument. As a result, we have a good overview of several ecosystem properties' pattern. As an illustration, we present the 2008 pattern of one of the defining elements of production, the Leaf Area Index (Figure 4).

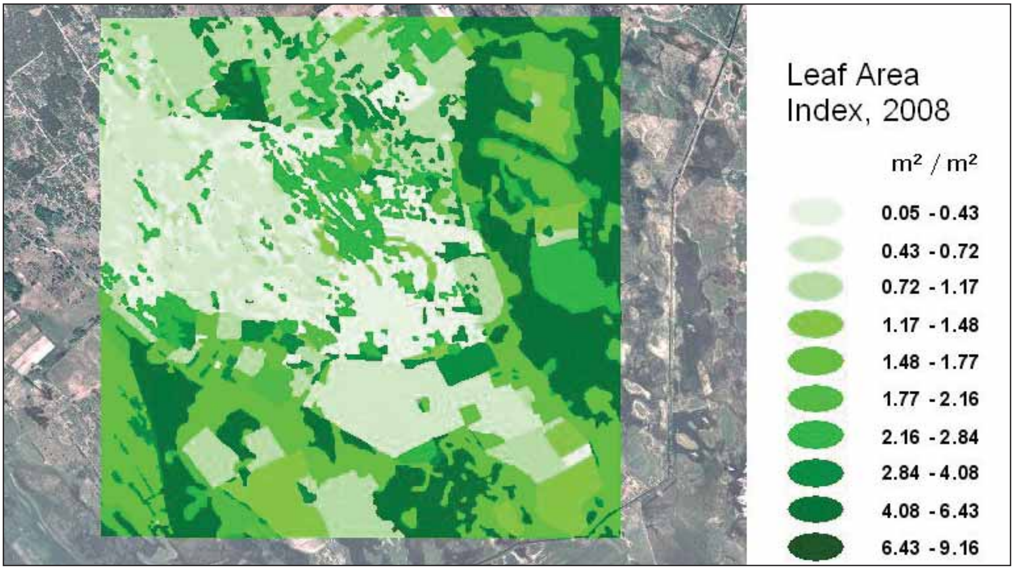

Figure 4: Leaf Area Index of KISKUN LTER's Orgovány research area in 2008.

Primary production is one of the most notable index of ecosystem services *(MEA 2005)*. Biodiversity, and the species composition - examined by us - have important, but at the same time controversial role at the forming of ecosystems. The diversity is definitely big in case of a low-production opened grassland, while on the meadows with high production it is not larger *(Kertész et al. 2008)*; and in the forests and reed beds it is lower. This is in contrast with the general expectations of the literature, according to which the diversity's maximum should be around the maximum of production *(Abrams 1995)*. The contradiction could be explained by the fact that meadows and wet meadows with potentially larger diversity have been placed into production more times before. The soil preparation has reduced the micro-heterogeneity of the area, and the repetitive regenerations have lead to species compositions less and less rich.

The plantations consist of mainly alien trees. They greatly contribute to production, but it is well-known that they impoverish and degrade the original habitat. Among these species especially the wood and honey serving black locust *(Robinia pseudoacacia)* and the dense (and so successfully planted) black pines *(Pinus nigra) (Biró 2008)* can be found, which in turn increase the fire danger also for the surrounding natural vegetation *(Kertész et al. 2011)*. The abandoned sandy arable lands can be well characterized with the invasion of honey serving milkweed *(Szitár and Török 2008)*. Despite its high production, this species greatly slows down, almost blocks the regeneration, and threatens the surrounding natural vegetation with further invasion.

Examples show that, biodiversity itself can not determine the possible level of ecosystem services, and at the same time that some introduced species play a prominent role. The greatest value of this varied land is diversity in terms of ecological services. The main interest of nature protection and of broader social environment is that this diversity continues to be maintained.

5.2. Calculating the biomass and modelling the carbon turnover of near-natural forests

Original or natural („old-growth") forests free from tree cuttings and from other forest use practices contribute significantly to the reduction of greenhouse gases in the atmosphere due to in their unbalanced carbon turnover. In addition, they hold and extract more carbon dioxide from the atmosphere than the intensively managed forests under same circumstances *(Luyssaert et al. 2008)*. Therefore, natural or near-natural forested lands have a great importance in terms of climate change. Today, habitats like these are hardly found in Hungary (a known exception at Czájlik 2009). However, there are reserves of these forests excluded from farming, that are becoming increasingly natural and can serve as good references of the old forests *(Horváth et al. 2001; Bartha and Esztó 2001; Somogyi 2002)*. In this study, we report the case of a forest reserve's biomass and carbon storage capacity.

We conducted our research at South-Bükk, at the 96 ha core area of Felsőtárkány's Vár-hegy forest reserve, where high variety of oak-dominated woods occur, from downy oak woodlands *(Cotino-Quercetum)*, through turkey oak (sessile oak and oak), hornbeam habitats to beech forests. Between 2005 and 2009 we surveyed the habitat structure at 406 permanent sampling points of the so called FOREST+n+e+t, stand dynamic and forest ecological observa tion system *(Horváth et al. 2005)*. In the results we describe the mix ratio and size relations of trees, the volume of living and dead woods. In addition, we revealed the history and age relations of the forest, delineated stands considered as homogeneous units *(Mázsa et al. 2008)*. For the 28 stand patches, we defined tree cohorts based on mixture proportions, size and age relationships. Their development and the volume stored in the forests were calculated with CO2FIX model *(Schelhaas et al. 2004; Balázs et al. 2008)*. On the whole research area the aboveground biomass was averaged as 186 ± 67 tC/hectare (N = 28). The estimated biomass volume for the shrub-dominated low forest was 148 ± 13 tC/hectare (N = 4), the average of turkey-oak – sessile oak woodlands was 188 ± 70 tC/hectare (N = 3), the hornbeam - oak stands showed 228 ± 67 tC/hectare in volume (N = 12).

6. Future perspectives

A) By the program and database of MÉTA we got an exact documentation and a summarizing inventory of Hungary's near-natural habitat types, their range, quality and pattern. By ecological-based grouping of habitat classes, ecosystem-types can be determined.

B) Basic plant species inventory of each habitat can be put together based on phytosociological data and evaluation of experts. By this we can make an important step towards understanding the biodiversity characteristics of ecosystem types.

C) A good method is to use well-characterized indicators for capturing the different types of ecosystem services. One indicator we suggest is the vegetation based Natural Capital Index (NCIlin), for proper description of the extent of regulatory ecosystem services. Another one is net primary production index for provisioning services. Developing further indicators of ecosystem services could open new perspectives.

D) Thematic classification of ecosystem types and ecosystem services provide a framework for deeper understanding of the two types – functional and structural context – approaches. A contingence table of „types" and „services", and within it firstly, its qualitative filling and understanding by experts should be our short-term goal (using, and reinterpreting the results of already existing and earlier tests), then our long-term goal could be to quantify elements of the framework system (the contingence table's blocks), based on further investigations.

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VEGETATION-BASED NATURAL CAPITAL INDEX: AN EASY TO UNDERSTAND, POLICY RELEVANT ECOSYSTEM STATE INDICATOR


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1. Introduction

Most human activities have a determinative influence on natural ecosystems. Even the minor routine decisions of individuals may impact the state of surrounding landscape, not to mention the decisions of local and regional spatial planning and environmental policies. In these cases, circumspect evaluation of possible alternatives is needed in order to determine how to use natural environment most effectively and have the least harmful effect.

In the last decades, much effort has been devoted to develop metrics, which can easily be understood by anyone, to provide a clear and scientifically sound evaluation about the state of ecosystems. Several, aggregated biodiversity indicators were developed for following up large-scale changes in the biosphere of our planet *(e.g. EEA 2007).* However, indicators related to land use changes are still lacking behind. Because most land-use decisions are made at the local or regional levels, instruments supporting decisions are also most needed at these levels. Local and regional policy-related questions (like environmental impact assessments or strategic environmental assessments, both built into law and order of Hungary and the EU) require different kind of indicators, which can provide high spatial and thematic resolution. Due to the lack of appropriate databases (fine resolution ecological data with a broad spatial coverage), such indicators are remarkably lacking worldwide.

In this paper we describe a new low-level policy-relevant ecosystem state indicator, the vegetation-based natural capital index of Hungary. That indicator was designed for the MÉTA database, the national vegetation database of Hungary *(Molnár et al. 2007)*, which is detailed enough for local and regional applications. However, the same concept can possibly be used for any database with similar habitat-categories and naturalness scores worldwide.

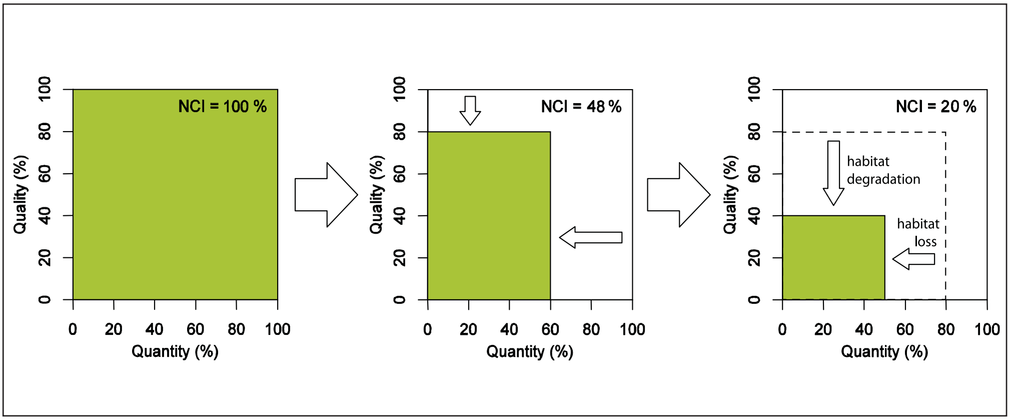

Figure1: Demonstrating the calculation of NCI: the NCI value of an area equals the product of the quality and quantity of the remaining natural and semi-natural areas, which falls into the interval [0,1]. For example, if the half of the habitats is destroyed in an area and the naturalness of the remaining ones is reduced to 40%, that means only the 20% of the original natural capital remains in the area.

2. The formulation of the indicator

The concept of the Hungarian vegetation-based natural capital index is based on an indicator of similar name (Natural Capital Index, NCI) developed in the Netherlands at the end of the 1990s *(ten Brink 2000)*. The original formula expresses the differences between former and actual natural conditions of a complex landscape using numerical data. The vegetation-based natural capital index we use is simply an adapted version of this original concept to the MÉTA database *(Czúcz et al. 2008; Czúcz et al. in press, Figure 1):*

$$\text{NCI} = \text{ecosystem quality} \times \text{ecosystem quantity}$$

If the landscape is composed of several patches of different size, ecosystem type and ecological quality, then the NCI value for the entire landscape is interpreted as the sum of the products of individual subunits, where size is interpreted as a proportion of the entire landscape, and quality is interpreted with respect to an intact baseline. In this way, the indicator estimates the proportion of the original ecosystems that have persisted in a particular region of interest. For this, the relative presence of ecosystem is characterized with the quantity and quality (naturalness) of the vegetation-cover. Defining relative naturalness of habitats can be carried out in several ways, among which two main NCI calculations were determined and built into MÉTA database, considering the contribution of vegetation to ecosystem services *(Czúcz et al. 2008).* Consequently, the greater the area and naturalness of semi-natural vegetation in a landscape, the higher the value of the natural capital index is.

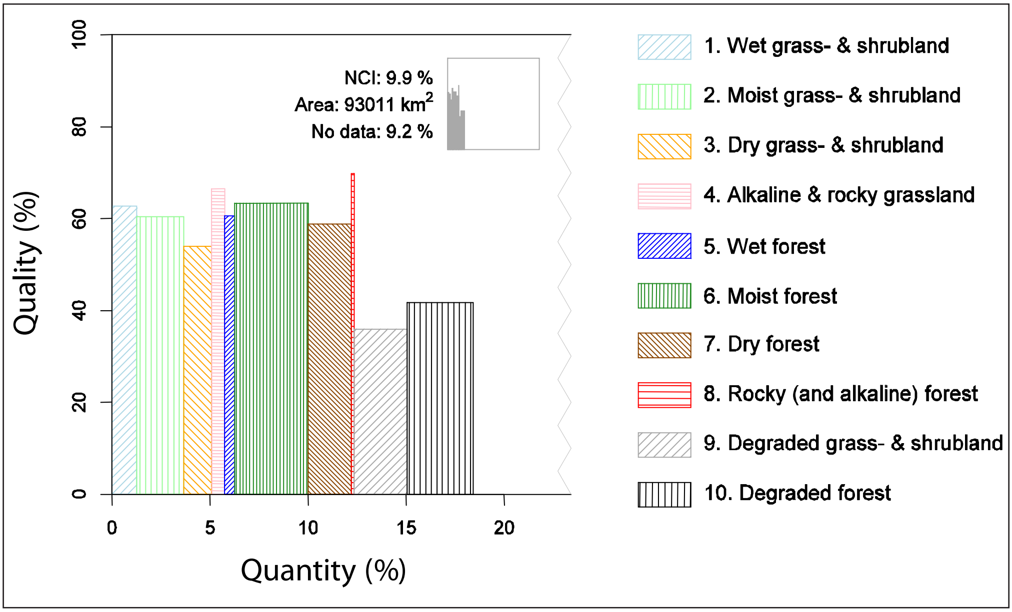

Figure 2: Natural capital of Hungary according to ecosystem types in a profile diagram. To enhance tractability and to reduce the blank space, the X axis does not reach 100%. The small diagram in the top right corner serves as an illustration how the diagram would look like if both axes filled their entire (0-100%) domain.

3. Utilization and interpretation

It is apparent from the definition and the methods of calculations that NCI is flexible enough to give evaluations of landscapes at various scales. An important and advantageous property of this metric is that it can be used for quick and superficial comparisons, as well as extensive and detailed evaluations. NCI values for larger areas can namely be disaggregated in various ways into the sum of different components:

Thematic disaggregation: the contribution of specific ecosystem types to the overall NCI value of a larger region can be easily estimated in a straightforward way. Thematic disaggregation produces a kind of habitat-profile, characteristic to the vegetation-heritage of an area (Figure 2-3).
Spatial disaggregation: the NCI value of a larger region corresponds to the area-weighted average of NCI values of its sub-regions, no matter how the sub-regions are delineated. This rule can help to identify the specific contributions of any area of interest to the NCI of the larger region (Figure 3).

The evaluation of the contributions of different subregions and ecosystem-types can bring new perspectives for policy applications. Flexible disaggregation makes it possible in a decision-making process to survey not only the factual quantitative values, but also the underlying causes and patterns. Consequently, this standardized metric can be used successfully in local and regional policy-relevant decision-making to handle practical questions or in planning and authorization tasks, as well as in environmental communication.

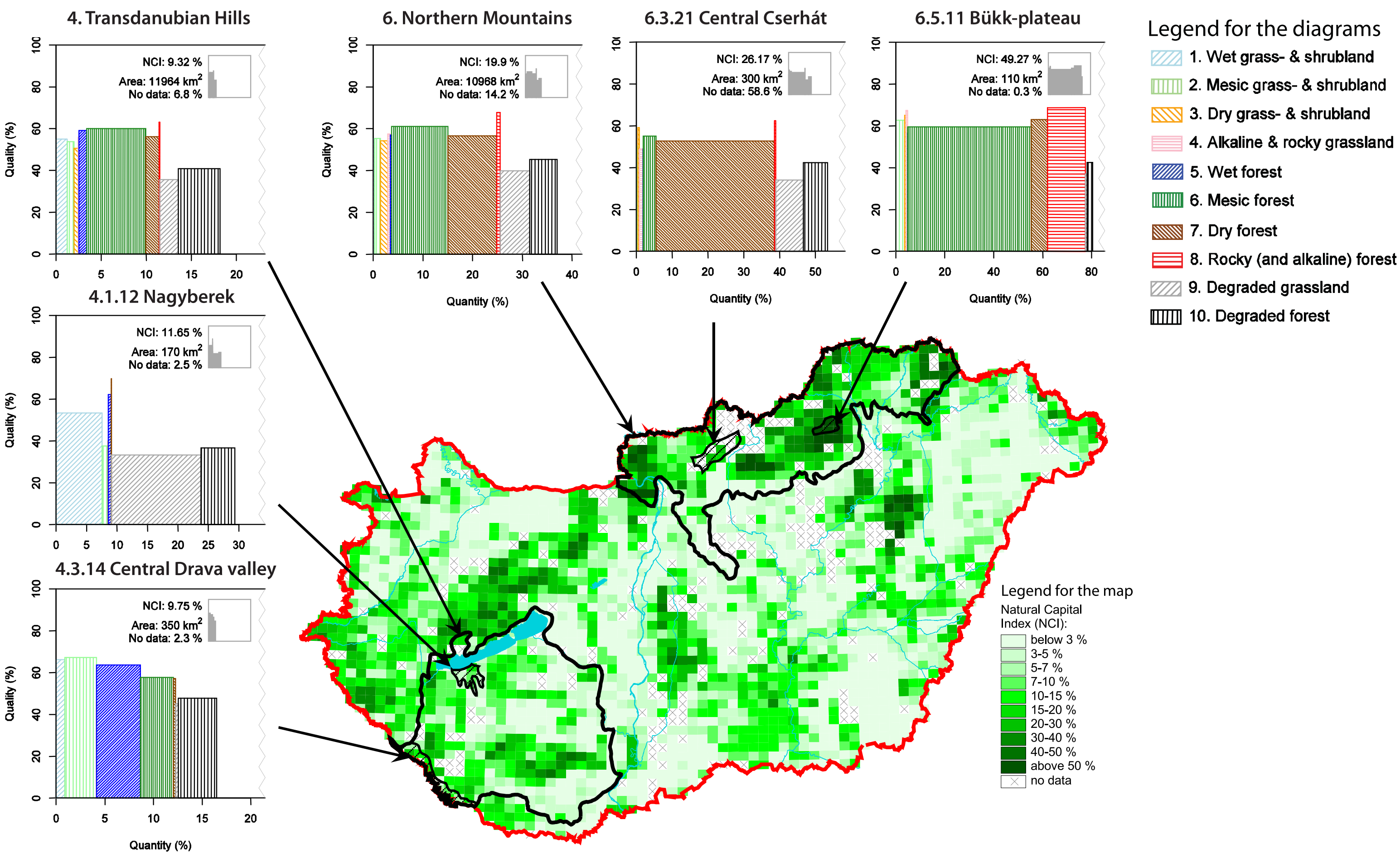

Figure 3: A NCI map of Hungary showing the NCI values of each MÉTA quadrat (~5×5 km), with profile diagrams for a series of nested geographic macro- and micro-regions.

4. Limitations and research needs

As every indicator, also the Hungarian vegetation-based natural capital index has several important limitations, which have to be taken carefully into account to avoid misleading interpretations. These limitations follow directly from the characteristics of the underlying datasets and the methods of calculation:

- The MÉTA database is the result of a single non-repeated survey *(Molnár et al. 2007)*. Consequently the NCI values calculated from the MÉTA database all represent ecosystem state at the time of the survey. Updates (new surveys) for smaller areas are simple, but for larger areas a complete survey may be infeasible. The site network of the Hungarian National Biodiversity Monitoring Network (NBMR), which covers 3% of the country and gets resurveyed every 8 years with a fundamentally similar methodology, can also add some temporal perspective *(Takács and Molnár 2009)*. The use of these new maps and older, reconstructed habitat-maps offer the possibility of monitoring NCI changes *(e.g. Biró et al. 2006)*.
- According to the characteristics of the MÉTA database, vegetation-based NCI primarily focuses on natural and semi-natural habitats, whereas anthropogenic habitats are hardly represented in the currently used version of this aggregate metric database. Nevertheless, agricultural and urban sites can harbour significant biodiversity if managed properly, and provide relevant ecosystem services to the society.
- Being an essentially linear, additive metric method, NCI cannot capture outstanding natural values. Unique values and other important nonlinear characteristics (like presence of specific and rare species, historical or landscape values, regeneration potential, etc.) need to be taken into account separately.
- NCI does not consider the spatial pattern of the individual patches (landscape ecological characteristics of the studied region). As an indicator of dynamic processes, landscape structure can be an important component of ecosystem integrity, for which MÉTA database offers additional metrics.

If these limitations are carefully observed and respected, the overinterpretation of the NCI values can be avoided. Vegetation-based NCI, as a standardised indicator, describes the ecological state of larger areas from just one perspective (even if it is perhaps the most general and meaningful from all the possible perspectives). In order to get a more complete analysis, NCI alone is not enough, and many other aspects and characteristics of local ecosystems should also be considered.

To improve the reliability of vegetation-based NCI, agricultural and urban areas should be more realistically represented in the underlying data sets. As there are detailed data sources for agriculture and land use, such improvements could even be incorporated retrospectively.

One further important task is to perform case studies, which estimate the connection between NCI and other relevant ecological and environmental indicators. Such studies could provide an important justification, and delineate a scope of practical utility for the use of this relatively simple indicator.

NCI is a useful tool in a broad range of local and regional policy contexts, as well as environmental communication. For critical decisions, decision-makers have to be familiar with all important aspects of the situation, and thus a limited selection of NCI values alone may not constitute an appropriate basis for the decision. As it is true in general, no single metric can replace professional competence and detailed local knowledge.

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MÉTA Programme, vegetation-heritage of Hungary. *(www.novenyzetiterkep.hu)*

FUNCTIONAL SOIL MAPPING TO REGIONALISE CERTAIN NATURAL SERVICES OF SOILS


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1. Introduction

1.1. The demand for the soil related data

The information demand about soils, about their state and about the changes in their state have been appreciably increased in the last decades *(Mermut and Eswaran 2000; CEC 2002)* and not only for the agriculture. Both the initial overview maps and the soil surveys based on systematic soil examinations were established to satisfy social demands and need for soil information. The current expectation about the information is that it should be widely available in digital forms. As a result, soil databases and spatial soil information systems *(SSIS; Burrough 2005; Lagacherie and McBratney 2005)* and their versions, which are accessible through internet maps and servers *(Rossiter 2004)* have become the most important soil information carriers. The SSISs are usually based on classic soil information, i.e. the digital processing of soil maps (and soil profile data). Numerous soil databases are organically integrated into land use, rural development *(Thwaites 1999)* and agricultural-environmental programmes *(Baylis et al. 2004).* They are also used in environmental modeling *(Hubrechts et al. 1998; Farkas et al. 2008; Fodor et al. 2008)*, in the survey of environmental energy sources *(FAO 1976)*, in habitat mapping *(Molnár et al. 2008; Bölöni et al. 2008)* or even in risk analysis *(Lim and Engel 2003)*.

The different functions of soil describe the role of the soil as environmental element in the preservation of the life and the conservation of the living environment in various aspects and mainly arise from the interface position of the soil. The soil is the sphere of the interaction of the atmosphere, the hidrosphere, the litosphere and the biosphere. Thus the transformation, storage, filtration, cushioning, nutrition, conservation, etc. can be listed as soil functions and they have effect on numerous substances (nutrient, water, gas) and energy flow processes. Each soil functions can be also distinguished in ecological way. According to this, (i) the biomass production, (ii) the environment and human protection and (iii) the role of the gen reservoir are ecological functions in contrast to the protection function of the (iv) physical basic sphere, (v) the raw material sources as well as the geological and cultural heritage. The various functions of the soil are discussed in detail by the works of Blum (2005) and Várallyay (1997).

1.2. The types of soil related data

We distinguish three levels of soil related data and soil maps, which are used for their regionalization and visualization *(Dobos et al. 2005).*

Primary soil data are collected, determined and measured in field and laboratory, as well as the categorization result of the classification based on them. Primary soil maps are compiled by the specific spatial extension of primary soil data. The traditional tool of this information extension is the classical soil map using soil mapping units. Crisp soil maps subdivide the region into disjunctive units in a way that within heterogenity of soil properties is less than for the whole territory *(Beckett and Webster 1971)*. According to the model behind the usage of soil patches, the mapped soil property is homogeneous within one patch, i.e. it characterizes each point of the area identically and it changes only along the borders; the soil patches stratify the variance. Numerous novel methods have been developed for producing more accurate soil maps; traditional crisp soil maps however are still extensively applied, since they offer the most easily interpretable results for the majority of users *(Leenhardt et al. 1994).*

Secondary soil information are created by the thematic derivation of measured/observed primary data through the use of pedotransfer functions and/or environmental models. Secondary soil maps, like the primary ones, are made by the spatial extension of the pointlike, basic data.

The information related to soil functions and processes deputize the highest level of soil data. Functional soil maps are maps, which display soil functions and/or processes, which are compiled by the regionalization of soil features related to soil functions and (mainly degradation) processes. The regionalization of these soil properties is made by the use of specific environmental models, through the integration and spatial analysis of primary and/or secondary soil maps and further spatial information related to so-called auxiliary environmental variables.

1.3. „Compromise”

Recently available legacy information collected in the frame of previous soil mappings and surveys is not always corresponding to that recently and specifically required by users. The aim of the data collection, sampling and mapping, the work done based on them, and even the resulted data may not be directly adaptable in connection with a given problem area that requires soil information. This can be mainly attributed to the fact that driving aspects of the classic soil mappings were usually agricultural *(Hubrechts et al. 1998)* because the biomass production function of soils was the most important for a long time. Nowadays soil functions related to environmental quality have become increasingly important. Society and sustainable development also relies on the multifuncionality of the soil *(Várallyay 2001)*. The adequate solutions to resolve the conflicts between the needs and capabilities are expected from the theoretical soil science in absence of new data acquisitions. One possibility is to develop task-specific pedotransfer functions whose introduction and calibration can bring significant development in the multiple use of the available soil information *(Wösten et al. 1998).* Digital, map-based knowledge related to various environmental parameters gain a significant role, because they can be purchased at lower price and can be used to estimate certain soil characteristics with the help of digital soil mapping *(Dobos et al. 2000; McKenzie and Gallant 2005)*. Digital soil mapping combines the new results of quantitative soil mapping with the traditional soil survey knowledge and integrates them in GIS environment *(Lagacherie 2006).* According to the basic assumption – with the generalization of Dokuchaev’s and Jenny’s conception – the soil properties can be estimated with reasonable accuracy by specific environmental variables featuring the given place, supplemented by information on further soil properties and location.

2. Material and Methods

Decision-makers needed the complex characterization of actual soil conditions – considering the agricultural suitability and degradation processes – apropos of the Vásárhelyi plan’s enhancement on pilot areas in the Great Hungarian Plain related to the planned locations of emergency reservoirs. To satisfy this needs RISSAC has developed and tested an experimental methodology, which is suitable to describe current soil condition and to detect changes in soil condition among other at Bereg, Bodrogköz and along the central Tisza. The experimental method is based on spatial and temporal data collection as: digital processing of archive soil survey data, their organization into database, fitting within appropriate spatial data infrastructure as well as the new survey planned on this basis and their overall integration.

The description of the actual soil conditions is enabled by new sampling whose execution is however made more efficient and economic due to the planning based on task-specific integration of archive data. For the estimation of the soil development and degradation processes, the knowledge of the previous states, to which the changes can be assessed, is essential. Usually we do not have such monitoring network concerning the examined area, which is sufficiently extensive and its operation would be commensurable with the valuable changes in soil aspect. In such a case an appropriate solution is to rely on data of an earlier mapping as starting condition.

2.1. Reference soil conditions

In the case of small landscape and sub regional level evaluation Digital Kreybig Soil Information System *(DKSIS; Pásztor et al. 2010)* can provide support, which processes the legacy data collected in the frame of Kreybig's soil survey. In national relations the development of the DKSIS has a privileged role in some ways because spatially this is the most detailed and nationally still complete map-based soil data set owned and managed by RISSAC HAS. By pure digital processing of the original Kreybig legacy data one can get information about soil condition of the years of 1930-1950; about the territory of cultivated lands and the rate of other land uses and through the soil profile data about the most important physical and chemical properties of the soil layers and their spatial distribution (henceforth: Kreybig1K data).

2.2. Actual soil conditions

Determination of the actual soil conditions means the upgraded delimination of agro- ecological units (soil landscape units), which is carried out on the basis of the data of on-site survey integrated with large scale digital elevation model, remotely sensed data and further spatial thematic datasets (e.g.: CLC-50) of the territory using digital soil mapping processes *(Pásztor et al. 2006)*. During the field work we revisit and verify the original survey places of the representative soil profile, which is assigned to the soil spot and determined by the compiler of the archive map for the soil spots. As a result, we get information about the soil condition at the moment of the sampling (henceforth: Kreybig2K data). With the comparison of the past and actual soil description we confirm the status of the revisited survey place as actual spot and with the help of the differing soil description we can interpret the changes caused by soil processes. Combining the data of the archive and actual experimental and laboratory examinations and making database from them as well as spatial extension of the examined soil profile data to the actually delimitated (thematically specified) agro-ecological units can help in the identification of changes in soil condition.

At the collection of the Kreybig2K data the target is not the general re-mapping of the area. The guidelines of the sampling planning strategy are appointed by the parameters of functional maps (range, thematic, precision) and the compromise of the financial limits. The visited soil profile places are marked out by the maximization of their functional relevance (e.g. agricultural suitability or evaluation of degradation processes) and regional representativeness.

3. Case Study: Bodrogköz

The SSIS of the Bodrogköz is built on the data available for the sample area in the raw DKSIS (Kreybig1K) and new surveys done in several dates between 2003 and 2006 (Kreybig2K). During the current survey we revisited the representative sites of Kreybig1K. We digested the site, made on-site examination of soil profiles and also recorded the description of environment and soil profile in new soil sampling records. We took digital photographs about the environment and the soil profile, the additional digestions as well as other characteristics. We collected disturbed and undisturbed soil samples from the soil layers according to the Kreybig1K stratification and we did laboratory measurements as well. Based on the results of 43 sampling locations and 35 laboratory measurement datasets, we determined the physical, chemical and biological soil characteristics and genetic soil types of the typical soil profiles in the Bodrogköz sample area. We have also made classical soil sampling supplemented soil contamination survey (in 10 representative spots), soil biological survey (in 50 spots) as well as soil hydrological measurements (in 4 representative spots).

The on-site soil samplings describing data from different times, such as the data of on-site examination for the whole soil profile and for the examined layers, the results of laboratory analysis as well as the photo documentation of the actual survey are managed by a database server. In this way management of the data of field observations and laboratory analysis is realized in a virtually unified, integrated environment, as well as provision of soil map databases, which ensure planning at regional level and map-based databases, which help in orientation (topographical maps, ortophotos, etc) and other complementary knowledge (field photo documentation, tables, graphs).

4. Results and discussion

During the identification of the soil condition's changes, the comparison of the reference and the actual data should be done very carefully because the two compared datasets have not arisen from methodically equal recordings furthermore certain laboratory analytical methods have changed meanwhile. Regarding of these points, the changes in soil reaction and carbonate-status (soil acidity) and salinity profile (salinization) can be tracked reliably.

During the evaluation we firstly considered all Kreybig1K and Kreybig2K data summarized to highlight the main trends of the possible change pocesses. The more detailed description and quantification of the changes taking place in the area are expected from the comparative analysis of those sample spot pairs, which current and previous recording places and regional representativeness are supposed to be identical with each other. These sample spot pairs have been selected after a strict pre-screening, by which we reduced the likelihood of the sampling failure related data differences to a minimum. This way opportunity opened up to examine changing of pH, calcium conditions, salinity profile and evaluate the changes in the aspect of degradation. 36 sample spot, out of 43 have related data from earlier laboratory sample analysis, after the pre-screening 17 sample spot pairs were selected and compared by pairs. As a result we determined the traceable, general changing processes, which were evaulated in two ways due to the previously developed methodology *(Szabó et al. 2007).* One aspect is the agricultural suitability of the given area, the other is the environmental responsiveness determined by harmful soil processes. By extending the soil profile related data to patches it became possible to make spatial inventories as well as primary, secondary and functional soil maps illustrating the condition parameters and indicators as well as the processes (Figure 1).

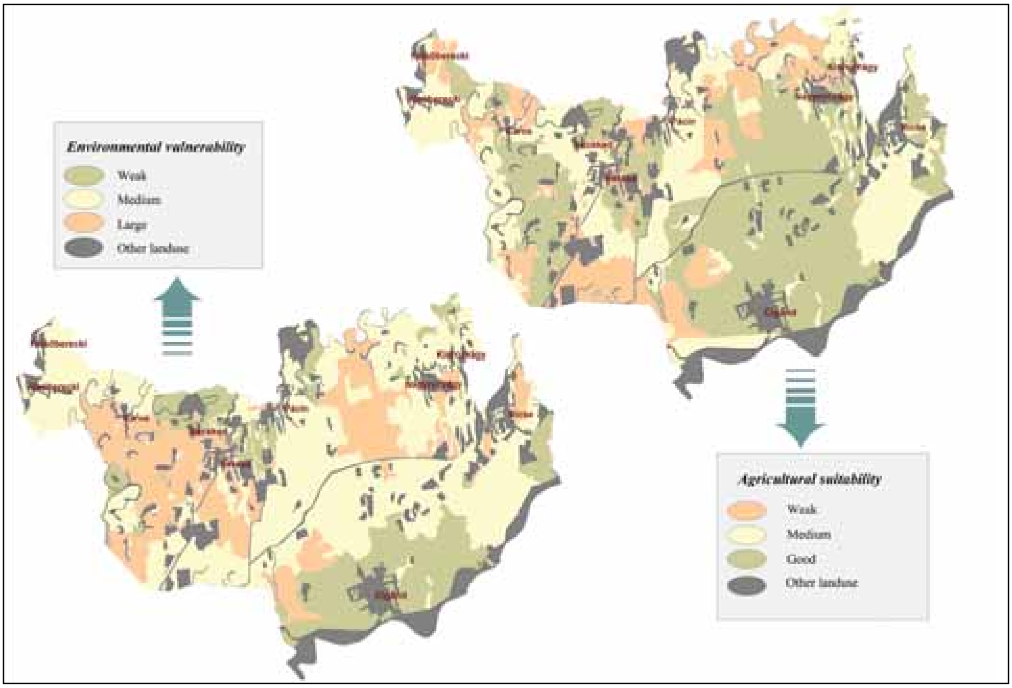

Figure 1: The functional evaluation of the Bodrogköz pilot area.

Spatial realibility of the information related to SMUs based on the upgraded profile database is variable, since it may be achived on various level of the spatial and thematic refinement. A user quality assessment can be achieved by a suitable characterization of this kind of spatial realibility. We introduced a simple indicator for this purpose.

During field correlation primarily the representative soil profile locations were revisited and one profile was sampled in an SMU. However in some cases multiple sampling was done, where within unit heterogenity seemed to be higher. That could lead either to the subdivision of the concerned patch, or the appropriate statistics of the multiple data were used to characterize it to reduce the variance. SMUs featured with multiple up-to-date information are ranked as 1st order reliable. SMUs characterized with single recent profile are ranked as 2nd order reliable. There were SMUs without new profile assessment. If they were originally represented by soil profile located in another SMU, which was revisited and newly sampled - and if there was no reason to deviate from the formerly applied soil property transfer – we ranked them as 3rd order reliable. If the SMU could be represented merely with legacy information it was ranked as 4th order reliable.

In the worst case even the legacy data are missing for some SMUs and certain parameters due to incompleteness of the original survey. In this case we inferred soil properties for SMUs as follows:

We turned to the neighbouring profiles (both legacy and newly sampled) and applied interpolation for the concerned soil property. The legacy information was treated with lower weight than newly assessed ones. For the estimation of the given soil property attributed to an SMU with missing data, the interpolated within SMU values were averaged. These SMUs are characterized by the most inferred values and are ranked as 5th order reliable (concerning the given parameter).

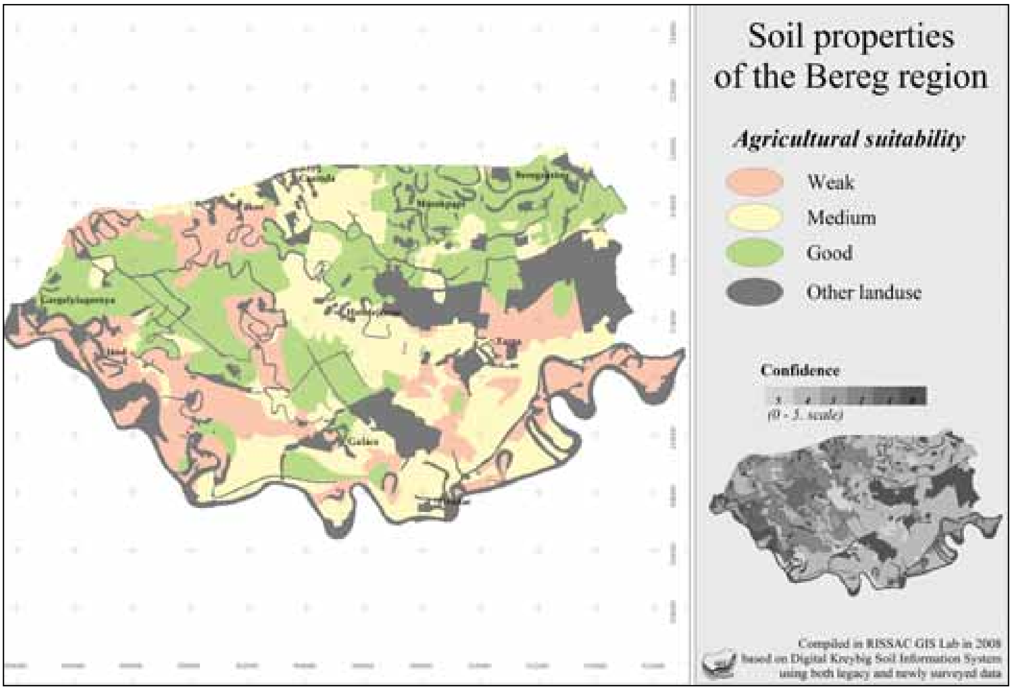

Figure 2: Sample functional soil map of the Bereg pilot area with indication of the relative spatial reliability.

As a result of the steps detailed above we produce upgraded crisp soil maps with the most detailed spatial resolution, which can be produced at this scale based on the soil mapping concept elaborated by Kreybig et al. The maps are supplemented with reliability charts indicating the spatial distribution of the probable soundness of the mapped primary or secondary soil property. Further DKSIS derived soil related features (like soil functions or threats) are suggested to be displayed on maps in similar way (Figure 2).

5. Acknowledgement

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THE POSSIBILITY OF THE ECONOMIC EVALUATION OF ECOSYSTEM SERVICES DESCRIBED THROUGH A DOMESTIC CASE STUDY

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1. Introduction

The evaluation of ecosystem services is a highly relevant issue worldwide; this concept is useful for the development of economic evaluation methodology. Such evaluations can provide significant assistance to European Union Member States in carrying out their obligations; for example, performing an economic analysis on the benefits or costs of the Water Framework Directive. However, this type of economic evaluation can be problematic. There is criticism of the methodology; for instance there are few practical examples, or there is the risk of double counting (e.g. counting the same ecosystem services several times), etc. Despite all of these problems, great efforts have been made to improve the methodology of economic evaluation throughout Europe. This paper presents findings from a piece of national research as part of international research effort. Aims of the research related to the above-mentioned WFD requirements were to determine specific evaluation methodology and develop environmental policy proposals. The novelty of the research is that it was the first time that so-called 'choice experiment' methodology had been used in Hungary. This method has many advantages and is widely accepted.

This evaluation technique was used in contrast to (or rather, in addition to) the contingent valuation method, resulting in added value, because this research relied on both methods and findings. Sixteen international research institutions from ten countries took part and formed three focused working groups: water scarcity, water quality and ecosystem restoration. A Hungarian research team (together with teams from Austria and Romania) belonged to the latter. The main goal was to investigate the estimated benefits of ecological restoration in the Danube floodplain in terms of welfare impacts. More specifically, the study attempted to estimate the non-market benefits of ecological restoration of the heavily modified international Danube river bed in three different countries. Common methodological and research principles were used. The results, which are now presented, include only the domestic results, but the overall aim of this research was international comparison of these results and testing the so-called 'benefits transfer'.

2. Methodology

2.1. Contingent valuation

Contingent valuation is one of the oldest and most commonly used stated-preference methods; through use of a survey that shows a direct way to express changes in related individual preferences, which occur with non-market goods. Ciriacy-Wantrup laid down its foundations around the middle of the 20th century, but in recent decades, it has been used in empirical research in thousands of occasions. This has resulted in a well-identified theoretical procedure (a number of exhaustive works have helped to define the method; see, for example, Mitchell and Carson 1989; in Hungarian Marjainé Szerényi 2005). During the research a hypothetical market is created in which the evaluated good is described. In addition, a hypothetical program can be presented, in which people's contributions are asked for, and the method of payment is defined and willingness-to-pay (WTP) is examined. Good in question is "traded" in the hypothetical market through a survey of respondents. This method reveals how much respondents are willing to offer (a maximum amount) for the presented hypothetical change. If respondent's willingness to pay (WTP) changes according to the welfare of members of society, a result of intervention can be estimated (through the aggregation of individual WTPs, in which all affected must be considered). The description of the hypothetical changes in the program must be as realistic and believable as possible. Attention must be paid to any aspects, which are already important during any public inquiry (i.e. ensuring the survey text is understandable and contains only proper amount of information, etc.).

Through the contingent valuation any benefits/damages can be estimated in connection to the whole change expected. The great advantage of this methodology is that it evaluates practically any stock and change. Moreover, defines the use and non-use components of the so-called total economic value, which has great importance regarding ecosystems. In many cases habitat is valuable, but not because people use it directly. In Hungary, the Contingent Valuation method has been used a few times, for example to evaluate the benefits of improved water quality in the Lake Balaton *(Mourato et al. 1997)*, and the conservation of the Pál Valley- and Szemlő Mountain caves *(Marjainé Szerényi 2000).*

2.2. The choice experiment

The choice experiment (CE) has much less history in the evaluation of non-market goods. It was first used to examine the impacts of environmental goods in the mid 1990's *(Adamowitz 1995).* Since then, the number of studies that estimated the welfare effects of changes with this procedure has rapidly grown *(Bateman et al. 2002; Krajnyik 2008 - gives a good summary about the method in Hungarian)*. Similar to contingent valuation, it can be classified as a stated-preference method, since it also creates a hypothetical market. But "trading" with the goods is done differently. The environmental goods being valued are examined through their features/characteristics at different levels. Different bundles/packages can be created from features defined at different levels, and respondents evaluate the goods and their features through the selection of these packages. One of the features is always a price component; a cost would be paid (hypothetically) to achieve the outcomes. The individual's maximum willingness to pay is not asked directly, but it is found out through indirect analysis of the chosen program package.

A good evaluation should put strong emphasis on two aspects: the attributes themselves and their levels. It is important that only the most important attributes are included in the study *(Hensher 2004)*, and that they must be independent. Too many attributes should not be involved in the study to avoid over-complicating the program packages and make the choice difficult. A similar principle prevails in determining the levels of attributes; an effort has to be made to determine transparent numbers of levels. As was mentioned earlier, features should contain one that represents price. It can be expressed as a cost factor, although it can also not have monetary value, for example travel distance, which can be expressed in monetary terms during the analysis. The program packages are formed from the combination of attributes determined at various levels. In the examination, it is important that any choice includes the possibility that respondents can be satisfied with current situation and have zero willingness to pay (so the interviewed can choose essentially between three options in case each of the choices: A, B and status quo). Interviewees express their preferences generally in more choice situations, so sample size is significantly reduced. Due to the complexity of evaluation issues, using personal interviews during surveying is best. Apart from electoral cards other tools can be used for improving information transfer.

Compared to contingent valuation, the biggest advantage of this methodology is that it assigns economic value not only to one specific program, but to all of the included attributes, making it easier to determine what kind of tradeoffs respondents make between individual attributes and their levels (i.e. how much a given level of some attribute is worth to them compared to other levels and other attributes). Like the previous procedure, this method shows the great potential for ecosystem assessment because it is suitable for estimating non-use value components. The disadvantage is that - depending on the complexity of the developed program packages – it can be very stressful/difficult for respondents to choose that package which contains their preferences. As more features and levels are used, respondents are less and less able to thoroughly review and decide using the choice situation.

3. Domestic case study presentation

3.1. The study area and the problem

The Danube is the second largest river in Europe. In the last century it has been exposed to various anthropogenic changes and environmental pressures. Among other things, the shape of the river has changed and most of the floodplains have been drained for agricultural purposes. The hydrological connection/permeability of the river has significantly decreased along with its side branches and connections to the surrounding floodplains *(see, e.g. Hohensinner et al. 2004, Brouwer et al. 2009)*. To ensure meeting the Water Framework Directive requirements and reach good ecological status, one possibility is to restore the river sections as closely as possible to the natural hydro-morphological state *(Brouwer et al. 2009).*

The Által-streamlet is located in north-western Hungary. Its basin surface area is 521 km2; the length of the stream arising from the Vértes Mountains is 50 km. In total, it has 31 tributaries; the two main ones are the Galla creek – which flows through Tatabánya – and the Kecskéd creek – which touches Oroszlány. The largest lake is the Old Lake (230 ha) of Tata. Only the two sections of the Által-streamlet can be classed as "natural bodies of water", according to the 2nd National Report concerning to the 5th article of the WFD (EU code: HU_RW_AAA206_0000036_S and HU_RW_AAA206_0000045_M; http://www.euvki.hu/content/2005jelentes.html). There are three bigger settlements in the catchment area, Tatabánya, Oroszlány and Tata. Earlier these were important industrial cities. Despite the fact that there are many rivers in the catchment area, only a few have significant and permanent water yield. For this reason, during the summer there is often lack of water but in the case of heavy rain, floods pose threat. This is mainly due to human intervention (together there are 19 man-made lakes in the area, land use has changed and agricultural land use now prevails).

Only a small quantity of water is used for irrigation while significant amounts of the Által-streamlet is used for ensuring the cooling water needs of industrial companies. A large part of the Által-streamlet's water body is heavily modified. In the area, the drinking water supply is provided by karst water *(AquaMoney Project, 2008)*.

3.2. Survey Specifics

The survey was carried out amongst residents of the pre-selected settlements of the Által-streamlet catchment area through personal interviews between November 2008 and January 2009. Attempts were made to include respondents in the sample who lived also in the upper, middle and lower parts of the catchment. The largest number of respondents was from Tata, Tatabánya and Oroszlány. Altogether 892 people were approached, of whom 471 completed the survey (a response rate of 52.8%).

In the survey, questions were formulated about the respondent's environmental attitudes, the use of the study area, water use habits, water bill, opinions about water quality, previous flood experience and numerous socio-economic features (age, income, education, type of home). The evaluation questions were compiled in two separate sections in the case of contingent valuation and choice experiment.

During the contingent valuation survey, a program was offered to "buy" (i.e. the contribution was asked for this purpose) an increase in the proportion of near-natural areas from the current 25% to 50%, or 90% on the hypothetical market. This program implementing the changes involved works to connect better wetland habitats and forests. The maps illustrate the difference between the situations (see Figure 1). The sample was divided into two parts. One group was offered the program, which described an increase to 50% of near-natural areas, while the other group was offered a program, which described an increase to 90% (i.e. the two improvement situations were evaluated totally independently from each other). The exact question was: "Using the next card can you tell me please how much your household would be willing to pay per year, maximum, above your annual water bill over the next 5 years to make this recovery happen?" The respondent could choose the amount of their contribution using a so-called payment card. On this card thirty different amounts were presented, which included 0 Ft and another category in which any amount of money could have been named.

In the choice experiment two additional features were selected for evaluation: frequency of flooding and water quality. The levels of flood frequency used the following options: flooding once every five years, once every 25 years, once every 50 years and once every 100 years. In case of water quality the options were: medium, good and very good levels. The additional cost of the water bill was set at four amounts: 50/200/650/1000 Ft per month. Pictograms were used to illustrate the water quality change and the resulting use opportunities (for levels of the features and pictograms, see Figure 2).

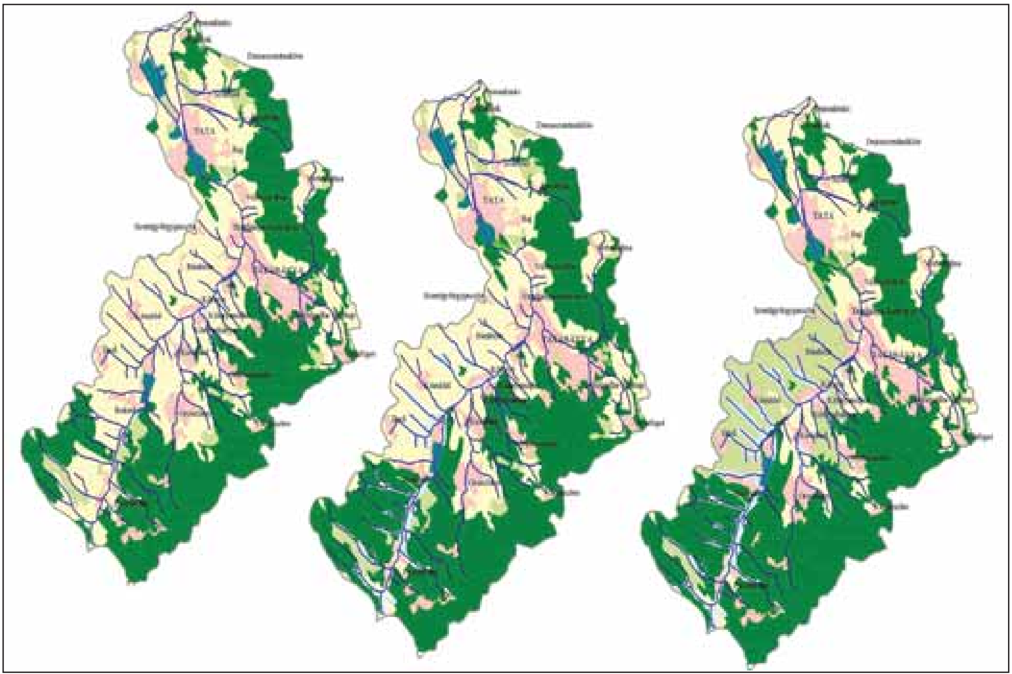

Figure 1: Maps used to illustrate scenarios of ecological rehabilitation: from left to right the current situation, 50% of the area, and 90% of the area in near-natural condition (these scenarios/maps were drawn up by Research Istitute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences).

A total of thirty-two choice situations were developed from each level of the three features (meaningless evaluation situations were corrected). Before that, it was explained that the program could improve water quality and flood situation. To ensure that the welfare effects (social benefits) could be correctly quantified, it was necessary to correlate them to the current situation, which was represented as a third choice situation next to the two alternatives (labelled "current situation"). In this alternative the flood frequency was once every three years, while the water quality is at a medium level (you can see one example of the choice situation in Figure 3) (the baseline scenario was also derived through expert input from Research Istitute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences). Of course, those who chose the current situation were voting against any restoration and were offering zero payment bids. All respondents could express their preferences in four choice situations. Before making concrete choices the interviewer explained the evaluation situation to ensure that the respondents fully understood the task.

Through the contingent valuation and the choice experiment the reasons for choices respondents made were looked for using follow-up questions. These helped to filter out responses not based on economic concerns.

<table>
<tr><th>Features</th><th colspan="12">Possible levels</th></tr>
<tr><td>Flood frequency</td><td colspan="3">Once every 5 years</td><td colspan="3">Once every 25 years</td><td colspan="3">Once every 50 years</td><td colspan="3">Once every 100 years</td></tr>
<tr><td>Water quality</td><td colspan="4">Medium
</td><td colspan="4">Good
</td><td colspan="4">Very good
</td></tr>
<tr><td>Cost (monthly in the water bill)</td><td colspan="3">50 Ft – 0.2 EUR</td><td colspan="3">200 Ft – 0.73 EUR</td><td colspan="3">650 Ft – 2.36 EUR</td><td colspan="3">1000 Ft – 3.63 EUR</td></tr>
</table>

Figure 2: Characteristics and the levels of the choice experiment method; use of pictograms to picture the benefits resulting from the improvements in water quality.

	Case A	Case B	Current situation
Flood frequency	Once every 25 years	Once every 5 years	Once every 3 years
Water quality	Medium	Very good	Medium
Additional monthly water bill cost	50 Ft	1000 Ft	0 Ft

Figure 3: An example of the choice situation; the "current situation" is always between the choice situations.

4. Results

4.1. The results of the contingent valuation

As already described above, the maximum willingness to pay (WTP) was explored using a payment card where a total of thirty amounts appeared, starting from 0 up to 62,500 Ft and the possibility to indicate an 'other' amount. Most frequently the 5,000 and 10,000 Ft sums were marked. Altogether, 111 respondents out of 471 said that they would not pay anything to support the restoration program while 23 out of these 111 provided invalid answers . The results are detailed in the Table 1. The average WTP (excluding invalid answer) is slightly above that caculated for the entire sample: 6,533 vs. 6,212 Ft/month.

Respondent maximum willingness to pay		
		frequency
WTP = 0	9 730	111
Valid WTP = 0	117 170	88
WTP > 0	14	357
Valid positive WTP	100 670	357
Missing	29 330	3
Average WTP in the total sample	202 060	HUF 6,212
Deviation	11 970	HUF 9,798
Median	95 820	HUF 3,000
Minimum (to the positive WTPs)	380	HUF 50
Maximum	70 200	HUF 100,000
N	66 220	471
Average WTP with the valid answers	346 740	HUF 6,533
Deviaton	204 690	HUF 9,944
Median	8 600	HUF 3,000
Minimum (to the positive WTPs)	6 050	HUF 50
Maximum	1 320	HUF 100,000
valid N	265 240	445
Other woodlands and woody habitats (RA, RB, RC, RD, P45, P7)	263 800	1.13

Table 1: The results of the maximum willingness to pay using the contingent valuation method.

Two of the results should be examined in detail and have relevance to environmental policy-making:

- the differences manifested in willingness to pay between two subgroups of the population; those who regularly enjoy the services offered by Által-streamlet ('users'), and those who do not use them ('non-users');
- the maximum willingness to pay for two programs, which increase the ratio of near-natural areas.

On the basis of economic theory, respondents who use the recreational and other facilities of the catchment area would dedicate on average a significantly higher amount to restore them to near-natural condition. The former would pay 7,094 Ft, while non-users would only pay ca. one-third, or 2,552 Ft annually (Table 2).

It is also on the basis of economic theory that we predict that greater improvements (i.e. a larger restoration area, which results usually higher welfare gains) will be coupled with a higher propensity to pay. Accordingly, increasing the rate of near-natural areas from the current 25% to 90%, in principle, leads to higher WTP. During the survey, respondents participated in approximately equal proportions in the two program scenarios. Although the average willingness to pay was higher for the better condition there is, statistically, no significant difference between the two scenarios. The average WTP is 6,385 Ft in the case of 50% scenario (€ 25.54), and 6,679 Ft (€ 26.71) in the 90% version case. That means the respondents could not distinguish the degree of change (no sensitivity to scope). It is likely that if the same respondents had been asked one after the other for WTP for the two scenarios, they would have been more sensitive to the scale of improvement.

	Average WTP (HUF/ household/year)	Deviation
Users (N=390)	7,094	10,401
Non-users (N=55)	2,552	3,921
Flushes, transition mires and raised bogs (C1, C23)	14	0.00

Table 2: The maximum willingness to pay of users and non-users.

4.2. The results of the choice experiment

In the case of the choice experiment, estimating the willingness to pay is much more complex than for the case of contingent valuation. Because of this, only the most important, easy to understand results are presented.

Each respondent could indicate their preferred situation from a total of four positions. From the total of 1,875 choices, 464 (25%) chose the current situation. This means that the three-quarters of the answers supported a development program. Results show that local population has a zero willingness to pay for reduction of flood frequency, so this outcome is of no value to the local population. In relation to water quality changes, WTP is positive. From a medium improvement to good was valued at EUR 21.2 (HUF 5,300)/household/year, while the value of an improvement from medium to good was EUR 42.5 (HUF 10,625)/household/year. From the results, various population utilities - meaning the implementation of individual program components in different combinations - can be calculated. Different scenarios can be developed (e.g. water quality changes from medium to good and flood frequency is reduced from once every 5 years to once every 50 years), to which in principle we can assign a total economic value (in our study, there was no point doing this since residents valued flood frequency reduction at zero, which is why different scenarios were valued the same, but this theoretical possibility is given).

5. Opportunities for further progress

The question arises, what can this research and its results be used for? Is a value obtained using this methodology exact and acceptable? The results cannot be considered perfectly accurate, nor even as correct amounts rounded to Forint. Rather, they provide guidance about the level of affected people's sacrifice, prepared to make for a given cause. Moreover, through such methodology, we can investigate whether social benefits are likely to exceed social costs. If the two values are very similar, proceeding with the intervention or program suggests underestimating benefits rather than the costs what are generally well known. Doing such a primary survey, as the case presented herein is very expensive, so it is important to create a wider database of cases of national evaluation. With such a database a lower budget, more feasible evaluation process becomes possible, such as benefits transfer and extrapolation from individual cases. In the short run this would require a great effort in Rural Development, but in the long run would repay the investment.

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POSSIBILITIES OF MODEL-BASED EVALUATION OF ECOSYSTEM SERVICES, ON THE EXAMPLE OF A CASE STUDY USING A BAYESIAN NETWORK FOR EXAMINING EUTROPHICATION

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1. Introduction

So far, ecosystem services have been evaluated mainly through case studies for individual areas, as international and national literature suggest. The application of GIS-based evaluation and targeted models is becoming necessary. In the article below, we give an overview of such evaluation methods, and of related international experiences. Then we describe a case study about the adaptation of one chosen instrument for a karstic study area in Hungary. To the good solubility of the constituent minerals, karsts are sensitive environmental systems, and they provide sources for the quarter of the world's water supply besides having other natural values. Because of this, evaluation of their services is important, especially because it is an underdeveloped field of international literature *(Kiss et al. 2011).*

2. Possible ways of plotting and modelling ecosystem services

2.1. Evaluation based on land cover or land use

The easiest way of mapping ecosystem services is the GIS-based visualization of the results received by value transfer. This means assigning natural service values to each land cover type based on earlier case studies *(Kreuter et al. 2001; Troy and Wilson 2006).* The aim of these studies, if they are well implemented, is to use background studies from landscape types, which are the most similar to the examined area, and thereby assign the most accurate value possible to each land cover and land use type. Even so, the estimation of ecosystem services provided by an area is more precise if the value of each category is defined within the specific landscape. An example for this is the research of Burkhard et al. (2009), where values for the CORINE database were given in a matrix. Therefore it was possible to examine separately the spatial pattern of each ecosystem. The method was applied in several projects *(CLMIRF, PLUREL)*. If we want to apply data other than the spatial pattern of land cover, land use or other, similarly different from integrated vector data (like habitat maps), a possible solution is the rasterization of differently patterned data. This makes calculations between different layers possible. For example, the direct use values of ecosystems in a Chinese study area were estimated like this *(Chen et al. 2009).*

Models that are based not only on the type of land use or land cover can be divided into two groups. We can use tools designed directly for evaluating ecosystem services, or also apply software not originally designed for analyzing environmental systems.

2.2. Models for evaluating ecosystem services

The InVEST software tool was developed for the GIS-based evaluation of ecosystem services within the framework of the Natural Capital Project, led by Gretchen Daily *(Tallis et al. 2008)*. This is a tool developed for ArcGIS, the most frequently used geospatial software, making it suitable for widespread use. The tool is under constant development. At the moment it is capable only of evaluating a few ecosystem services (for example: biodiversity, carbon sequestration, hydropower, inhibition of erosion, wood production, pollination), although even the review of only these parameters help in examining the capabilities of an area. A known application of InVEST is from a study area in The United States *(Nelson et al. 2009; Tallis and Polasky 2009)*. The automatisation of evaluation allows us to examine the temporal changes of ecosystem services in different landscape change scenarios.

The MIMES (Multiscale Integrated Models of Ecosystem Services – Boumans and Costanza 2007) initiative lead by the University of Vermont also aims to evaluate ecosystem services. This is an integrated model system, in which a general model and some submodels are developed for evaluating ecosystem services, based on case studies collected in different locations and at different scales. The system is based on Simile, one of the most common software programs designed for describing complex systems and processes.

Even though we try to base „complete" natural service models on universal correlations, and make them suitable for application in different fields, the diversity of landscapes presents a challenge. Obviously an area can only be evaluated accurately if the type of area, the exact goals and aspects of the research are taken into account already when the tool is being selected. Because of this, the application of other, already existing tools or self-developed systems provides further possibilites for evaluating ecosystem services.

2.3. Using other systems for evaluating ecosystem services

Even general some geospatial software have model-building options, which can be useful for evaluating ecosystem services. The Model Builder module of ArcGIS is suitable primarily for making process models and thus can be used for data preparation. But with simpler correlations and equations it can also be used for specific evaluation. Very complex models of Erdas Imagine image processing software's Spatial Modeler application can be used and built on roster data. However, it is suitable only for analyzing a particular state and not for dynamic simulation or to incorporate time-varying phenomena. Two self-developed software eliminate this problem: PCRaster from Utrecht *(van Deursen 1995)*, and SME *(Maxwell et al. 2002)* developed by the University of Vermont. Originally they were developed to make spatial modelling possible. Both applications are equipped with good display functions, dynamic simulation possibilities, and successful environmental science applications, but since they are self-developed systems, their handling is difficult (PCRaster is script-based) and not recommended for widespread use. Another possibility for making more complex models 'spatial' is to link the model with GIS software. The SimArc software tool, developed by the University of Naples, can attach models built in Simile to the polygons of ArcView. This solution is more user-friendly than the two previously mentioned applications, and as it is based on the two most commonly used modelling programs; the number of tools and equations available is maximal. Raster-based 5D, which handles Simile and Matlab models, works similarly. Evaluation based on Bayesian networks applies a special approach, based on a different logic, which uses a probabilistic framework. The latter was used in the present case study.

3. Examination of karstic lake eutrophication with Bayesian networks

3.1. Filling up processes of karstic lakes: introduction and measurement methods

Surface water eutrophication and related issues began emerging more vigorously in the middle of the previous century. Nutrient load, increased due to human activity, caused deterioration in water quality. At first, this manifested itself only in the loss of some functions, but later led to the total disappearance of ecosystem functions. The initial changes had worried only experts, but when algal blooms, water discoloration, various odours and sometimes fish die-offs *(Somlyódy and van Straten 1986)* occurred, threatening public use, a demand to stop and reverse the process emerged. After the exploration of drivers, different measures were carried out more or less successfully in order to prevent pollution, or rehabilitate water bodies. Point source pollution is easier to localize and eliminate than diffuse pollution, which is more difficult to manage. Such diffuse pollution originates mainly from agriculture, settlements, and to a smaller extent from transportation. Increased soil erosion, due to improper management, also plays a role. In some cases the elimination of polluting sources is not sufficient, and more expensive actions are required to restore the balance.

Our research on the subject is carried out in the Gömör-Torna karst region. Our goal is to examine the still waters in the area, and quantify the environmental conditions affecting them. These examinations are especially important in karstic areas, as water is the principle forming factor of karstic systems. It infiltrates quickly, and due to this, affects groundwater quality, underground wildlife and formations, especially caves. Contamination caused by human land use accumulates in the water in karstic depressions, becoming obvious firstly through the change in water quality, which is later transported underground. The fact that in the last few decades several still water bodies got in the state of being filled up or even disappeared in the area, also justifies the need for investigation. Shallow, small-scale ponds are at increased risk of eutrophication, as a decrease in water quality can be followed by complete termination. In dry, karstic plateaus it means an even greater loss, in terms of human use, but also in terms of decreasing biodiversity, as the living and breeding places of several (often protected) species are bound to their water.

The subjects of our investigation are Lake Papverme, Lake Vörös, Lake Kender and Lake Aggteleki.

Lake Papverme lies south-east of Silica village in a blocked sinkhole at a lower elevation than the village itself. Its area is about 1 hectare; its average depth is 1.85 m with 2.46 m as the deepest point. Its longest extent is in west-east direction. A farm is located directly adjacent to the lake in north-western direction. From there a water inflow arrives to the lake. Farmlands are also found on the northern and western sides of the lake meadows, on the southern side forest and on the eastern side. Near the lake a dirt road, which is open to car traffic, connects Silica to the next village. Intensive fishing activity takes place on the lake, resulting in a significant amount of scattered waste.

Lake Vörös (~0.7 hectares, Kunský (1939), average depth: 156 cm) lays in south-western direction from Jósvafő village, in a sinkhole filled up with red clay. The lake's relatively natural state is only disturbed by a busy road passing nearby. Its water supply comes directly from runoff and indirectly from the road and the roof of the Lake Vörös cave entrance through drains established in 2005 by Aggtelek National Park *(Huber 2006)*. In 2001, because of its advanced stage of filling, the ANP Directorate had the lake dredged.

Lake Kender (~0.4 hectares) is located south-east of Aggtelek village. Its environment is the most natural among the studied lakes, as forests and pastures compose its immediate surrounding environment. Behind these habitats there are fields, but only at lower elevations. Today, only the nearby pastured herds, or wild animals use it as a source of drinking water. The water supply comes only from direct precipitation and runoff.

Lake Aggteleki is at the north-eastern boarder of Aggtelek village, and it is the most exposed to anthropogenic effects. Its area has decreased by at least the quarter of its original area during the past 20-25 years *(Kunský (1939): 1.13 hectares, today: ~0.3 hectares)*. According to Barančok (2001), the lake was able to keep its relatively large free water surface for a relatively long time. On the southern side of the lake there is a road, on western side are gardens, and on the northern side it is flanked by houses. The eastern side of the lake is girdled with karrenfield named Ördögszántás (Devil's plough). The water supply comes from precipitation directly and indirectly (runoff from the road, from the hillside, and from the northern side of the village).

In our study we examined the changes in the amount of ammonia, which affects the health of fish stock. Ammonia is excreted by plants and animals, and it occurs in the water due to the decomposition of living organisms, industrial emissions, and fertilizer run-off *(Randall and Tsui 2002).*

Ammonia is a free, non-ionic molecule, which can permeate through most biological membranes, and it affects living organisms as a neurotoxin *(Szilágyi 2007)*. It is formed from ammonium, especially at higher pH levels and higher water temperature. Algae blooms, occurring in waters overloaded with nutrients, cause assimilational alkalisation, leading to alkaline pH. Areas with a limestone bedrock are especially vulnerable in this respect, as their composition may further increase this effect. In the summer especially, ammonia can build up to concentrations toxic to fish.

In our study we used data from 2009, from April to October. The sampling points were chosen in four or two directions according to the points of the compass, near the shore. The reason behind this in the case of lakes is that coastal water quality signifies the determining factor *(Bardóczyné and Szabó 2007)*. In addition, samples were taken at points where inflows reach the lakes. According to this, in case of Lake Papverme eight sampling points were marked, in case of Lake Tengerszem four sampling points were marked, and two each for the other lakes. In the field tests, we used a WTW pH/Cond 340i instrument for measuring pH and conductivity. Water temperature was measured with a Hach Lange thermoluminescent dissolved oxygen meter. The measurement of ortophosphate, nitrate and ammonium were carried out in a lab, by a Fia Star 5000 meter. The determination of alkalinity was based on the MSZ EN ISO 9963-1:1998 standard. Chlorophyll-a content was measured by the North Hungarian Environmental Protection and Water Management Inspectorate.

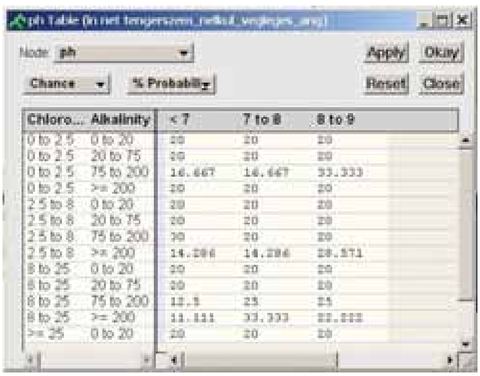
The lakes and their fish stock have a crucial role in providing many ecosystem services. The filling up of karstic lakes causes reduction in the diversity of landscapes and in the value of scenery. For instance the walking path leading to Lake Vörös plays an important role in increasing the number of visitors at the Lake Vörös cave entrance. Fish have a significant role in the lakes' ecosystem processes, namely in the maintenance of its balance and thus they contribute to the provision of an important regulating service. Proliferation or decline in fish species at different levels of the food chain influences the flow of elements and also the population of other species. Moreover, through terrestrial fish consumers they can also affect the processes of other habitats *(Holmlund and Hammer 1999).*

The wetlands' and their wildlife's role in carbon sequestration is not that significant, due to the small size of the lakes in our study area. For the same reason, fishing today means the exploitation of cultural services.

Economic aspects of environmental analysis can help in studying the euthropication of lakes. The filling up of lakes is basically a natural process, and the accelerated eutrophication can also lead to an increase of some ecosystem services. In order to find the most appropriate interventions, the methods of environmental economics can help, which has several examples in both domestic and foreign literature *(Hein 2006; Csutora 2005).*

3.2. Bayesian networks

The Bayesian networks are increasingly applied tools for examining complex systems and problems, including studying ecosystems. Their advantage is that they can handle relations between variables described by conditional probabilities; therefore they are capable of incorporating different human interventions to the model. Another advantage is that conditional probabilities can be set up also based on experts' decisions, so measured data is not always required to prepare a model (only for validation). The Bayesian networks were first used for medical diagnostics, but now they are also applied in many other professional fields like solving financial, telecommunicational and text analysis problems. Most of the examples in environmental modeling and management up until now have been from studies of fisheries and hydrobiology *(Varis 1997; Lee and Rieman 1997).* But there are also studies on water usage and on the effects of climate change *(Kuikka and Varis 1997; Bromley et al. 2005).* In graphic models variables are marked with nodes, while causal relationships are marked with edges. The probabilities are given in the matching conditional probability tables (Figure 1) (the whole probability table contains the combination of each variable's every possible value).



Chloro...	Alkalinity	< 7	7 to 8	8 to 9
0 to 2.5	0 to 20	20	20	20
0 to 2.5	20 to 75	20	20	20
0 to 2.5	75 to 200	16.667	16.667	33.333
0 to 2.5	>= 200	20	20	20
2.5 to 8	0 to 20	20	20	20
2.5 to 8	20 to 75	20	20	20
2.5 to 8	75 to 200	30	20	20
2.5 to 8	>= 200	14.286	14.286	28.571
8 to 25	0 to 20	20	20	20
8 to 25	20 to 75	20	20	20
8 to 25	75 to 200	12.5	25	25
8 to 25	>= 200	11.111	33.333	22.222
>= 25	0 to 20	20	20	20

Figure 1: The conditional probability table of pH as variable.

If a node has multiple parent nodes, the conditional probability distribution needs to be defined for every possible combination for every possible value. Beside conditional probability, there is a possibility of including deterministic relations. The variables can be discrete or continuous, although in the latter case they need to be discretized. Bayesian networks make it possible to calculate the likelihood of different causes from the impacts (diagnosis). By using probabilities, results drawn from measured data can be extended with expert knowledge.

The Bayesian network in our model was made by Netica 4.09 software using 80 cases, which means that the calculated probabilities are based on the results fully introduced above. The model was tested with 15 data, which were also measured, but omitted from the model. The study of Borsuk et al. (2004) is a good basis for studying euthropication with Bayesian networks, but instead of case files, it is based on describing the connections on the basis of submodels and expert knowledge.

3.3. The structure of the model

The probability network (Figure 2) generated on the basis of our data illustrates one of the possible consequences of euthrophic conditions in the lakes, using the present conditions. These conditions have been formed and already stabilized as a result of nutrient stress. Namely, the share of toxic ammonia, converted from the potentially present ammonium, has been raised due to its dependence on the level of alkalinity and the rise of water temperature. Ammonia, and especially its permanent presence, may be harmful to the health condition of fish, even in small quantities. In those lakes where fish farming is carried out, this presents a serious problem, while in other lakes it indicates that the ecosystem is not capable of supporting higher forms of life, leading to a decrease in species diversity. The direct contribution of nutrient load to the higher rate of ammonia mainly means a higher ammonium-input, but also works indirectly. The algae proliferating due to the abundance of nutrients shift the pH towards an alkaline environment with their photosynthetic activity, and they also increase turbidity, which in turn increases water temperature, another important factor of ammonia-formation. The particles suspended in the water (soil, algae) absorb and scatter the sunlight, so the surface temperature of these waters increases (especially at noon) (Paaijmans et al. 2008). Therefore, the model is built from parameters influencing the ammonia rate directly, and of other parameters affecting it indirectly. These are the anthropogenic impacts, expressed by the nutrient supply, the weather conditions, which can enhance anthropogenic effects (SPI drought index) and the air temperature that directly affects the temperature of water. As an external influence, we can mention alkalinity, which affects the quantity of ammonia through the pH. As alkalinity increases pH, in waters where the level of alkalinity is high, the ammonia is more toxic *(Wurts and Durborow 1992)*. The value of the SPI drought index affects the quantity of the three types of nutrients by providing information on the appearance and length of wet and dry periods. During wetter periods, the rate of diffuse pollution may increase. The calculation of the index is based on the amount of precipitation of a chosen base period *(McKee et al. 1993)*. Precipitation data are from the meteorological stations of Jósvafő and Silica. The index was calculated for the period 1958-2009. In the model, the values are valid for one-month periods. The categories used are moderately or extremely wet and dry periods.

The next step in the model is determining the chlorophyll-a quantity, which is influenced by the nitrate and phosphorus content. The threshold limit values of ammonium and nitrate are given based on the no. MSZ 12749:1993 standard, in five water quality categories (from excellent to highly polluted). The limit values connected to ortophosphate are given based on the trophic state *(Szilágyi and Orbán 2007).* The chlorophyll-a levels were classified on the basis of OECD's (1982) trophity-grades. The limit values of alkalinity were determined based on Wurts and Durborow (1992), according to the ideal level present in a lake ecosystem. The limit values of air and water temperature were designated arbitrarily. The lower limit is the temperature, which may be relevant in terms of ammonia formation and durability of persistence. This was also the basis of the pH value categorization. The possible categories of ammonia levels were determined according to the health effects on fish. Four classes were determined: no damage; some irritations occur (loss of appetite, or degradation of digestion); poisoning occurs; and the rapid development of mass fish die-off *(Szakolczay 1997).* For the latter there was no example amongst our measurements, but our researches led us to the conclusion that in the examined lakes there is a risk of die-offs occuring at certain times (especially on summer days).

3.4. Results and conclusions

With the help of the sensitivity test in the program, it is possible to determine within the multi-factor system of the constructed Bayesian network, how much each factor influences the final outcome, or the development of any (other) chosen variable. Using this method we can test if the constructed structure is adequate or not (this has an especially high importance in the case of Bayesian networks, which are based on experts' knowledge). As a result of the sensitivity analysis that was executed on the variable „effect on fish populations" we found that in accordance with the preliminary assumptions, the fish were the most sensitive to pH and water temperature. The next most important parameter was the ammonium rate. The chlorophyll-a amount precedes both the air temperature and the alkalinity. It means that this parameter plays a more important role through its effect on pH and water temperature than air temperature or alkalinity. Following air temperature, the drought index is the first parameter that does not have a direct impact on the two most important parameters, but its extensive impact justifies its place in the list. The health state of the fish is the least sensitive to the alkalinity, and to the nitrate and phosphate rate. Considering the initial independent variables in this respect the climate parameters – especially air temperature – are determinative, in contrast to bedrock and atmospheric CO2-content, which influence alkalinity.

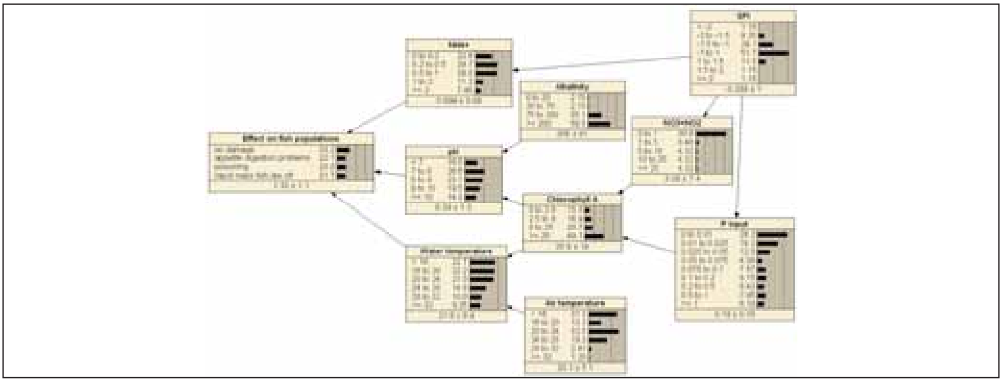


Figure 2: Euthropication model of the lakes in Gömör-Torna karst.

When measured data are used, in addition to the determination of the model structure's quality, the result of the sensitivity test can also help us determine which parameters are the most important and which are the least if we want to find out what causes the presence of ammonia in a certain place, how persistent it will be, and where we have to intervene in the system to eliminate or minimize an unfavourable outcome.

We checked the accuracy of the generated model with the help of a test file from the measurement data. During the verification process we eliminated a variable from the system, and the program estimated the result for each test case on the basis of the probabilities set up for the original cases (Figure 3). The estimation was compared with the real value, and an error rate was calculated from this. The error rate compares the number of estimation errors to the total number of test cases. The accuracy of classification can be defined by a confusion matrix, which shows the distribution of misclassifications between the categories. Based on the 15 test cases the error rate was estimated 20%, probably caused by the low number of test data, and the disproportionate distribution of cases between the categories. Based on similar results, Marcot et al. (2001) determined that the actual occurrence of rare events is underestimated, because the forecasts of the model are based on the most probable events. This is also true in case of the data we used, because in our measurements, the state when there is no harm to the fish is dominant. The model estimated this state correctly in every case, but in opposite, instead of the state of „decline in appetite and digestion" two times out of two, and instead of the case of „poisoning" once out of three „no damage" state was given as a result. For estimating the correctness of the model, the software calculates even more indicators, one of them is the so-called „spherical payoff" *(Morgan and Henrion 1990, briefly introduced in Marcot et al. 2001)*, its value varies between 0 and 1 (1 means the best possible model performance). In case of our model the spherical payoff was 0.77 which, considering the low number of available data, is a relatively high value.

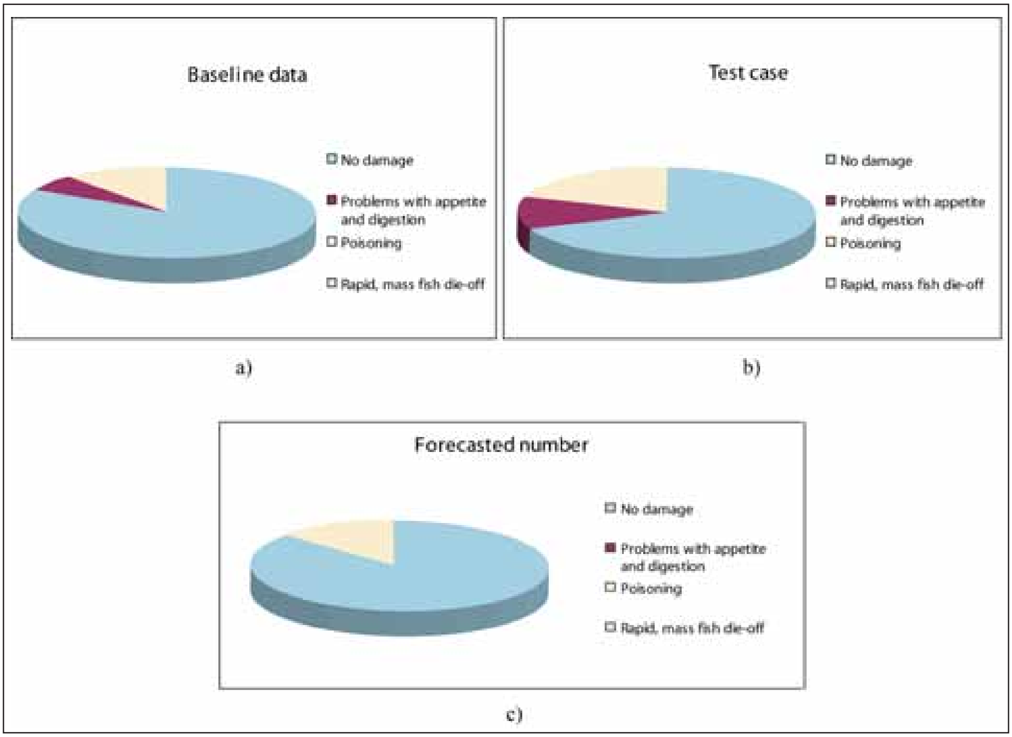


Figure 3: Distribution of values of „Effect on fish" variable, in case of model basis (a), test cases (b), forecasts of test cases (c)

4. Summary and possibilities for further progress

With this article, we would like to provide a methodological support for the evaluation of ecosystem services. The introduced case study also brings up the possibility of using Bayesian networks in other areas of environmental sciences. However, the model we built still needs to be improved in several different aspects. First of all, it must be able to determine the value of the ecosystem services. Secondly, for specifying the different causal relations more precisely, the model might need some modifications e.g. using some correlations, which are not based on our own measurement data. Due to the possibility of including probability-based relations and experts' decisions in the model, Bayesian networks might be capable of handling also economical and sociological data, and might be able to examine the future tendencies as well. In the case of these karstic lakes it may mean applying the method of restoration costs for decision support. This would mean that with the help of Bayesian networks, different alternatives of treatment (for example dredging, protection from erosion, regional drainage) can be compared. With the help of a software tool made at Queensland University (ArcGIS Bayesian Classification Tool), we can examine the correlation between variables with spatial dimension. As a result of the methodical overview and the case study, we found that tools suitable for building more difficult models (Bayesian networks, Simile) primarily have a role in evaulating role in evaluating certain ecosystem services. However, for evaluating the total economical value, we should rely on general geospatial software (ArcGIS, Erdas Imagine). All these methods can be applied in evaluations in Hungary according to the aims of this research and the chosen study area.

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ECOSYSTEM SERVICES AND DISTURBANCE REGIME AS LINKAGES BETWEEN ENVIRONMENT AND SOCIETY IN THE KISKUNSÁG REGION

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1. Introduction

The Kiskunság sand-ridge in the Danube-Tisza Interfluve represents a biome transition zone (ecotone) between temperate deciduous forests and continental steppes. The characteristic feature of the landscape is the hierarchic mosaic pattern of ecosystems, which appears in different levels *(Kovács-Láng et al. 1998).* This can be principally related to geomorphology and geological structure, to water-flow systems and to the history of human land-use. Underground water forms a complex water-flow system, which covers the whole area of the landscape *(Tóth 2001; Mádlné Szőnyi et al. 2009).* Levels of this water flow system (regional, intermediate and local) can be related to the levels of processes analyzed in this study. Precipitation recharges at higher elevations and starts gravitational water-flows towards the lower regions *(Mádlné Szőnyi et al. 2009).* Local and intermediate flow systems are based upon these ridge-level flows, and operate the subsystems between the dry and wet habitats. Landscape and habitat patterns formed this way show similar, fractal-like structure in different scales *(Biró et al. 2007).* Natural vegetation forms different communities, such as dry grasslands, sand forest-steppe mosaic to marshes, fens and alkali lakes. Human activity forms fine mosaics from the fragmented patches of the natural habitats through afforestation, agricultural production, settlements, roads and canals.

The climate of the Kiskunság sand-ridge is semiarid; the region regularly suffers from drought. The most common substrate is the coarse-grained, calcareous sand, which contributes to the drought sensitivity of the habitats not affected by underground water, due to its extreme moisture regime. The driest habitat is the open sand grassland, which is the richest in protected and endemic plant and animal species. Due to its low agricultural value, this is the most natural remaining habitat in the region.

The Institute of Ecology and Botany of Hungarian Academy of Science with the collaboration of several other institutions and universities joined the International Long-Term Ecological Network *(ILTER, http://www.ilternet.edu)* and founded the KISKUN Long-Term Ecological Research site (Kiskun LTER) in 1995. Research originally focused on the complex and long-term study of natural communities in many scales and taxonomic groups. Since then, reflecting upon the increase of human impacts (e.g.

climate change), the KISKUN LTER's research scope has expanded to include the analysis of mutual interaction between human activity and the surrounding ecological systems. The interdisciplinary work is built upon previous research about the interactions of natural and human modified ecosystems in the Great Plain led by IEB HAS (NKFP6/013/2005). This helped to form active cooperation between natural and social scientists in the thematic field of ecosystem services.

The purpose of this paper is dual: to work out a comprehensive framework that can sum up the historical, sociological and ecological research experiences in the sand ridge, and to identify the most important research directions for the near future. The elaboration of this framework is part of the cooperation initiated by the ILTER, which aims to compare different LTER research sites and identify critical social and ecological changes within them, as well as global patterns and trends of the changing ecological services.

2. Material and methods

2.1. The history of the analyzed landscape

By the end of the Turkish occupation (late 17th century), this region was nearly treeless and sparsely inhabited, where extensive grey cattle grazing maintained the sand surface constantly open. Strong winds combined with the effect of grazing kept sand surfaces mobile and caused catastrophic sand storms, which seriously affected the region's crop production. Immobilization of the sand became the central project of the Kiskunság region; the first afforestation started in the 18th century *(Biró and Molnár 1998; Biró 2003).* Meanwhile, as a consequence of local population growth and the growing demand for agricultural products on the European market, the proportion of cultivated land (arable fields, vineyards, orchards) increased, which was accompanied by the division of large pastures into small, fragmented plots. During the first part of the 19th century cattle grazing was gradually replaced by less intensive sheep pasturing, which caused the rapid encroachment of sand dunes. Parallel to the socio-economic changes in the second half of the 19th century, afforestation to immobilize sand continued and became more intensive based on regional decisions and on subsidies from the government *(Biró 2003)*. At first, mainly poplar and black locust were planted, but from the

20th century black pine and Scotch pine were planted as well. By this time, the effects of large-scale afforestation could be seen at the regional level (altered landscape pattern, climate, water resources, and alien propagule pressure). Intensive afforestation of large areas reduced the extent of the semi natural dry sand vegetation to 8%; 45% of the area covered earlier by the original vegetation became tree plantations *(Biró et al. 2009).*

A special small scale farming system (homesteads or "tanya" in Hungarian), adapted uniquely to the natural conditions was developed at end of 18th and blossomed at the end of the 19th. Its prosperity lasted until the first half of the 20th century. From the mid 19th century the ploughing of humic sand and chernozem soils accelerated and arable agriculture spread at the landscape level, causing the rapid destruction and fragmentation of the semi-natural areas. The cultivation gradually increased until the 1930s and eventually reaching the very unproductive drift-sand areas as well *(Biró 2003; Molnár 2008, 2009; Molnár and Biró 2011).*

The small-scale farming system disintegrated in several steps starting in the 1960s, and resulted in extensive land abandonment by the 1980s. Dominant processes within the dry sand area by the end of the 20th century were the emigration of the local population, the drastic decline of grazing and the regeneration of abandoned fields, the closure of bare sand areas due to succession, the spread of invasive species, and the dramatic decrease of the groundwater table *(Molnár et al. 2010).*

2.2. The „Integrative Science for Society and Environment" (ISSE) framework

The LTER sites participating in the project apply the "Integrative Science for Society and Environment" strategic initiative of US LTER (ISSE framework) in order to compare the flows of ecosystem services across different environmental and socio-economic contexts. The ISSE framework summarizes the status of the society, the disturbance regime, the status of the biophysical environment and the major ecosystem services, and finally the causal relations between them *(Collins et al. 2007; Robertson 2008).* The framework is based on a scheme, which shows the social and ecological subsystems as well as the causal relations between and within them (Figure 1).

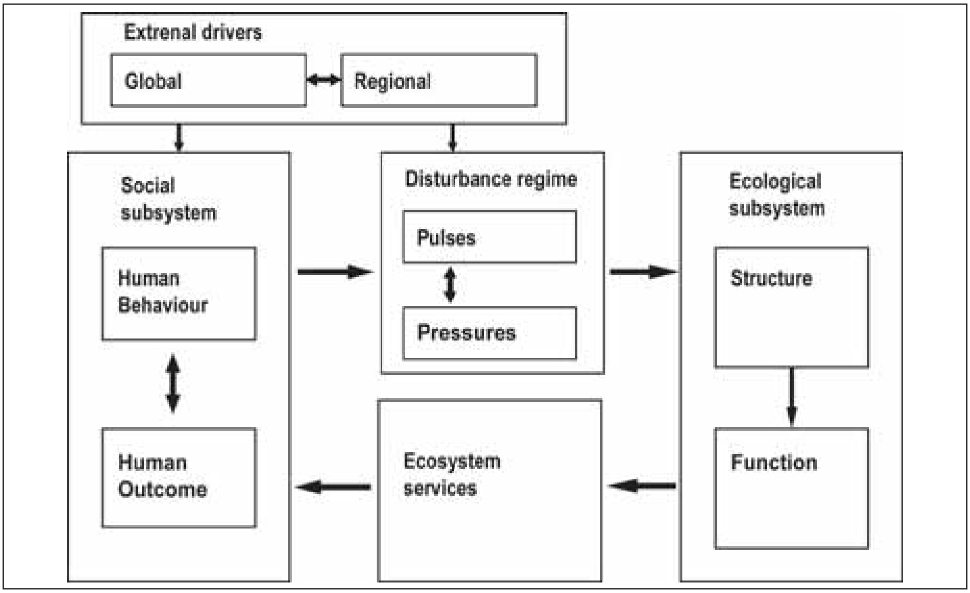

Figure 1: Basic structure of ISSE framework.

The basic subsystems are the social subsystem and the ecological subsystem, while the disturbance regime and ecosystem services connect these two. At a particular spatial scale, the causal relations between the subsystems are strictly directed. The social subsystem only affects the ecological subsystem through the disturbance regime, and the ecological subsystem only has an impact on the social subsystem through the ecosystem services. It supposes causal interactions between the subsystems and disturbance regime, but among the ecosystem services it does not. In the basic scheme, there is no shorting causal cycle at a particular scale. However, according to the examples of Collins et al. (2007) there can be shorting between the disturbance regime and the ecological structure, which corresponds to the ecological research practice.

Collins et al. (2007) recommends the use of the mentioned scheme in three spatial scales, e.g. local – landscape – regional or elementary catchment system – larger catchment system – regional level. However, each level has a subsystem, which displays external influences in the global and regional levels, compared to the particular scale, e.g. in the case of regional scheme at national level. The external factors have direct effect only on the social subsystem and the disturbance regime. In the examples of Collins et al. (2007) the shorting causal cycles are possible between the regional external effects and the social subsystem as well as among the regional external effects and the disturbance regime.

As we tried to ensure the international comparability of the results of our analysis, in the case of ecosystem services we used the typology of the Millennium Ecosystem Assessment (2005).

Collins et al. (2007) propose the adopters to summarize the critical ecological, economic and social changes as well as the non-obvious relations between them. The "critical" change means here that it also affects other subsystems and levels, and it is difficult to reverse. The "non-obvious" means to determine relationships, which prevail between different subsystems and levels, e.g. effect of landscape level economic changes on the regional ecosystem. The scheme used here (Figure 3) differs from the first scheme (Figure 1 and 2) in that it separates the social structure into economic system and socio-cultural structure and it only represents the change of ecological structure in the ecological subsystem. It does not necessarily imply that all three kinds of critical changes happen in every level. At local level often only ecological, at a coarser level usually ecological and economic, finally on the coarsest level all three kinds of changes are realized.

The use of the ISSE framework is iterative. In an examined area first those levels that are relevant are determined, and then various basic schemes are interpreted based on the results of field research, statistical surveys and expert decisions. This iterative process generates further questions through completing the schemes and discussing the experienced uncertainties. In response to the emerging questions, further data collection and analysis, or a new research process is issued, and on the basis of the results the original schemes are revised. The basic requirement of the whole process is the close cooperation between ecologists and social scientists both in the questioning and the answering phase.

In the case of the Kiskunság sand-ridge we have completed the first phase of this iterative process. Based on our previous research results and experiences *(Kovács-Láng et al. 2008; Biró et al. 2007, 2008, 2009; Gómez-Baggethun and Kelemen 2008)*, we interpreted the schemes in three scales via expert decisions and asked research questions. Since that time (autumn 2008) questions have strongly influenced our current application and research activity as well.

3. Results and discussion

3.1. The applied scales (levels)

At the local scale we consider the fine mosaic structure of the Kiskunság sand-ridge, consisting of juniper-poplar thickets, open and closed sand grasslands, dry sand forest-steppe habitats, and of inter-dune mesophytic vegetation. We studied these habitats within the KISKUN LTER in several sites, such as Ágasegyháza, Bócsa, Bugac, Csévharaszt, Fülöpháza, Kéleshalom and Tatárszentgyörgy.

The landscape scale means the sand dune formations including shallow depressions in their vicinity. Beside the above mentioned habitats, it also contains forest-plantations on sand-dunes, small-scale farming areas (home gardens, orchards, vineyards and arable fields as well as the abandoned, spontaneously transforming areas) and large, shallow depressions, which used to be affected by groundwater (reed beds, fens, marshes, temporary alkali lakes and their current derivatives).

The regional level is the Kiskunság sand-ridge itself, the middle part of the Danube-Tisza Interfluve, which can be characterized with coarse-grained, calcareous sand and the interposed basins as well as the villages and farm systems settled there.

3.2. Local level disturbance regime and ecological subsystem

The two most important disturbances on the poplar-juniper steppe woodlands and on the open and closed sand grasslands are the decline of grazing pressure and sinking groundwater level. The latter is the local result of the regional level groundwater decrease *(Pálfai 1996)*. It does not affect directly the open sand grassland and the greater part of the poplar-juniper steppe woodland because those habitats are independent from the groundwater effect.

However, the *Salix rosmarinifolia* and the *Scirpoides holoschoenus*, which are characteristic to the close sand grassland and the deeper inter-dune depressions, gradually give way to a successional vegetation type consisting of common open sand grassland species and the locally invasive *Calamagrostis epigeios*. The *Salix repens sp. rosmarinifolia* survives, probably because the wetland is only necessary for its establishment, but the *Scirpoides holoschoenus* gradually disappears, parallel with the decrease of the moisture *(Bagi 1997; Molnár 2003).*

The local result of a special, global level disturbance is the extinction of the rabbit *(Oryctolagus cuniculus) (Katona et al. 2004)*. Exactly how long this species had been a part of the juniper-poplar thickets remains debatable, but it surely had a role in shaping the current habitat structure *(Kertész et al. 1994).*

The aboveground biomass of the open grassland is increased by the decrease of the grazing and the disappearance of the rabbit, but this does not directly change the species diversity of the vegetation. Together with the decline of livestock grazing, fire hazard increases, threatening the juniper *(Ónodi et al. 2008)*. Landscape and regional level disturbance such as afforestation, especially the extensive black pine *(Pinus nigra)* plantations, further increases the fire hazard. Although the fire does not harm the herbaceous layer, it changes the structure of the landscape and reduces habitat diversity.

Overall, the local habitat structure becomes more homogeneous, the grass is closing, and the poplar-juniper steppe woodlands turn into poplar - open grassland mosaic due to its spontaneous spread and the frequent fires as well as the disappearance of water-affected habitats.

3.3. Local level ecosystem services and social subsystem

When we start the analysis of the social subsystem at local level – the poplar-juniper and the open sand grassland habitat complex – the question may arise if it makes sense at all to talk about changes in the social system at the finest scale, because humans are hardly present and are not acting directly at this scale. However, although socio-economic effects of changed ecosystem services are truly better felt at landscape level, we can also observe changing human behaviour at the local level, which can inform us about the subsystems' interactions at this level. As an example, we highlight the advancement of cultural ecosystem services (recreation, aesthetic values, education), which favours eco-tourism and environmental education in the poplar-juniper and dry sand dune vegetation of the Kiskunság region. This creates a new kind of subsistence opportunity and activity to some local people (e.g. mounted tour guiding).

The changes of human actions induced by the rise of eco-tourism are often accompanied by changes in attitudes and in the emotional connection with the particular area as our interviews have proved. Tourists and nature lovers visit the area and talk about it in the local community (e.g. to their host) as being highly valuable. These discussions foster gradual change of the local population's value system as they reinforce the idea that natural areas have greater value than those under intensive cultivation. This recognition poses the question whether the gradual change of the local community's value system and attitudes could help (and if they could, how) to mitigate the (negative) human impacts on the environment, and to encourage social adaptation to the environmental changes.

Changes in human activity and behaviour can also lead to long term changes in the disturbance regime. For example the sinking of the groundwater table, which is important at the local level, can partly be traced back to changes in human activity at landscape and regional level, such as increased water extraction (building illegal wells) and canalization *(Pálfai 1994, 1996)* (the 3.6. chapter has more details about this). However, we still need further research to investigate which human behaviours and actions contribute to the disturbance regime at local level and to what extent.

3.4. Landscape level disturbance regime and ecological subsystem

The two most important landscape-level related disturbance factors are afforestation with alien species *(Bagi 1997; Kovács, Farkas 2007; Molnár et al. 2010)* and the cycle of cultivation and abandonment, which is typical in the surroundings of sand dune areas *(Molnár 2003).*

Afforestation significantly reduces biodiversity by radically transforming the habitats of the sand dune area. In the interior patches of the black pine plantations, where afforestation failed or which were left clear for fire tracks, only a part of the original vegetation remains. A large black pine forest stand can preserve the elements of the original flora, and thus the regeneration potential of the area. To a lesser degree, the same is true for the plantation of alien poplar species. By contrast, the black locust *(Robinia pseudoacacia)* plantations remove the original vegetation and the black locust itself can spread spontaneously as an invasive plant. The understorey of the closed Robinia stands almost completely lack the elements of the original vegetation. The tree of heavens *(Ailanthus altissima)*, which does not provide timber of commercial value, completely outcompetes natural grassland species. But the small patches, after upgrowth and self-thinning let some elements of natural forests colonise. In addition, as we mentioned in part 3.2, forests, especially pine stands, increase the fire hazard of natural and protected habitats.

The regional decrease of groundwater level is one of the most important drivers of the cycle of cultivation and abandonment *(Pálfai 1996)* as new areas become unsuitable for agricultural production. The cultivation first destroys the original vegetation; the tillage homogenizes the microrelief of the sand surface, followed by the abandonment and spontaneous succession. However, the post-abandonment succession often leads to a rapid establishment of invasive species in the natural communities. One of these invasive species is the milkweed *(Asclepias syriaca)*, which can interrupt recovery for long time periods. Its extended populations exert large propagule-pressure on habitats with natural vegetation. Another common invasive species is the common ragweed *(Ambrosia elatior)*, which does not spread in natural areas and disappears quickly during the succession. However, it is abundant in newly abandoned fields and because of the regular soil disturbance to control weeds, in fallows *(Csecserits et al. 2009).* Due to cultivation and abandonment of the former wetland areas, meadows have featureless vegetation. They still keep the previous rich flora at the regional scale, but they are species poor at the local scale *(Kertész and Ónodi 2008).*

Overall, the landscape, which used to be mainly natural with an extremely rich biota, has become dominated by tree plantations of alien tree species and species-poor, featureless secondary vegetation, typically with adventives including invasive species that threaten the remaining natural habitats.

3.5. Landscape level ecosystem services and social subsystem

It is easy to point out the connection between changes in flows of ecosystem services and changes in the social structure (especially in land use and ownership system and conservationist decisions) at the landscape level *(Gómez-Baggethun and Kelemen 2008)*. Due to the growing importance of regulating services (e.g. regulation of biodiversity) and the deteriorating productivity of provisioning services (especially food production and animal husbandry), land use favouring nature conservation has come to the front. This often leads to top-down changes in rules, norms and conventions, determining local land use through the implementation of formal, top-down conservationist regulations. In the long run this may also alter the system of property rights (e.g. reduction of the proportion of private property and increase the proportion of state property as well as the proportion of leased agricultural land).

Changes at landscape-level ecosystem services can induce considerable changes in individual behaviour and actions. As provisioning services (especially food production and animal husbandry) become less profitable, possibilities for creating local livelihoods are narrowed, which leads to emigration of the more mobile (generally the wealthier, better-educated and younger) people, leaving the homesteads abandoned. Emigration contributes to the continuous growth of average age within communities, and to the disappearance of local/traditional ecological knowledge and traditional agricultural practices *(Kelemen et al. 2008)*. State subsidies and EU funds, which encouraged the establishment of small-scale black locust plantations also contributed to the change of landscape mosaic previously dominated by the peasant homesteads, because acacia was planted mostly in oldfields *(Biró 2011)*.

However, social reactions are not limited to emigration; they are also reflected by technological and economic innovations. For instance, recently in some protected parts of the sand-ridge, new livelihood forms (tourism) appeared and new technological solutions emerged to replace of some ecosystem services and adapted to the altered ecological conditions (i.e. water replacement, cultivation of drought tolerant plants). These changes affect the disturbance regime at landscape level (e.g. the cessation of grazing contributes to the spread of invasive species), but so far we have little knowledge regarding the background mechanisms. Therefore, the following could be important research questions in the future: which interactions result in the above mentioned changes of the social subsystem and in which ways do the social changes influence the disturbance regime at the landscape level.

3.6. Regional disturbance regime and ecological subsystem

The most important regional disturbance factor is the decline of groundwater level *(Pálfai 1996; Molnár et al. 2010)*. Reasons for this are complex but include: canalization to decrease the danger of inland inundation *(Lóczy and Szalai 1995)*, a series of droughts in the 1980s *(Liebe*

1993; Kertész and Mika 1999), water extraction *(Major and Neppel 1988)*, extended forest plantations *(Major et al. 1991)*, crude oil research *(Pálfai 1996)*, and also the long term shift in the balance of infiltration and evaporation due to recent climate change *(Lóczy and Szalai 1995; Kertész and Mika 1999)*. The relative importance of the above mentioned factors is heavily debated *(Lóczy and Szalai 1995; Szilágyi and Worosmarty 1997)*, but the severity of the phenomenon is beyond question *(Pálfai 1996)*. The debate over forest plantations is especially animated, because of the substantial changes they have caused; in the past two centuries more than 180 000 hectares of tree plantations were established compared to the 20000 hectares of forest existing in the 18th century.

The impacts of the decrease in groundwater table appear at each level of the analysis. The most important of these is the increased drought sensitivity, which primarily affects agriculture and leads to mass land abandonment *(Csatári and Kanalas 2007)*. Another regional consequence that greatly influences biodiversity is the disappearance of the alkali lakes and meadows from the sand ridge area, which not only leads to the homogenization of the soil and the vegetation, but also to the dramatic decline of bird diversity *(Boros and Bíró 1999)*.

As a result of the drainage of formerly wet habitats, some species, which originally lived in dry and sandy areas, spread over the dried-out habitats and abandoned agricultural areas. Abandoned croplands, gardens, vineyards and orchards established earlier on dry sand areas show fairly quick regeneration. This is due partly to the similarity in the species pool of the original and secondary sand habitats, and also to the rich and diverse propagule source provided by the fine-mosaic landscape structure. As a consequence, the dynamic connectedness of the original, the secondary, the natural and the disturbed ecosystems is greater here than in other parts of the country. The regeneration process, however, is slowed down by alien tree species coming from intensive forest plantations, abandoned homesteads and unmanaged tree lines. Until now, invasive herbaceous species have mainly spread over abandoned territories at the regional level, but the latest observations point out that they are more intensely occupying natural ecosystems.

The long term consequences of the regional sinking of groundwater level, so far, are not predictable. The main question is: to what extent can we reverse the unfavourable phenomena experienced so far, provided that the actions supposed to raise the groundwater level are accomplished in time?

3.7. Regional level ecosystem services and social subsystem

There are also changes in water balance, which create the biggest challenges for the social subsystem at the regional scale. Beside the global and regional drivers (EU subsidies, governmental decisions), changes in regulating and provisioning services have the most serious effects on social structure and human behaviour. This is well indicated by the fact, that from 1980-90 nearly 20 000 hectares of semi-natural habitats were converted to ploughland due to the low water table and the favourable agricultural subsidies *(Biró et al. 2008)*. This destruction primarily affected fens, which are influenced by subsurface waters. In order to adapt to the altered circumstances, nature conservation aimed to preserve wetlands and retain water. Making fens 'ex lege' protected helped halt the destruction of semi-natural habitats in the sand ridge. Regional development plans at the same time aimed to restore the former farming conditions by artificial water replacement.

Changing land use and economic structure, if not compensated by appropriate development policy, eventually leads to the regional realignment of the population by increasing the proportion of urban population compared to rural population. This can lead to increasing social disparity, infrastructural drawback, and the impoverishment and segregation of homestead dwellers. Emigration and segregation accelerate the process of agricultural land abandonment and intensive afforestation, which opens more space to invasive species and further decreases the groundwater table. To break this vicious cycle, region-specific regulations and development plans, which consider equally the natural and social-economic conditions of the Kiskunság are necessary,. However, this requires strengthening local decision-making processes empowering local communities, and transforming both the development and conservationist policy and the institutional system *(Mertens et al. 2009).*

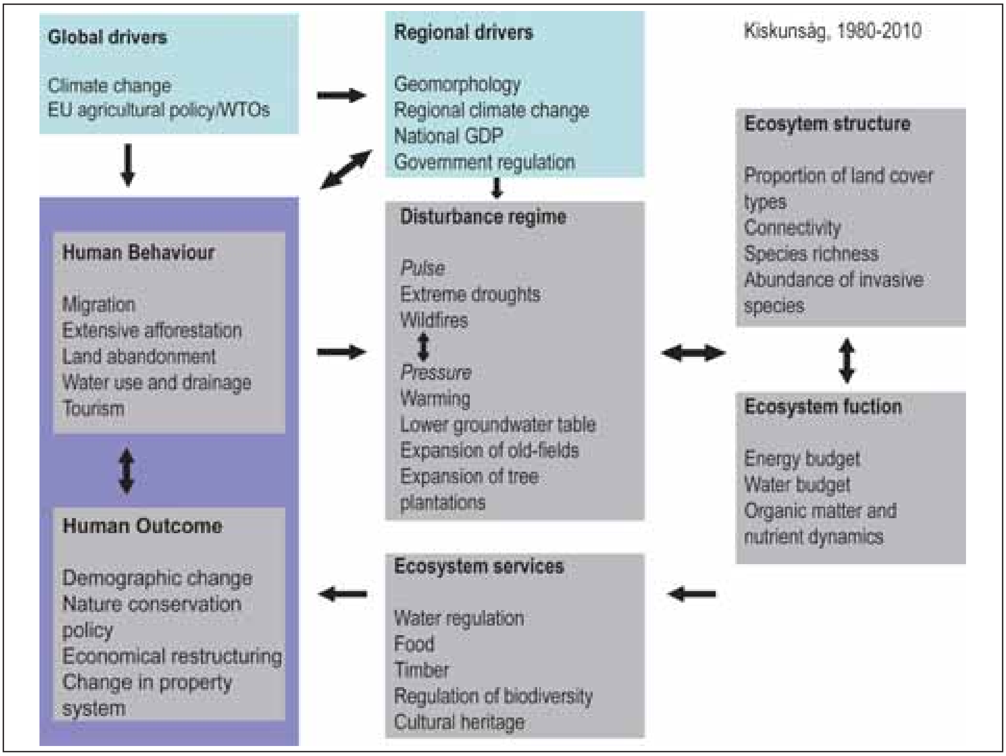

Figure 2: Regional scale ISSE framework for Kiskunság region.

3.8. Synthesis: critical changes and not evident relations

The ISSE framework points out not only how changes in ecosystem services affect society, but also shows how the social subsystem disturbs the ecological subsystem. It interprets interactions between the social and the ecological subsystems not solely as feedback loops within a closed system, but considers the external driving forces such as global and regional drivers.

Analysis of the local, landscape and regional levels shows that attitudes and values towards ecosystem services influence many processes. On one hand, they affect the socio-economic decisions, which determine the social structure (technological, institutional and economic measures balancing or adapting to the change); and on the other hand, they directly or indirectly define human behaviour. Thus, changes within the ecological system can initiate or modify processes between or within the elements of the social subsystem. They can influence for instance the access to natural resources by changing the regulatory system (property rights and nature conservationist rules); they can affect social stratification, demographic situation, social exclusion and the structure and processes of decision-making, etc. These reactions, along with social responses fostered by external (global or regional) drivers, feed back to the ecological subsystem. Disturbances close the circular interactions between the two subsystems (within and beyond certain scales), irrespectively of whether the disturbance regime is the result of accidental social reactions to changes of ecosystem services or the conscious adaptation and intervention of society.

Since both the social and the ecological subsystems have delayed reactions to the changes affecting them, we need to apply a long-term research approach in order to analyze these interactions. Analyzing ecological changes and social transformations of the past, we can explain why humans alter the functioning of ecological system, and which adaptations were reactions to the ecological system. Understanding the co-evolution of ecological and social systems can help us interpret the present natural and social processes and thus propose more sustainable and socially just adaptation strategies.

The most important and most critical change going on in the flows of ecosystem services is the deterioration of the water regulation service, which we addressed at all scales and in each subsystem.

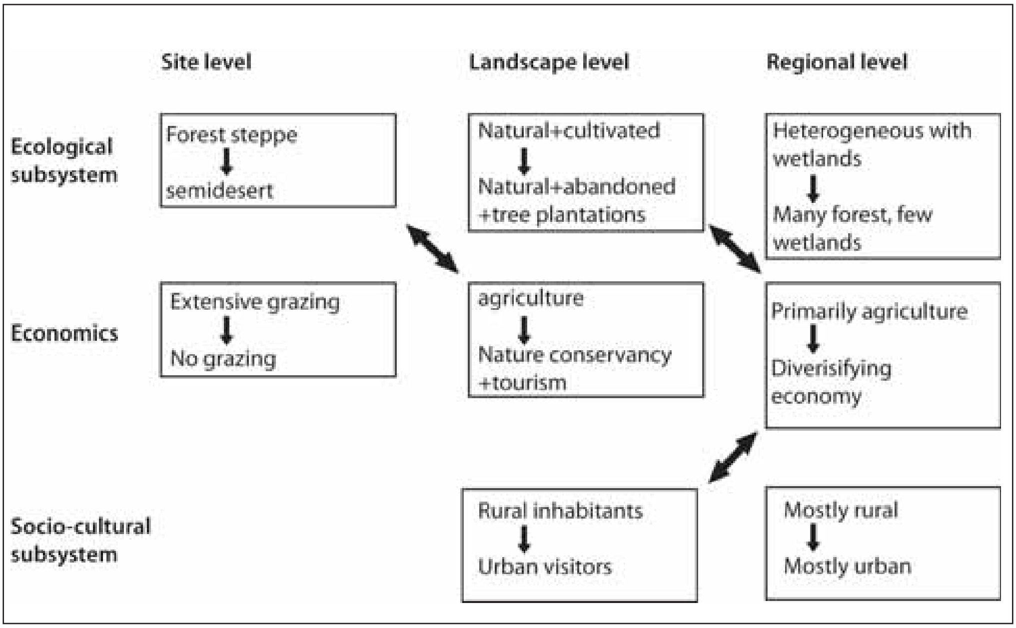

Figure 3: Critical changes and their major non-evident (i.e. cross-scale and cross-subsystem) interactions in the Kiskunság region.

In Figure 3, critical changes and the most important non-evident relations are shown. Now we will explain why these changes are said to be critical. Landscape and regional level ecological changes are critical because afforestation does not allow the regeneration of the original vegetation. Since forests are established for the long term, this effect is hardly reversible. This is further aggravated by the fact that after logging, according to the present regulations, it is mandatory to re-establish the forest plantation on the same area.

Change in the landscape level socio-cultural setup is critical because the traditional peasant lifestyle, well-adapted to the natural context and accommodating traditional ecological knowledge forms, disappears due to emigration and aging of the rural population (especially of homestead dwellers). This disappearance seems to be permanent. In order to halt aridification of the sand ridge, challenges of global climate change and the increasing water demand of the local population should be addressed, but this is a difficult task both for politicians and engineers.

Though the ISSE framework represents a given time period (in our case it is about the last 30 years), we would like to mention some longer-term non-evident relations, mainly related to afforestation. In the eighteenth century, this region was almost completely treeless and therefore the effect of wind was much more intense than it is today. At local level, this hindered the closure of sand grasslands. At landscape level it sustained the bare sand surface of pastures and arable fields in move and blew it to the settlements, agricultural areas and wetlands, and sometimes even caused big sandstorms. While the indirect impact of wind appeared locally by opening up the grassland and shifting the sandy soil, all these local effects generated landscape level and regional processes. The wind intensified the effects of trampling caused by overgrazing. With this, it limited the access to past local and landscape level ecological services (animal and human food, healthy air, etc), which was then addressed by the society with landscape level and regional arrangements (urban and state laws, tree-planting on sand etc). Because of tree plantations, the wind has virtually ceased to be a disturbance factor at all three scales. This change made the whole area more suitable for settlement and cultivation around the middle of the 20th century, and at the same time, exposed natural areas to human disturbance. Since then, the decrease of groundwater level has become the major disturbance factor.

3.9. General experiences of the ISSE framework application

The first and most important experience of the ISSE framework is the deepening of scale- and system-consciousness, although experts involved in the work had already been very scale-conscious in their own respective research fields (partly for methodological reasons). They had already interpreted cautiously their results obtained at a given scale but less consciously connected the studied phenomena to geographical scales than the ISSE framework required in this work. On the other hand, each phenomenon they had considered important had to be placed in the whole framework. This process generates many questions, and greatly helps researchers consistently consider those effects and consequences of their own work that are traditionally examined by other specialists, during both the planning of their future investigations and the interpretation of the results. At the same time, it is confirmed that complex questions could be effectively examined by an interdisciplinary team consisting ecologists, economists, and socio-cultural researchers.

The ISSE framework's first scheme (Figure 1 and 2) is similar to the Millennium Ecosystem Assessment's (2005) causal scheme, which is also scaled, and to the DPSIR scheme *(OECD 1993)*, used by the European Environment Agency. At the same time, we found that the causal network of the ISSE scheme is the easiest to apply. The application of the ISSE framework in the KISKUN LTER site is part of a program of international cooperation, initiated by the US LTER and pursued by the ILTER (see acknowledgements). In the context of the cooperation, 15 similar examinations are summarized. Compilation of the summary and an article are still in progress. According to the prior experiences, the ISSE framework is useful to compare the socio-ecological status of very different areas. KISKUN LTER is also involved in an ongoing European assessment of ecosystem services of LTER sites.

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POTENTIAL LAND USE CHANGES IN FLOODPLAIN AREAS FOR ENHANCING THE PROVISION OF ECOSYSTEM SERVICES

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1. Introduction

In 1950, the world's population still had not reached three billion. But in just the past 50 years, this number has more than doubled, increasing to almost seven billion people. It is projected that by 2050, that number could come close to or even reaches ten billion. Population growth can be foreseen especially in developing countries *(World Population Prospects 2007)*. Demand for natural resources, such as food, water, timber or fuel has grown considerably due to this population boom. All these unfavourable trends will continue to put pressure in unprecedented scale on the Earth's ecosystems. Key impact factors in this process are habitat degradation, climate change, biological invasions, overexploitation, pollution and other pressures caused by humanity *(MEA 2005; Török 2009)*. The article entitled „Planetary Boundaries" published in 2009 with the involvement of approximately forty scientists searched for where the threshold lie, the crossing of which would exert irreversible and fatal consequences to humanity. Out of the ten factors (climate change, ocean acidification, stratospheric ozone depletion, nitrogen cycle, phosphorus cycle, global freshwater use, land-system change, rate of biodiversity loss, atmospheric aerosol loading, chemical pollution) assessed, three have already passed the level of sustainability *(Rockström et al. 2009)*:

1) The greatest in extent is the loss of biodiversity, which means that the number of wildlife species is decreasing at the same pace as it did in the older geological eras' great extinction waves *(MEA 2005).* In 2002, the European Union set a target to halt the loss of biodiversity in Union territory. But, since that date has passed, it has now become clear, that the target was not met *(Walpole et al. 2010)*. Key steps to mitigate biodiversity loss include reduction or stop altogether the dramatic decline of green areas and restoration of degraded areas.
2) According to the article, industrial and agricultural activities have greatly damaged the nitrogen cycle of the biosphere, rising above greatly the threshold of sustainability.
3) Although the loss of biodiversity is the most frightening, climate change is put higher on the agenda of current political decision making. Professionals say that the primary cause of global warming is the increasing concentration of greenhouse gases (first of all the carbon dioxide) due to human activity. However, this view does not take into account the role of biodiversity plays in carbon capture and storage.

The currently fashionable concept of sustainable development has become outdated, because the Earth's carrying capacity has long exceeded levels of sustainability, which can properly illustrated by the changes in ecological footprints *(Vida 2008)*. It is necessary to see clearly that there is a strong correlation between biological diversity and the well-being of human society, since all services obtained from nature depend on biodiversity to some extent *(de Groot 1992; Costanza 1997; MEA 2005; Kettunen et al. 2009; Rockstöm et al. 2009)*. Reduction and destruction of nature (grass breaking for agricultural use, highway and shopping centre construction, etc.) impoverish our environment and thus make our socio-economic system vulnerable. As a well-known proverb says: we cut the tree under ourselves.

Ecosystem services are natural assets and services, which are used by humans directly or indirectly over their respective lifetimes *(MEA 2005)*. The primary role of this concept as a tool is to support and substantiate decision making having impact on ecosystem functioning or their management. It should be seriously considered by both local and global political decision makers *(Kelemen 2009)*. There are a number of different definitions of ecosystem services. However, often the newest ideas are simply an advanced version of the previous one and are thereforevery similar to one other *(de Groot 1992, 2006; Costanza 1997; MEA 2005).*

Most researchers still refer to the typology of the Millennium Ecosystem Assessment (2005), which contains four groups: supporting, regulating, provisioning and cultural services. Assets and resources provided by the provisioning services are used up directly, such as food, timber or water. Recent studies separate 'provisioning services' from so-called 'habitat services' - the latter is to summarize services of habitats provided to species for everyday life activities and reproduction *(e.g. de Groot 2006).* Climate control, water purification or pollination of plants are categorised as regulating services. Supporting services are indispensable for the standard functioning of ecosystems (primary production, soil generation), thus constituting the fundament for all other services. Quite a lot criticism has been formulated over the years *(eg. Hein et al. 2006)*, so these groupings are increasingly ignored against these categories' in some studies. Cultural services of nature include activities related to recreation, education, arts and leisure.

In this paper we present the main ecosystem services provided by floodplains found in Hungary. In addition, we will show the regulation of Tisza River and its consequences. Moreover, through one case study we will suggest a landscape use change with valuing ecosystem services gained through this practice.

2. Natural services of floodplain areas

Results of all international research assessing the value of ecosystem services have demonstrated that wetlands, especially floodplain habitats, are one of the most valuable habitats *(Costanza 1997; de Groot 2006; Turner 1983, 2000)*. It is not a coincidence that human civilizations around the world have usually first been established in river valleys and developed typical floodplain landscape management *(Csemez 1996)*. Water from higher mountain ranges is enriched gradually with nutrients on its way down. This flow is forced to stop by the plant communities in the lower parts of the catchment area for several months, while carbon, nitrogen, phosphorus and other essential components were incorporated in the land resulting invaluable resources of food and nutrients to wildlife and indirectly to man *(Oláh 2002).*

Among regulating services the floodplain forests contribute significantly to climate change mitigation through capturing large amount of carbon dioxide, and thus directly filtering and purifying the air and regulating humidity. Forest vegetation binds and takes up the carbon dioxide, which is the most important greenhouse gas and a major cause of global warming *(Luyssaert et al. 2008)* and prevents it from accumulating in the air. The other significant role of floodplain forests is flood control, since the top ten-centimetre layer of the forests soils rich in organic matter is capable of storing 160 mm rain water *(Oláh 2002)*. It is known that the most productive soils are in the large river delta areas where water and nutrients create excellent productive soil (nutrient provision). *(Csemez 1996)*. The most important elements are carbon, nitrogen and phosphorus, which formerly delivered the abundant of fish also to the Carpathian Basin, where rich grazing lands have been formed supply eight million livestock currently *(Oláh et al. 1991; Oláh 2002).* Natural self-purification of waters primarily has importance in neutralizing pollution. Significant amounts of pollution can come from the upper catchment area, including heavy metal pollution, such as during the 2000 cyanide disaster. Researchers have shown that one hectare of floodplain wet ground can detoxicate up to 300-400 kilograms dissolved metals per hour *(Bender and Philips 1994).* Besides, the floodplain areas would be suitable for purifying domestic wastewater as well. Through these services, metabolic processes, which contribute to maintenance of the groves of gallery forests, resulting in significant value of secondary profits *(Oláh 2002)*.

The river valley ecosystems provide natural habitats and reproduction sites (habitat services) for the wild fauna and flora. They maintain biological and genetic diversity, and thus provide the basis of all other natural services *(de Groot*

2006). There are two main factors that determine individual habitats: their quality and their quantity. Besides adequate size of a habitat, its proper quality and proper neighbouring feeding sites are essential especially in case of large, disperse animals.

In the past provisioning services were much more valuable than they are today. Ancient alluvial land management included activities, such as fishing, fruit and vegetable growing, beekeeping, or hunting. These activities were once almost unlimited in the river valleys, but they have been pushed into the background or have completely disappeared mainly due to landscape homogenisation. Secondary services arisen from this type of land management are timber products, herbs and other decorative materials that are easily accessible in these habitats in principle *(Balogh 2001, 2004).*

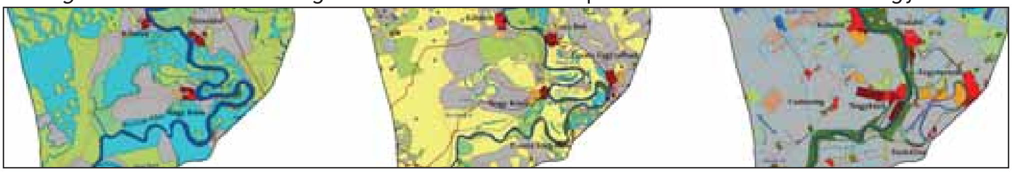
The scenery along rivers has always been an attractive place for humans. Along the two major rivers, the Danube and the Tisza, there are still places covered by natural environment even if extension is small. In these areas more attention has been paid to eco-tourism in recent years. This type of activity, namely visiting relatively undisturbed natural areas in a way to preserve natural and cultural values, contributes actively to the livelihoods of local people. In addition, conservation of these natural habitats contributes considerably to maintain human health, through spiritual enrichment, recreation and aesthetic experiences. All these benefits are listed as cultural services.

3. Regulation of the Tisza river

Before the river regulations, the Tisza valley was a "gentle water country" opposite of the public perception. The river roamed on a large part of the eastern basin of the Carpathians, forming typical floodplain areas *(Molnár 2004).* The typical management form was floodplain-, also known as oxbow lake fish management, extensive livestock husbandry, fruit and vegetable growing. The husbandry method practised in the floodplains relied upon the annual floods, which reached the plains through incisions ('fok') cut into scroll bars. Higher elevations ran along the length of the river, and were drained back into the main river bed once the flood subsided through the same openings *(Balogh 2001, 2004).* From 19th century onwards, demand for regulating the Tisza grew. In order to increase agriculture- and the habitable areas, a lot of wetland habitats were drained *(Bellon 2004; Sendzimir et al. 2008).*

After the regulations, the original 1419 km length of the river was reduced to about ʿits two-third, approximately 962 km. The earlier flowering floodplain management declined and practically disappeared, and various degradation processes started in the valley. Salinification has been accelerated on the agricultural lands due to the lack of regular water coverage, the risk of accessing surface water has increased, ecologically valuable wetland habitats have been highly degraded, many of them have dried out, invasive species have appeared in their place, the groundwater level has fallen, and the grade and speed of the water have increased in the narrow main channel (Somlyódi 2002). The process is clearly visible in the following series of maps, where wetlands marked in blue and are largely pushed back compared to agricultural land marked in yellow and grey *(Nagy 2008)* (Figure 1).

Figure 1: Historical vegetation and land use pattern in the area of Nagykörű



(from left to the right: the end of the 18th century (1783-84) – the middle of the 19th century (1858-61) – the end of the 20th century (1998-99).

4. Landscape Development Programme in Nagykörű

The Landscape Management Programme started in the mid-1990's creating an exemplary initiative in the Tisza valley. The main goal of the Landscape Development Programme in Nagykörű is to take advantage of the benefits provided by the land and the river in a sustainable way. The main objective of the programme is to develop a state-of-the-art land use pattern that is able to provide secure livelihood (structural changes in agricultural production), ecological safety (landscape rehabilitation) and flood control (water resources management) as part of a single comprehensive system. The specific activities are most relevant to the alluvial Nagykörű area; however, the lessons learnt can be applied across the Tisza region. In the course of revitalization project they connected the digging pits - which are separated from the main river bed - with the Tisza, a channel network in it helped by allowing the natural reproduction of fish. By demolishing of the summer dam, which was built between the main river bed of the Tisza and Lake Anyita, the natural function of Lake Anyita was restored, and the intensive agricultural cultivation was reduced. Restoration of the Nagy-fok (meaning large incision on the river bank) included inter alia the landscape reclamation project between 2009 and 2011 launched by ICPDR-UNDP-SZÖVET with the title „Integrated land development (ILD) program to improve land use and water management efficiency in the Tisza basin", which handles the rehabilitation of a 30-hectare cropland, grassland and wetland area. The pilot site is a part of the divergent residual channel, which is in the middle of the floodplain polder's protected side working for flood control. The pilot site is on the floodplain low floor, where the flood level of former river bed was. Length of the entire pilot site is 800 metres, with a width of 600 metres on the western side and of 200 metres on the east. Within this area the depression of the former river bed is 400 metres long and 50 metres wide, with an average depth of 1 metre. A total of six parcels are situated in the area, five of which are arable lands and one of which is an orchard. Excess water drainage canal No 19 runs on the northern edge where water currently runs off. One fundamental goal was to retain locally generated water in the area and that surface cover and land use patterns accommodate the year to year variation in water cover. In other words the project aimed to establish grass or wetland habitat on the lower lying areas, which stand transient inundation for a while and to set up extensive orchard, grassland or mixed cultures on higher elevations *(Balogh 2001, 2004).*

5. Case study: Land use change in Nagykörű floodplain polder

Land use change is an extremely long process that may last 10-15 years, or even more. It is very important to carry out personal meetings and interviews with the stakeholders, including visual interpretations (dummy, drawings, model, etc.). Affected farmers are better understand why it is important to manage the landscape more ecologically when they can see "the finished product" in front of them . For our study, the six owners of the 30-hectare pilot site were approached individually. The objectives of the project were presented to them, and then their attitudes towards potential land use change were examined. The interviews revealed that due a significant yield loss occurred at spring season to the inland waters, especially in extremely wet years such as 2010. In the majority of cases we received positive feedback, so we organized a focus group discussion with stakeholders. Based on the needs identified, we prepared to map the area in four different versions. For all of these versions, theatrical maps were prepared by staff members of Pagony Landscape and Garden Architect Ltd. based on site visits and in line with the natural boundaries of the landscape. In these four models, changes were indicated, which local people wanted, and we outlined desired land use in the area. On one hand, we illustrated the current land use; on the other hand, we presented models for alternative land uses. In addition to the graphic display, location maps of the area were presented. The intensive land use model included fish ponds, camp sites and intensively cultivated arable land. In the semi-intensive, partially natural use model a planted forest was surrounded by an extensively cultivated fish pond, grassland, arable land and orchards. In the ideal landscape patterns (natural land use), model boundaries were adapted to natural state with periodic wetland coverage containing wet and dry grasslands. Most stakeholders considered the semi-intensive, partially natural and the ideal (natural) land use version as the most acceptable ones the four options presented.

Each land use scenario provides different natural services at different scales. This study compares the current and ideal (natural) land use using the ecosystem assessment matrix developed by Burkhard et al. (2009) as a basis. Supporting services were not considered here. The horizontal axis reflects the natural services and the vertical axis represents the CORINE land surface cover categories. The former were evaluated on a 0-5 scale depending on the size of their role with regard to the land surface cover category in question. The 0 value is associated with no natural services, while 5 provided the maximum amount of ecosystem services. The scaling system was developed using expert estimates and case studies. We assessed only those ecosystem services and land cover categories relevant to the pilot site.

Instead of general plans, we illustrate with graphic figures for easier comprehension. Figure 2 shows the current conditions; five of the six parcels of arable lands are mainly cultivated as corn, one of them as an orchard, which is dry. Trees along an oblong depression – the result of the regular excess water coverage in springtime – crossing the area can be seen especially clearly.

Figure 3 was planned by Pagony Landscape and Garden Architect Ltd. and reflects the ideal state in which surface cover matches the natural boundaries of the landscape. Due to the water cover in the springtime, a temporary water body with sedges forms, which dries up by the summer season. In the case of more abundant rainfall, a permanent water body may be formed. This can also occur in other depressions. Directly next to the water body, wet and dry grass compose most of the natural land cover. All these can be best exploited by extensive livestock husbandry, such as grazing sheep. Due to natural succession, soft wood gallery forests couldform along the oxbow lake called Sulymos with predominantly willow trees *(Salix sp.)* and poplars *(Populus sp.)*. Another possibility is that ecological succession would take place next to the water body in some places with forest cover at the end. Next to the dirt road along the main road and the channel, tree and scrub line are starting to grow.

Figure 2: Current land use of the pilot site.

Figure 3: Natural land use of the pilot site.

We tried to apply the assessment matrix developed by Burkhard and his colleagues to the changes already mentioned in case of this pilot site. We do not deal with the size of habitat spots and the strength of natural services, although both of these factors may have an impact at both local and global levels. Also, the quality of the various habitats was not considered. For instance a plantation forest plays a much less significant role in climate regulation than an untouched primeval forest. Comparing the current state with the natural state the following results were obtained (Table 1).

Current state	Provisioning Services ∑	Crops	Livestock	Fodder	Capture Fisheries	Wild foods	Timber	Wood fuel	Energy (Biomass)	Biochemicals / Medicine	Freshwater	Regulating services ∑	Local Climate Regulation	Global Climate Regulation	Flood Protection	Groundwater Recharge	Air Quality Regulation	Erosion Regulation	Nutrient Regulation	Water Purification	Pollination	Cultural Services ∑	Recreation & Aesthetic Values	Intrinsic Value of Biodiversity
1. Non-irrigated arable land	21	5	5	5	0	0	0	0	5	1	0	5	2	1	1	1	0	0	0	0	0	1	1	0
2. Orchards	13	5	0	0	0	0	4	4	0	0	0	19	2	2	2	2	2	2	1	1	5	5	5	0
3. Annual and permanent crops	20	5	5	5	0	0	0	0	5	1	0	7	2	1	1	1	1	1	0	0	0	1	1	0
4. Line of trees and shrubs	5	0	2	0	0	1	0	2	0	0	0	3	1	0	0	0	0	0	0	0	2	4	2	2
Total: 104	**59**											**34**										**11**		
Future state																								
1. Pastures	10	0	5	5	0	0	0	0	0	0	0	8	1	1	1	1	0	4	0	0	0	3	3	0
2. Forest	21	0	0	1	0	5	5	5	0	5	0	39	5	4	3	2	5	5	5	5	5	10	5	5
3. Grassland	5	0	3	0	0	2	0	0	0	0	0	22	2	3	1	1	0	5	5	5	0	6	3	3
4. Line of trees and shrubs	5	0	2	0	0	1	0	2	0	0	0	3	1	0	0	0	0	0	0	0	2	4	2	2
5. Wetland	7	0	2	5	0	0	0	0	0	0	0	14	2	2	4	2	0	0	4	0	0	0	0	0
TOTAL: 157	**48**											**86**										**23**		

Table 1: Natural services and their values during the current state and the results of natural land use according Burkhard and his colleagues, 2009.

It can be stated that four new land cover categories would be formed if the natural land use method is applied, while the three existing ones would vanish altogether. The current structure is geared toward intensive agricultural production, which can be seen from the results. In this case provisioning services would provide higher values even though the number of categories is less here. However, in the case of regulating and cultural services, this ratio is turned round and the values in the case of a natural land use profile would provide twice as high values than the current one.

Because pastures and grasslands are similar, it is not worth separating them. The presence of the livestock is evident through provisioning services and concomitants from the amount of organic manure. All of the grasslands and pastures provide effective bastions against erosion and ecological corridors through their vegetation coverage. It is important to call attention to the role of grasslands in nutrient regulation and water purification.

The high value of provisioning services with natural land use is primarily attributable to the forests, which provide wild edible plants, raw materials for the wood industry, raw materials for the chemical and pharmaceutical industries and energy. We have already mentioned the major climate control capacities of forests, as well as the role they plays in flood protection. They can also clean the air and prevent erosion by binding large amount of soil. They contribute to the cultural services in significant scale, primarily through tourism. Transitional woodland-scrub areas can play a similar role in the course of natural succession.

Wetlands primarily play a major role in regulation; in addition, they have significant ecological value. By capturing water, they contribute significantly to flood protection. During floods, waters flow into natural depression along the river, and thus reduce the intensity of flood waves. At the local level, water also plays a role in regulating the climate. Although it does not appear significant in the table, we consider it important to emphasize.

6. Conclusions and possible further steps

Earlier we presented a matrix for assessing ecosystem services applied to a Hungarian pilot site. Of course, this method is strongly artificial, since the values of the individual services cannot be transposed to Hungarian habitats without modifications. Yet they still provide approximate results. Natural and semi-natural habitats are mostly fragmented because deeper laying areas are also ploughed up or used as agricultural productive land. This has numerous harmful effects: the quality of habitat decreases, invasive species spread, and the genetic deterioration of invertebrate species as a result of isolation. In order to eliminate constant damages, we must fit land use patterns to the natural boundaries of the landscape. Additionally, this process would facilitate the development of ecological network in accordance with principles laid down in the Natura 2000 programme.

The following actions should be taken as next steps:

1) the preparation of a uniform typology for ecosystem services, which is accepted by every stakeholder
2) "translation" of CORINE land cover categories to set up a typology better suited to the value of ecosystem services and habitat types
3) creation of a matrix developed specially for the valuation of ecosystem services and completion of it by experts based on domestic case studies and investigations
4) determination of additional steps in order to make the matrix more accurate.

7. Acknowledgements

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PRIMAL STATEMENTS AND SOME EMPIRICAL RESULTS RELATED TO THE ENVIRONMENTAL CONSCIOUSNESS IN THE GREAT HUNGARIAN PLAIN

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1. Introduction

As a consequence of human activities, the surface of the Earth has been radically changed. Due to unfavourable impacts resulting from intensive production and consumption, the natural systems – together with social communities – of our planet are in danger. Although most countries of the world regard the protection of the environment as one of their tasks, the real aspects of sustainability are either neglected by most of the states or not fully taken into consideration. This is mainly because economic considerations still dominate development concepts and national policies. Today, we should be able to provide solutions for numerous problems, such as tackling global and local environmental conflicts, but we are still hindered by short-term economic interests.

Thus, stopping negative processes threatening natural systems requires a change in our priorities. This change must take place at all social levels (international, national, regional, local) at the same time since reaching this change depends on whether smaller and bigger communities (settlement, regional, national, EU, UN) are able to protect and maintain geographic space in a harmonized way and cooperate with each other.

Our starting point is the idea that environment-conscious activities may fulfil an outstanding role in solving most national environmental problems and create and maintain favourable future living conditions. Environment-centred thinking and responsible acts may contribute to the renewal of rural regions in the Great Plain. Gaining knwoledge of environmental conflicts experienced within settlements in certain regions of the Great Plain is very timely. Therefore, exploring certain cultural-mental factors – environmental consciousness of inhabitants and their attitudes, stand-points as well as professional views of certain prominent persons – was found to be essential.

Familiarity of environmental consciousness between selected communities could be advantageous for several reasons. Firstly, because environmental problems related to these settlements become comprehensible and can be resolved with the help of summarized opinions of inhabitants and professionals, and thus certain environmental-social-economic issues could become interpretable. Secondly, expectations, worries and local ideas and needs in connection with environment could be more effectively outlined and contribute to development of more valid, region-specific local environmental policies. Besides, mapping environmental consciousness may help for prepare educational and training schemes, by which local communities can be encouraged to live a more environment-conscious life.

2. Definition of environmental consciousness

Our environment consists of systems, complex subsystems and their elements. The main subsystems are the natural, the transformed, the built, the economic and the cultural-mental environment *(Enyedi 2000).* Environmental consciousness is regarded as the determining element of the cultural-mental environmental subsystem in this approach (Figure 1).

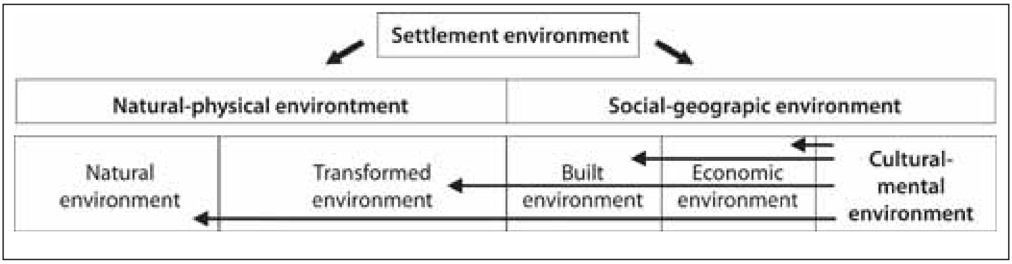

Figure 1: Main environmental subsystems based on Enyedi György's settlement environmental categories.

Environmental consciousness – according to this model – has a strong effect on each environmental subsystem, i.e. culture towards the environment and approach of the society have impact on our whole environment.

Environmental consciousness or the expression of it has become very widespread in the local discourse lately. However, its meaning is not clearly explained in the Hungarian literature, so it is important to pay attention to the real content of this term. Environmental consciousness includes ideologies ensuring long-term sustainability, human and social communities as well as behaviour types and all concrete activities based on them. The aim of environment-conscious activities is creating and maintaining a dynamic balance between the environmental subsystems. In modern societies protection of environment must be in harmony with technical, scientific knowledge and principles, economic and political policies, as well as civil activities of society.

3. The examination of environmental consciousness and some specialities in Europe and Hungary

Environmental consciousness examinations have become actual due to the expansion of social activities related to environment protection. It has risen in response to classical problems that are becoming increasingly urgent to solve, such as waste management, air and noise pollution, energy management, biodiversity, water management, in urbanized areas of developed countries. Research examining personal and communal responsibility and people's opinions connected to environment is particularly widespread in the United States and the countries of the European Union. Creating environmental image has been shown up as a new target including settlement construction that considers environmental issues, environmental collaborations, and partner relations between settlements and regions, developing communication as well as new (holistic) environmental teaching and education.

In our continent, the first international comprehensive research was carried out by the European Commission through the European Co-ordinational Committee (INRA EUROPE) in 1995. The aim of this research was to provide insight for environmental policy decision-makers from EU Member States into the inhabitants' common environmental knowledge, anxieties and role-taking capability. These examinations focused on the following questions: What kind of global, regional and local environmental problems are the inhabitants aware of? Which are the most important environmental anxieties? What are the main environmental needs of people and what are their perceptions for the future? How would people participate in the protection of the environment?

The main lesson learnt from this research is that more than 80% of the population thinks that environmental problems are very pressing, but at the same time they do not feel responsible for solving them. In 2002 the Eurobarometer conducted another survey in the member states of the EU. These newer results showed a a substantial increase in anxiety, although the inhabitants – according to the data – were still waiting for the solution to come from others. However, in some countries – e.g. Sweden and France – most residents thought that they could solve environmental problems by themselves. In these states civil environmental advocacy has since become very effective. They have become advanced in "the best environment-conscious practises".

In Hungary, surveys exploring environmental consciousness have been carried out by The Gallup International. "The Health of the Planet Survey" conducted in 1992, is an international representative poll estimated and compared environmental attitudes in 30 European Countries including Hungary. The Hungarian Gallup Institute in 1994, with the title of Greening Hungary - Environmental attitudes in the autumn of 1994, repeated this examination. This analysis – at that time only made among Hungarians – was more varied than the 1992 survey, but basically showed similar results about the Hungarian people's attitude towards the environment. The survey also demonstrated that compared to other critical questions, environmental problems became more significant in Hungary as well. Ecological sensibility, e.g. the anxieties towards environmental safety, increased, and citizens wanted to play a greater role in environmental questions. In the decade followed the regime change in Hungary, society realized that beside centrally developed environmental policies and expert decisions, the civil population's opinion is also authoritative in environmental issues. Inhabitants could even have veto in some cases. These statements are confirmed by some researches and case-studies *(Fazekas 2001; Fischer 1994; Havas and Cziboly 2000; Kerekes and Kindler 1994; Kerényi et al. 2000; Pataki 2001; Szirmai 1999; Valkó 2003; Varga 2004; Vári et al. 1998; 2001; 2002).*

According to further examination of the results in study groups, it has come to light that young people who participate in special environmental education develop more positive environmental approaches. They are able to acquire higher level environment-conform thinking and activity. (Generally, environmental consciousness is significantly higher among higher educated people, e.g. graduates show much more notion of collecting household waste selectively.) Moreover, surveys conducted Corvinus University of Budapest and the Waste Reduction Alliance (HUMUSZ) showed that younger generations are more environment-conscious in Hungary as well.

Unfortunately, recent national surveys (e.g. Cognative-WWF Ecobarometer, Hungarian Gallup Institute) primarily pointed out that the general population of Hungary is still not environment-conscious enough in terms of daily lifestyle. Most people worry about the state of the national environment but only few of them are willing to make any real changes. According to the majority, environment protection is not the persons', but the state's responsibility. These results indicate that activities that are harmful for the environment should be taxed instead of taxing human labour. This would contribute to decrease people's tax and leveling off burdens. In addition, the state should take stricter action against polluters who do not pay for the damage they cause.

However, two thirds of the interviewees would not like to pay environmental tax even if the government guaranteed that this income would be used to improve the environment. The more recent studies show that most Hungarians are aware of the negative effects of the environment damaging processes, but they do not feel responsibility at the individual or household level. In practice, they do nothing and think that they could not act. Some segments of society still show total disinterest towards the environment. Even those who have sufficient knowledge can only be motivated to carry out activites that do not require financial contribution and do not take much time.

4. Environmental consciousness - examining the Great Plain regions

In the past decade numerous studies regarding environmental consciousness have been conducted in the regions of the Great Plain under the aegis of the Regional Research Centre's of the Great Plain. These surveys were carried out in model areas, where their problems are typical in most of the rural areas of the Great Plain. Many of the problems of rurality are complex and many specific natural and social conflicts are present.

According to our assumption, most of the conflicts within these areas are not only associated with economic problems, but also with the population's behaviour (this ignores the possession of proper natural knowledges and the implementation of adequate approaches) as well as with the deficiencies in environment-political and management found on the professional and decision-making levels. Beside the negative factors, we also expected that positive features of environmental consciousness would be found among the concerned local communities *(Kovács 2008).*

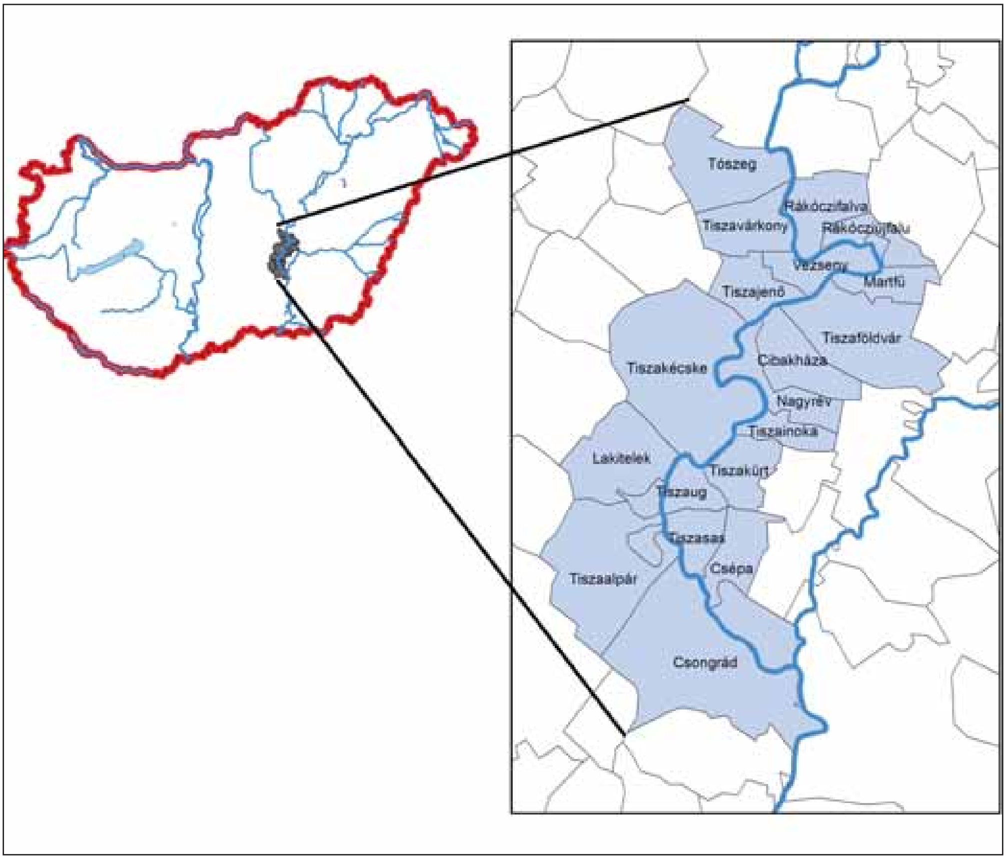

Figure 2: Model area along the Tisza River.

The research had several goals related to the characteristic environmental problems found in the model areas, focusing on the opinions of inhabitants and contacting prominent persons (experts, autonomous decision makers). On one hand, the study aimed to present questions about the geographical parameters of the model areas, the most important environmental problems, and the development and sustainability of the studied settlements. On the other hand, it aimed to collect experts' opinions and explore environment-conciousness of people living in the local communities of the model area. Finally, in accordance with the results, we attempted to summarize those environment-concious development possibilities and principles that might be generally applicable to the Great Plain's rural areas in the future.

Applying international methods for the study of environmental consciousness, we conducted surveys in an area along the Tisza River among inhabitants and experts who know these areas well, and are professionals in environment protection (Figure 2). At the same time, we carried out surveys in areas around three national parks in the Great Plain: Kiskunság- , Hortobágy- and Kőrös-Maros National Parks (Figure 3). Essentially, with these empiric examinations we intended to explore special rural development functions of these national parks in the Great Plain. During this work, we assumed that improvement in the state of the environment of areas covered by national parks may influence environment-consciousness. We thought that these national parks display such a specific (bordered by regional and legal bases) area-type, where ecological and cultural values and sustainability of rural areas must be kept in mind in a wider sense. This means that directorates of national parks in the Great Plain may have further tasks beyond common environment protection function. They could play a significant role in multifunctional rural development with agriculture, environmental management, tourism, and environmental education. These are important to the development of the studied rural regions. Thereby, professional activities of national parks can be connected to environmental consciousness oriented regional development in many ways.

In order to recognise environmental consciousness oriented cues of national parks, we had to know the standpoints of national parks' directorates in the Great Plain as well as the opinions of decision-makers in concerned settlements.

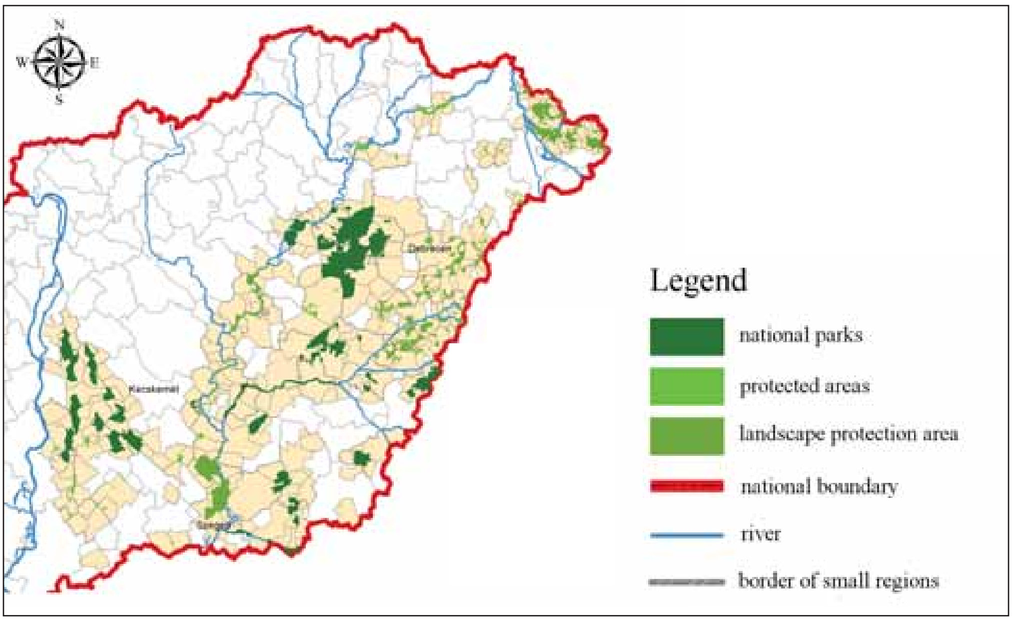

Figure 3: Settlements concerned by the examined national parks in the Great Plain.

5. Summary of the Great Plain researches' results

According to the surveys (frequent questionnaires, interviews, document analysis), environmental consciousness of inhabitants has changed slightly between 2000 and 2008. The majority of people have become more sensitive to both local and to global environmental issues. Despite these improvements, surveys prove that environmental knowledge of average persons is still deficient. People still cannot understand the connections between different problems. On one hand, due to the financial and cultural poverty caused by the underdeveloped socio-economic state, environmental problems are found not to be interesting. Our experiences were underscored by competent local specialists. However, we can also state that in the examined settlements environment-conscious communal aims and activity forms are becoming more and wide-spread. They would be further increased if socio-economic conditions improved.

Surveys related to national parks show that the parks' stance towards rural environment is much wider than we supposed. Although their basic aims are still connected to the conservation of natural or semi-natural ecosystems, specialists of national parks are increasingly paying attention to other aspects of rural area's sustainability. These include farming, improving living conditions of concerned inhabitants' and developing subsistence of rural society. From the answers of the questionnaires, it has became clear that notions of nature conservation specialists are in line with new, environment-conscious centred European rural development principles.

According to most of the interviewees, the Great Plain's national parks have the potential to improve settlements and regions. They can help develop ecologically-based, environment-conscious general concepts and deal with the complexities of regional and rural development. They can also contribute to making them acceptable to regional and national environment decision-makers and thus assist to raise funds and EU support. These roles, according to our view, can contribute to and strengthen the importance of national parks in activities related to landscape integration.

Unfortunately, despite the positive factors such as the spread of environmental consciousness – that have been explored during this study, environment protection activities are still insufficiently evolved in the ex amined regions. There are several reasons for this. Firstly, supporting systems as well as governmental and autonomic funds that could allow coordinated regional and local settlement environment programms are missing. There are no such institutions or organizations that would undertake particular environmental management of the Great Plain. In other words, the financial and human basis of local environmental management is rather weak. Secondly, appropriate partnership has not been formed between institutes interested in environment protection and rural development. Thirdly, central institutes and regional authorities dealing with environment protection in Hungary do not pay sufficient attention to the potential of environmental strategies in rural development.

Special environmental conflicts of the examined regions have not been solved yet. Existing plans and strategies of the area and programmes related to rural development are general, and reflect only one emphasized (mostly political) aspect. Most of them ignore local environmental interests. Our experiences correspond with István Berényi's critical observation, made 15 years ago: values related to "the previous individual – self-defense – use of the environment have been broken, but has not replaced by rationally organized environmental institution system, the operation of which is based on regional and local interests" *(Berényi 1992).*

In conclusion, it can be said that environmental consciousness of the studied social communities is evolving, but it cannot yet be reinforced properly. Impacts of environmental consciousness and cultural-mental factors are felt in the studied settlements, but people's knowledge needs to be extended and their attitudes still must be changed. Practical implementation of certain special duties – like environmental ideas and rural development methods also emphasised by national parks – can be realised only if local communities strive to achieve long-term environmental objectives in co-operation with local governments, institutions and civil society.

The expectations of local communities and ideas important for experts must be more visible. All demands of the settlements and social needs must be subjected to criticism. Substantial settlement-microregional, regional-national, or in some cases international co-operations have to be formed. Tasks related to environmental protection, nature conservation, farming and the improvement of social welfare have to be realized properly, bearing in mind expectations of rural communities of the Great Plain. This requires the identication of activities, which may exhaust the natural resources and thus have a harmful impact on the future of the landscapes and settlements. All these mean that conserving local values and systematically regulating environmental interventions serve the given social communities.

Environment-conscious developments have the potential to create a balance between natural and artificial, traditional and modern landscape use. This is how the rural lifestyle could become complete again, this is how people would be able to create cosy homes and a liveable environment for themselves and this is how farmers on the area of national parks can cultivate their lands considering natural conditions and values. With this potential environmental consciousness towards landscapes and settlements related to the Tisza River and Great Plains, national parks may become one of the determining key issues of sustainability within the entire Great Plain.

6. Literature

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In modern societies, humans are largely managing the world's natural resources as if they were limitless. In fact, even the so-called renewable resources require time for renewal once they have been used. This kind of human attitude puts pressure on Earth's ecosystems at an unprecedented scale. In order to reverse the recent trend, policies shall tackle the roots of the problems and the drivers behind them must be addressed in order to reduce the pressure on ecosystems, including the overuse of natural resources and ecological space.

This publication aims to show good examples for evaluating natural values and for showing possible environmental and social impacts of various policies. Considering carefully the examples presented in this publication could play fundamental role in proper decision making that considers environmental and overall sustainability aspects.