László Jeney – Dávid Karácsonyi (eds.)

Minsk and Budapest, the two capital cities

Selected studies of post-socialist urban geography and ecological problems of urban areas

Department of Economic Geography and Futures Studies, Corvinus Univ. of Budapest
Geographical Institute, RCAES Hungarian Academy of Sciences
Faculty of Geography, Belarusian State University
Institute for Nature Management, National Academy of Sciences of Belarus

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I. Instead of an introduction: Minsk and Budapest – a basic compare

László Jeney – Dávid Karácsonyi

A quarter-century ago the transformation not only rearranged the map of Europe, but also actuates significant changes in the social and the economic processes. While Belarus was carrying the special model of post-Soviet course for development into execution after they have had marked out from Soviet Union, Hungary got a member of the European Union with the Visegrád Four Countries and the other post-socialist countries in the Middle Europe.

The changes have been worked on the urbanization process, also on the region of the two capital town and on the agglomeration of Minsk and Budapest. However the historical improvement of the two capitals were pretty different and the processes of the last 20 years were variant too, the direction of the changes were similar in the early 1990s. In Budapest and Minsk got the market the most important regulator instead of the state. The real estate market started to improve and the price of the plot turned up, however it was different in the two capitals. The cycle of the urbanization – agglomeration, suburbanization (or exurbanization), dezurbanization (or counterurbanization) and reurbanization – came out almost in the same time, as an obstruction. There are no differences in the two capital's data – the population of both capital cities are about 2 million people – and neither in their roles in the urban network, so they can give a great ground to compare the similarity and the diversity of the post-Soviet and the post-socialist urbanization.

Looking at its metropolitan scale and history, Budapest surpasses Minsk in this respect. Its population has already surpassed 300 thousand in 1870 as long as Minsk has only reached this in 1941. The boost of the Hungarian capital started in the end of the 19th century, along with the industrialization of the Austro–Hungarian Monarchy and turned down approximately by the 1950s. It was exactly in the 1950s that the boost of Minsk started, as a result of the Soviet industrialisation and the industry has an important role in the city since the transition.

Budapest had half-million inhabitants in 1890 and doubled in 20 years. This was in Minsk a shorter process, but 60 years later between 1959 and 1972. Since the World War II the population of Minsk has grown constantly, it was 2 million people in 2013, in opposite of it the population of Budapest was the highest in 1980 and since then it showed a fall as a result of the suburbanization. Since the end of 2000s the population has represented a low rising, because of the reurbanization and the effect of the financial crisis in the rural region and the east side of the country, which one was much more smitten than the others. The Hungarian capital city has now odd 1.7 million inhabitant *(Figure 1)*.

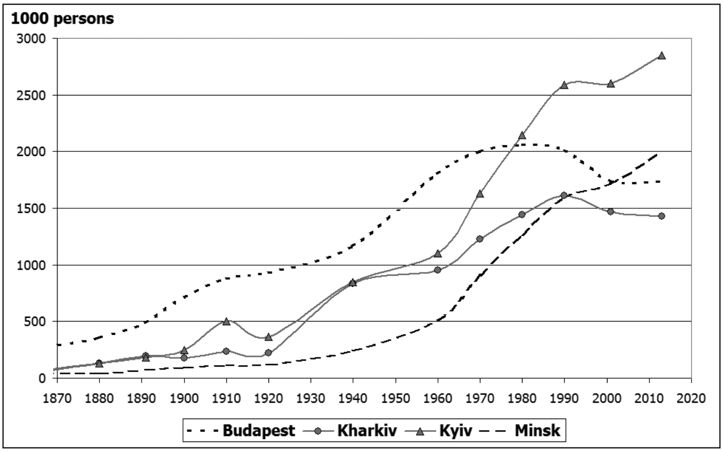

Figure 1: Population growth of Budapest, Kharkiv, Kyiv and Minsk (1870–2013)
Source of data: homepage of POPULSTAT[1]

As a result of the different development in time also the facade of the two cities are basically varied from each other. While the inner city of Budapest is characterized by the classicism of the late 19th century, the image of Minsk ruined almost totally during the World War II practically begun to shape after the restoration. The city centre is dominated by the 'Stalin's baroque styled' buildings even today, although the renovation of the medieval city core is steaming ahead nowadays. The different facade of the two inner cities is demonstrated by the two representative avenues, the Andrássy Street from built in the late 19th century and the Independence Avenue of Minsk reflecting to the 1950s *(Figure 2)*.

1 http://www.populstat.info/ – 2014. 06. 30.

(2a)

(2b)

Figure 2: Representative sites: Andrássy út (Andrássy Avenue) in Budapest from the late 19th century *(2a)* and Praspekt Nezalezhnastsi (Independence Avenue) – built during the 1950s, called after the anniversary of liberation of Minsk from German occupation (July 1944) *(2b)*
Source: photos of Balázs Szabó *(2a)* and Dávid Karácsonyi *(2b)*

While the huge factories of Minsk is operating to this day, like the Minsk Tractor Works (MTZ 'Belarus'), the Minsk Automobile Plant (MAZ), to mention just the most gigantic ones, in Budapest the post-industrial revitalization (MOM Park, Millenáris, Graphisoft, Marina etc.) of the brown fields (e.g. Csepel Works) is in a far-gone state *(Figure 3)*.

(3a)

(3b)

Figure 3: Millenáris Park (former Ganz Works) in Budapest *(3a)* and the Minsk Tractor Works (MTZ) *(3b)*
Source: photos of Balázs Szabó *(3a)* and Dávid Karácsonyi *(3b)*

The atmosphere of the suburbs is basically different. While the greenbelt of Budapest is dominated by the buildings with gardens, which is rarely broken by a housing estate, in Minsk the suburb dominated by the housing estates incorporate the former villages as a bubble *(Figure 4)*.

In the first chapter of this book, titled with 'Socio–economic development', the study of Zoltán Kovács and Ivan Pirozhnik and his co-author focus onto these development features, the former one is according to Budapest, and the latter one to Minsk. The study of Pirozhnik analyses the city development through planning documents. The study of Ekaterina Antipova and Liudmilla Fakeyeva aims to examine the demographic situation of Minsk. The study of Ágnes Erőss and Balázs Szabó perambulates the issue of the rehabilitation of the housing estates. This was perhaps one of the acutest issues of the development of the Hungarian capital in the last one and a half century, and by this will be a central theme also in Minsk probably, where huge housing estates are being built with industrial technology even to this day.

Despite the differences there are universal problems being valid generally for the cities, which got the focal point of the science with the world-wide urban explosion, the spread of the urbanized areas, the appearance of the problem of the global warming. The summer hot waves, the extent and the quality of the built-up areas of the state of the environment affects the life conditions like the urban development regulation or the land values. The second chapter of this publication deals with these issues, such as the urban climate or the urban heat islands. Ferenc Probáld has already take up these issues the apropos of Budapest since 1960s. His publication offers a great summary of these questions. Longinov academician circuits a similar problem; he examines the effects of the urbanization on the extreme weather conditions.

The first part in this tome there are two–two studies about Minsk and Budapest, but shares of the four studies of the second part on the environmental issues dominate by Minsk. Five among the eight studies all together deal with Minsk, three of them with Budapest, and this one with a compare of the two capitals, so we tried to prevent the shares in the structure of the book.

(4a)

(4b)

(4c)

(4d)

(4e)

Figure 4: Suburbs of Budapest and Minsk: Housing estate in Budapest *(4a)*, slum district in Budapest *(4b)*, greenbelt in Budapest *(4c)*, Housing estate near Kamennaya Horka metro station in Minsk *(4d)* and Building of new block-of-flats near Kamennaya Horka metro station in Minsk *(4e)*
Source: photos of Balázs Szabó *(4a–4b)*, László Jeney *(4c)* and Dávid Karácsonyi *(4d–4e)*

Part A

Socio-economic development

II. Budapest a Central European metropolis: historical trajectories and post-socialist transformation

Zoltán Kovács[2]

Abstract

This paper focuses on the main driving forces of urban development in Budapest, with special attention to the socio–spatial differentiation of the city and its metropolitan region in a historical perspective. The political and economic changes of the early 1990s generated large scale transformation process in the spatial pattern of the city. Due to the reestablishment of market mechanisms, the privatisation of housing, the liberalisation of the property market, and the growing presence of global capital the socio–economic structure of the city started to change abruptly. The different zones of the urban region were affected differently by the transformation, generating both up- and down-grading processes in the city. There are two major areas where upward processes are most evident in metropolitan Budapest: the central business district and the suburbs. Neighbourhoods lying between these two dynamic zones reveal some more controversial development. Only a limited number of neighbourhoods provide clear examples for upward trajectory, and in most cases no signs of new investments can be observed. In some of these neighbourhoods physical deterioration is also accompanied by extreme forms of social segregation and social exclusion.

Keywords: Budapest, urban development, urban restructuring, post-socialist cities

II.1. Introduction

Budapest is the symbolic heart of Hungary in terms of its political, economic, administrative and cultural functions. More than one third of the national GDP is produced in Budapest, and nearly half of the foreign direct investments arriving into the country after 1989 was realised here. Most of the global companies have their headquarters there; all the main national institutions have their seat in

2 The author is grateful for the Hungarian Scientific Research Fund (OTKA) Grant Agreement no. K 105534..

the capital city. It is also home to a fifth of the Hungarian population. Politically, socially and economically Budapest has gone through significant changes in the past quarter of a century (Földi, Zs. 2006). The objective of this chapter is to introduce the main phases of urban development in Budapest, to demonstrate the socio–spatial differentiation in the metropolitan area of the city and to define the main trends of urban transformation. It is also aimed at showing how local underlying structures, the new contextual elements (e.g. free market, urban policies) and legacies of the past work together in setting a diverse path of development in the different urban zones within the city.

II.2. The main phases of urban development before 1990

Budapest as one of the youngest capital cities in Europe was officially established only in 1872, however, the roots of present-day city go back to the early middle ages. From the middle of the nineteenth century the Hungarian railway network was extensively developed which generated rapid industrial development. All the main railway lines radiated out from Buda and Pest in all directions across the Carpathian Basin. Due to the rapid development of railway network the twin cities became the centres of Hungarian industrial revolution where the products of an enormous agricultural hinterland were stored and processed. Industrial development was coupled by an inflow of labour. As the population grew the city is continuously expanded and new residential suburbs were built. At the time of the 1869 census with a total population of 280 thousand the three cities ranked already seventeenth among the large cities of Europe.

II.2.1. Budapest between the unification and World War I

The compromise between Austria and Hungary in 1867 created the political preconditions for the unification of the three urban cores what was eventually carried out in 1873. Through the compromise Hungary was granted a status equal to that of Austria within the

Habsburg Empire. This made Budapest the twin capital of the dual monarchy and opened the second great phase of development of the city. The last third of the nineteenth century was the period of rapid urban growth and territorial expansion. Migrants were attracted primarily by the vigorous industrial and economic development. The rate of population growth was especially dynamic during the last decade of the century (45 percent in one decade). As a consequence, by the turn of the century the population of Budapest increased to 750 thousand, and the city advanced to the eighth place in Europe.

To keep control over the vibrant development a powerful body, called Fővárosi Közmunkák Tanácsa (Council of Public Works) was set up in 1870. The Council elaborated an imposing master plan which laid down the main features of spatial development, setting the direction of expansion and dividing the city into land-use zones (Lukács, J. 1989). Its regulations set the purposes of buildings, the size of plots, the height of the houses, as well as the material of the walls. Architecturally, the outcome was fascinating, a neatly built town consisting of four- and five-storey buildings in eclectic style, displaying fully harmony. The modern infrastructural development of the city was also impressive. Bridges were built over the Danube making physical communication between Buda and Pest easier, in 1887 trams appeared, in 1888 the first suburban railway line was opened and in 1896 the first underground railway of the continent was opened in the city.

II.2.2. The interwar period

World War I and the consequent dissolution of the Austro–Hungarian Monarchy altered the spatial relationships of Budapest. In the Trianon Treaty of Versailles Hungary lost 71 percent of its territory and 66 percent of its population. Budapest with more than 1 million inhabitants became the lonely star of the Hungarian urban system. Typically, the population of the second largest country town (Szeged) was only just over 100 thousand. Right after the war 62 percent of the country's industrial output, and 45 percent of industrial employees concentrated here. Budapest became the over-sized capital of a small country, and it could not regain its earlier international functions.

During the inter-war period the development of Budapest slowed down. Its population continued to grow, mainly due to the migration of ethnic Hungarians from the separated territories, but at a much slower pace. Typical of the inter-war period was the spontaneous unplanned nature of urban development much of it speculative. Traditional single family homes were built along the expanding urban fringe of Pest and as public utilities and urban infrastructure were not provided these neighbourhoods acquired a rural rather than an urban aspect (Compton, P. 1979). This was also the epoch of extensive suburban growth. As a consequence, the population of the suburbs increased from 130 thousand to 540 thousand between 1900 and 1949. By the 1930s Budapest was beginning to overcome the consequences of World War I, when the next world war overwhelmed it, causing enormous losses. As a consequence of World War II the population of Budapest dropped by more than half a million and the pre-war figure of 2 million was reached again only in 1972.

II.2.3. Urban development during state socialism

At the end of the 1940s a new communist constitution was implemented in Hungary, land and property was nationalised and nearly all commercial functions were prohibited or severely controlled (Enyedi, Gy. – Szirmai, V. 1992). According to Act I of 1950 local governments were replaced by hand-picked councils where representatives of the communist party were in absolute majority. This act also solved the question of 'Greater Budapest' that is the administrative union of the suburban settlements with the core city. Originally Budapest was divided into ten districts in 1873, later in the 1930 administrative reform the number of districts increased to fourteen. In the 1930s as contacts between Budapest and its hinterland intensified plans were made for the merger of suburban municipalities with the city. Finally, 1 January 1950 twenty-three independent suburbs were attached to Budapest, at the same time twenty-two districts were created within the new city boundaries *(Figure 5)*.

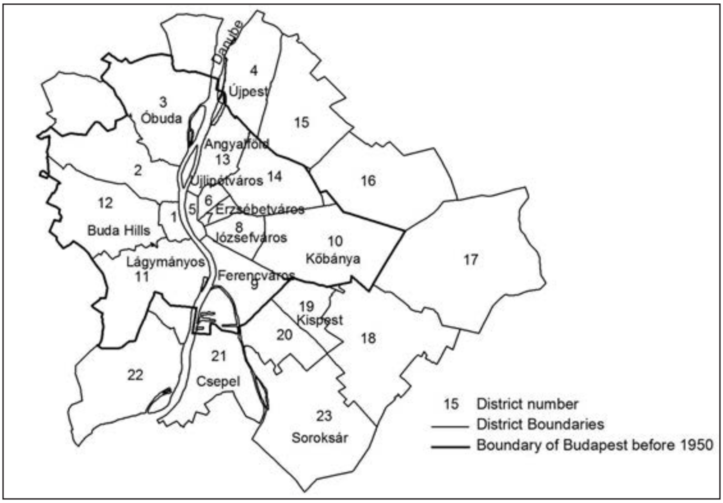

Figure 5: Territorial expansion and administrative division of Budapest
Source: edition of ZOLTÁN KOVÁCS – BALÁZS SZABÓ

The post-war economic upswing and the forced development of industry which was the top priority of communist economic policy in the 1950s attracted many immigrants from the countryside and resulted in very intensive population growth again. In this period the average population growth was even higher than at the peak of the capitalist industrial development. ENYEDI, GY. (1990) identified this rapid socialist urban development as the first stage of global urbanization, which was in fact the completion of the capitalist urban boom, interrupted by the world wars and the interwar stagnation. As a result of the growing concentration of industrial workplaces and labour force the dominance of Budapest further increased in the Hungarian space structure. To prevent the mass inflow of people the communist regime introduced administrative measures in 1958. Only those were allowed to settle down in Budapest who had worked and lived at least 5 years in the city previously.

In accordance with national demographic trends and the new regional development policy gradually slowed down the growth of Budapest from the mid 1960s. The city entered the post-industrial phase of urban development, factory employment started to decline, at the same time the rapid growth of services took place. The number of industrial employees peaked with 612 thousand in 1964; twenty years later the industry of the city employed only 340 workers. The shrinkage of industry was also fostered by administrative measures. Between 1968 and 1981 approximately 250 industrial plants were closed down or removed from Budapest mainly for ecological reasons, while new establishment was strictly restricted.

The spatial expansion of the city accelerated from the 1960s due to large-scale housing development programmes. The basic premise of communist housing policy was that every family was entitled to its own home at reasonable cost and each family member to a separate room. A new national housing policy was started in 1960, called the 'Fifteen-Year National Housing Development Plan' which was intended to satisfy housing need in full, and set the target of 1 million new dwellings in the country, and 200 thousand in Budapest alone, in the subsequent fifteen years. The late 1960s and 1970s were the 'golden age' of housing construction, when 15–20 thousand dwellings were completed annually in Budapest. Great part of the new dwellings was built by the state mostly in the form of large housing estates *(Figure 6)*. As in the other state-socialist countries, the state housing industry in Hungary relied on pre-fabricated technology and the establishment of gigantic housing factories. These factories were able to build extremely high density and high-rise estates of 12–15 thousand dwellings housing 40–50 thousand people. Due to site constraints, these estates were constructed on undeveloped 'greenfield' sites in peripheral locations. Most estates were poorly served by transport and other facilities and the organic link with the city was broken (Kovács, Z. – Douglas, M. 2004).

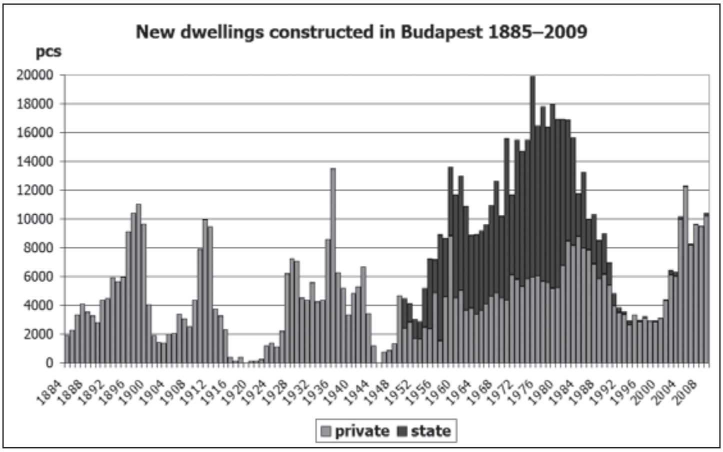

Figure 6: Main phases of housing construction in Budapest
Source: edition of ZOLTÁN KOVÁCS – BALÁZS SZABÓ

While there was an upswing of urban periphery from the 1960s onwards, the building stock of the historical quarters started to decline due to the lack of maintenance. The decline of historical neighbourhoods was basically the result of rent policy: heavily subsidised rents did not even cover the costs of basic repairs. Investment and disinvestment in the urban arena generated new flows of migration which led to social erosion of the historical quarters. From the early 1970s the exodus of young middle-class families who migrated from the inner-city neighbourhoods mainly to the new housing estates became evident. The vacant dwellings released by better off families were allocated to lower status, poorer families, often Gipsy.

II.3. Main factors influencing the post-socialist urban development in Budapest

II.3.1. Administration and planning

Administration and planning in Budapest is complex. Collaborative working is difficult for many post-socialist countries and Hungary is no exception. Act 65/1990 was passed on August

3 1990 and the system of councils was replaced by democratically elected local governments. According to the Act, Budapest has a two-tier public administration. The city is divided into 23 districts (before 1992 22) which have their own resources and are governed by an independent elected body. Powers and responsibilities are divided between the Municipality of Budapest and the 23 districts. The Municipality of Budapest is responsible for public services, such as transport, and it provides cultural, educational, health and social services that cover more than one district. It makes it difficult for planning in Budapest to be co-ordinated. A Regulation Framework on Urban Planning for the whole capital was prepared in the early 1990s by the Municipality, and the district development plans were supposed to be consistent with this framework. However, the arrangement did not prove to be very successful from the outset, as the two governments could easily block each other's development plans, e.g. the Municipality of Budapest through its zoning authority and the district governments through their right to issue building permits. The 1994 modification of the Act on Local Governments gave the Municipality more power in strategic planning issues that were relevant for the whole of the capital city (Tosics, I. 2006), but conflicts were still common. Overall city planning and management is fragmented and the districts tend to focus on their own autonomous interests.

II.3.2. Economic restructuring

Soon after the change of political system the old structure of the Hungarian economy collapsed and it underwent profound changes. Large state companies were privatised and/or disintegrated. The decline of industry was marked in Budapest lowering the share of industrial workers from 36 to almost 20 percent of the active population between 1990 and 2001.

The impact of the economic breakdown was tremendous but was still the least dramatic in Budapest compared to the rest of the country. Also the economic recovery was much quicker in the capital city, just like its integration into the European and global networks which commenced quickly in the first half of the

1990s. After 1990 Budapest and its metropolitan region became the magnet of capital investments. Due to the aforementioned conditions causing its high competitiveness, Budapest became a major target of FDI basically for its size, favourable geopolitical position and good accessibility from Western Europe.

The special position of Budapest could also be attributed to the high concentration of human and financial capital, the highly developed infrastructure and means of production. Typical for the weight of Budapest in the Hungarian economy that in 1996 35 percent of the national GDP was produced here, and the per capita GDP was 181 percent of the national average. Since then the weight of the city in the national economy has not decreased at all. In 2008 the city produced 38 percent of the Hungarian GDP, and the per capita GDP was 221 percent of the national average. In certain creative sectors of the economy (e.g. cultural industries, R&D, business services, ICT) the role of Budapest is extremely dominant (Kovács, Z. et al. 2007).

II.3.3. Transformation of the housing market

In the transformation of housing market privatisation of public dwellings played a very important role. Before 1990 public housing made up 51 percent of the total dwelling stock in Budapest. In most of the centrally located districts housing was owned predominantly (95–97 percent) by the state. Privatisation of state housing in Budapest meant a pure ‘give away’ type of privatisation to sitting tenants, at a very low price. Most public dwellings were sold for between fifteen and forty percent of the estimated market value depending on the physical conditions of the dwelling. Further forty percent discount was offered to those who paid in cash, which meant that the great majority of the public dwellings was sold for nine percent of the market value. Due to these circumstances the privatisation of public housing was very rapid in Budapest and in the first half of the 1990s a large segment of the public housing sector became privatised.

The logic of privatisation favoured the better-off families, since tenants (now ‘buyers’) of best quality dwellings with desirable location gained the biggest amount of value gap. These changes in the housing market had far reaching ecological implications. First of all, households had more opportunity to actualise relocation desires as they became owners, secondly, new conditions allowed a greater plurality of values and promotion of self-interest. Factors in housing preferences of households like security or accessibility of green spaces gained great importance. The outcome was a rapid differentiation of the housing market.

While public housing became residualised and served as a shelter for urban poor, new residential areas for the better off were developed. Geographically, public housing became increasingly concentrated in traditionally low-status areas (Józsefváros, Erzsébetváros). In a survey conducted in summer 1995 we found that households who remained in the public housing sector were on average less educated, with lower incomes and they had much higher probability to become unemployed than other housing classes (Kovács, Z. 1998). All these changes on the housing market had their imprints on the socio–spatial pattern of Budapest.

II.4. The socio–spatial structure of Budapest

The ecological structure of Budapest shows astonishing coincidence with the physical features of the city. In order to demonstrate the existing dimensions of social and residential segregation, the ratio of highly educated residents (i.e. people with university education) was selected in the 2001 census. The indicator reflects a very strong east–west polarisation in the social structure of the city *(Figure 7)*.

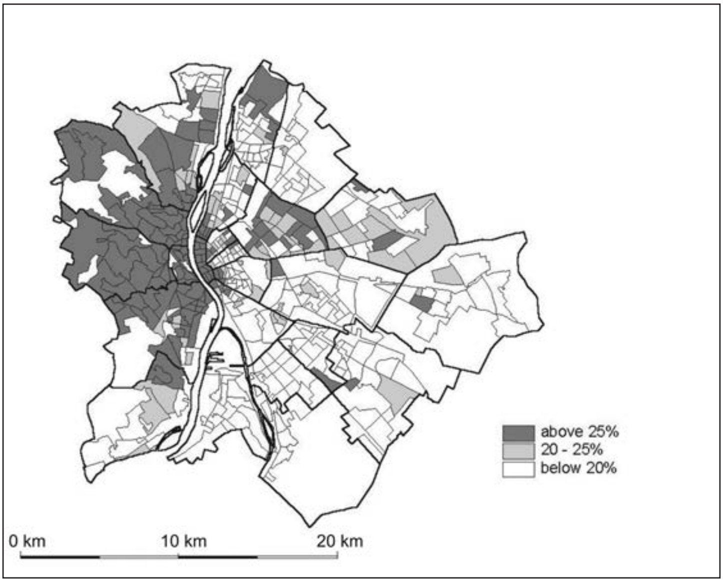

Figure 7: Social structure of Budapest (percentage of people with university education, 2001)
Source: edition of Zoltán Kovács – Balázs Szabó

The traditional high-status areas of the city can be found on the hilly Buda side, whereas the plain Pest, east of the Danube is the traditional stronghold of working class. Moving from the Danube towards the urban periphery, the social status of the residents gradually declines. Regarding the functional and morphological characteristics the metropolitan region of Budapest can be divided into seven major zones following the traditions of the classical human ecology (Szelényi, I. 1987). Each zone can be characterised by distinct socio–economic, functional and architectural features, thus, the boundary between the individual zones is fairly clear. This concentric structure is the outcome of the organic growth of the city in the last 130 years, when the expansion of Budapest has occurred concentrically from the centre of the town outwards *(Figure 8)*.

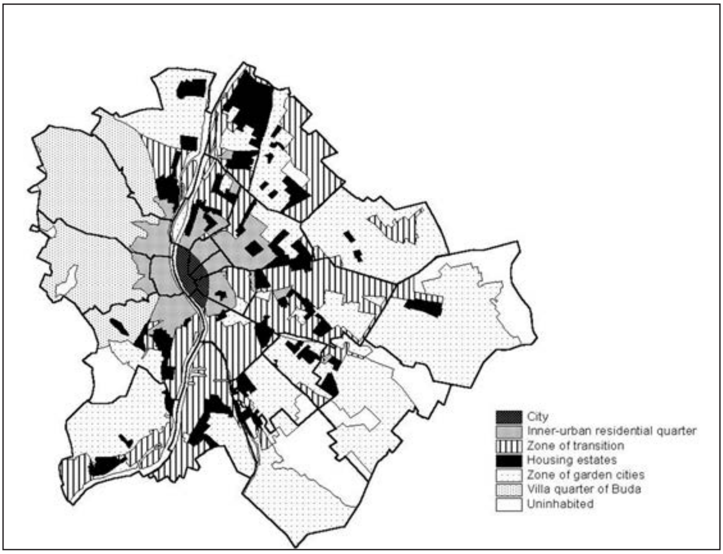

Figure 8: Spatial structure of Budapest
Source: edition of Zoltán Kovács – Balázs Szabó

II.4.1. The City

The City is the oldest part of Budapest where the building stock was built in the 1880s and 1890s. This is a densely built up area stretching on the flat Pest side of the town, inside the arc of the Nagykörút (Grand Boulevard). (Some classification includes also the Várnegyed (Castle District) on the other side of the Danube in this zone.) This is a commercial district and the traditional shopping centre of Budapest, including also the governmental quarter (Lipótváros). The street layout here is regular, with representative public buildings from the late 19th century including the Hungarian Parliament, the National Museum and the Hungarian Academy of Sciences (Dingsdale, A. 1999). Another important characteristic, that despite the constant decrease of population the residential function of the City remained dominant up until the political transformation of the 1990s (Enyedi, Gy. – Szirmai, V. 1992). This was mainly due to the lack of market economy, as retail trade and service sector took up only a relatively small area of the inner city, the growth of a sizeable CBD similarly to West Europe was simply not possible.

II.4.2. Inner-urban residential quarter

Moving from the city centre towards the periphery we reach a densely built residential area on both sides of the Danube, with 3–4 storey blocks of flats from the late 19^{th} century. This is the so-called inner-urban residential quarter of Budapest, which provides housing mostly for the elderly. In terms of the quality of the building stock and the social status of the residents the zone is rather heterogeneous. On the Buda side, and in the northern sector of the zone on the Pest side the quality of housing is better and the social status of residents is higher. On the other hand towards the eastern edge of the inner residential zone, extensive slum areas are stretching. Many dwellings in these areas date from the turn of the 20^{th} century, when they were built on a speculative basis, and provided housing for the poor. As there was no proper maintenance of building and/or regeneration of old housing stock during socialism, these quarters started to decline irresistibly and became slums. Younger and better off families gradually moved out to the newly erected housing estates in the 1960s and 1970s, and they were replaced by other less affluent strata (e.g. Gipsy) (Ladányi, J. 1997).

II.4.3. Zone of transition

Close to the former administrative boundary of Little Budapest (i.e. the city before 1950) a wide zone of industrial and transport functions was developed from the 1880s when the first wave of industrial revolution reached Budapest. As pressure on the land was relatively low the use of land here is less intensive, follow areas and low quality, low-rise housing for the working class are mixing with industrial estates, warehouses, transport areas (railway stations etc.). The name of the zone is symbolising that once it was the very periphery of the city, the place of urban–rural transition. The use of this zone became more intensive during the early phase of state socialism as the development of industry speeded up again.

New plants were settled here others were further developed in the 1950s. However, as the city entered the post-industrial phase of its development the decay of the transitional zone started to accelerate. Many industrial plants were closed down or removed from Budapest after 1968 mainly for ecological reasons. Virtually all of them were located in the zone of transition. Some part of the newly evolving derelict land was re-used in the 1970s and 1980s, mainly for housing purposes of smaller housing estates. This gave new impetus to the re-development of the zone, though large-scale regeneration could not take place. With the collapse of socialism, most of the industrial plants were closed down, and a massive brown-field zone of derelict industrial areas has evolved.

II.4.4. Housing estates

After World War II similarly to other state-socialist cities a ring of housing estates were gradually developed in Budapest. The peak of development in this zone was generated by the socialist housing policy in the 1960s and 1970s. To ease the serious housing shortage the state started to produce a vast number of almost identical 2-roomed flats in the form of housing estates (Egedy, T. 2000). These modern housing estates were located nearly exclusively on virgin sites close to the city boundary *(Figure 9)*. The first generation of estates, built in the 1950s and 1960s was built close to the zone of transition and made use of existing transport and other infrastructure links. In typically low rise (2–3 storey) socialist–realist or 'Stalin baroque' style, they became symbols of the new political system. However, from the late 1960s pre-fabricated technology was applied which made the establishment of high density large scale housing estates possible. A typical housing estate of the 1970s comprised 12–15 thousand dwellings in ten-storey buildings and housed 40–50 thousand people. Due to site constraints, these estates were often constructed on undeveloped 'greenfield' sites in peripheral locations. Most estates were poorly served by transport and other public services (e.g. schools, shops, leisure facilities) (Kovács, Z. – Douglas, M. 2004). Altogether one third of the housing stock of Budapest is located on housing estates of different age.

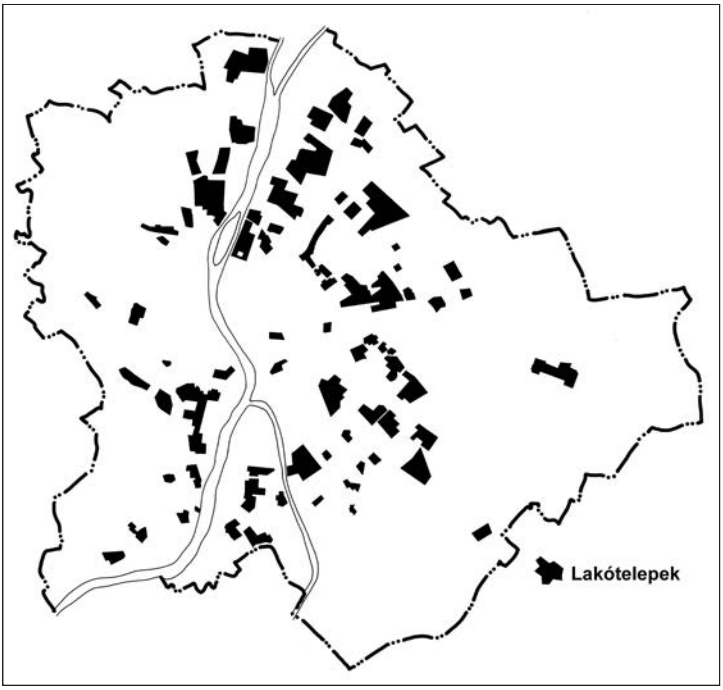

Figure 9: Location of housing estates in Budapest
Source: edition of the author

II.4.5. Zone of garden cities

The rise of what is now the outer residential ring started at the beginning of the 20th century when the lack of building plots and the extremely high rents within (Little-) Budapest fostered the growth of suburbs. Later the immigration waves from the disintegrated territories of Hungary after World War I and the world economic crisis generated mass movements towards the suburbs. As a consequence the population of the suburbs of Budapest increased from 130 to 530 thousand between 1900 and 1949. Most of these settlements were commuter villages or small towns prior to 1914 with low-rise, rural character. Some of them grew to large cities with 60–70 thousand inhabitants due to new industrial functions arriving here in the inter-war period (e.g. Újpest, Kispest, Csepel). In 1950 as part of the newly introduced communist type administrative system (council system) these suburbs, altogether 23 independent settlements, were forcefully attached to mainland Budapest. As a consequence, the total area of Budapest was enlarged from 207 to 525 square kilometres, and the population grew from 1 to 1.6 million. Despite its excessive development during state socialism this zone retained its rural character with lots of green areas and predominantly single family houses.

II.4.6. Villa-quarter of Buda

In general the Buda side is dominated by hilly landscape with forests. The rise of the Buda Hills started in the late 19th century when aristocrats and industrial magnates erected their elegant villas with spacious gardens. They were followed by members of the middle class who built their summer cottages in the upper lying regions in the subsequent decades. After World War II these villas and cottages were nationalised and divided into smaller dwelling units. A new renaissance of the Buda Hills started in the 1970s and 1980s when members of the communist ruling class started to build their single family homes and row-houses, reflecting the increasing polarisation of the socialist society. This is the stronghold of the middle class, comprising not only successful private entrepreneurs, but also some representatives of managerial and intellectual elites, most of whom made their fortunes rapidly in the favourable climate which emerged for them following the collapse of communism.

II.4.7. Suburban zone

This zone comprises the suburban settlements around Budapest which maintain strong ties with the city, lying in its daily commuting zone. After the ‘decapitation’ of the former suburban zone around Budapest in 1950 gradually a new zone of agglomeration evolved. Through the development of the metropolitan transport network the city expanded its zone of influence dynamically in the 1950s and 1960s. Already the National Settlement Network Development Plan (OTK) approved in 1971 specified a new zone of agglomeration around Budapest, which consisted of 44 independent settlements. The functional connections between the suburban settlements and Budapest were further intensified after 1990; this was also recognised by regional planning, when the Hungarian government extended the boundary of the agglomeration with its decree in 1997. Today the agglomeration of Budapest officially consists of 78 settlements, some of them are towns of middle rank *(Figure 10)*.

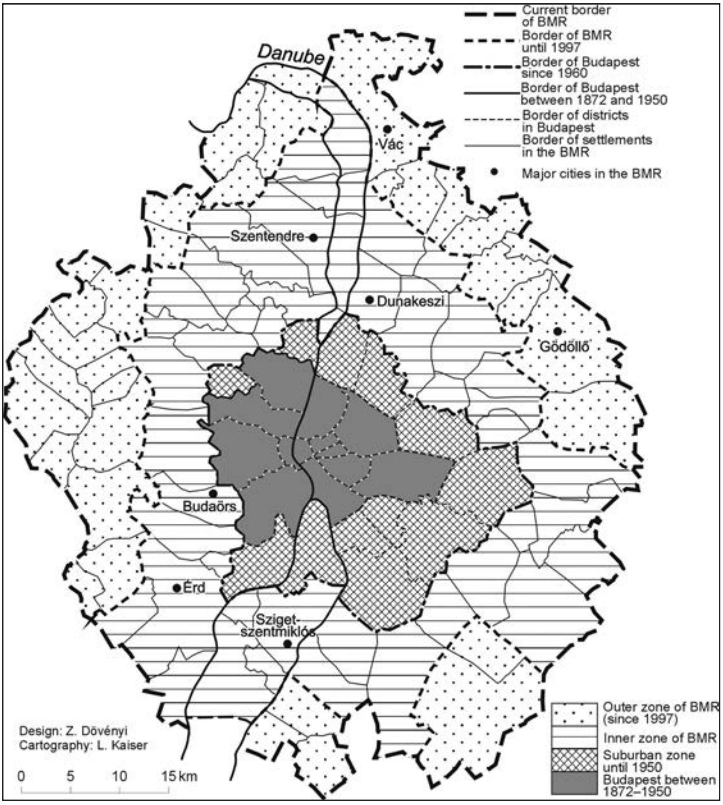

Figure 10: Division of Budapest Metropolitan Region (BMR)
Source: edition of Zoltán Dövényi – Lívia Kaiser

II.5. Main features of urban transformation after 1990

After 1990 the political and economic transformations have generated far reaching changes in the internal socio–economic structure of Budapest. Due to the migration of better off households to the suburbs the population of Budapest has decreased by over 300 thousand residents – from a little over 2 million in 1990 to about 1.7 million in 2009. As a consequence of suburbanization the balance of population between the core city and the agglomeration has shifted. In 1990 only 17 percent of the functional urban region resided in the zone of agglomeration whereas the share of agglomeration increased to 35 percent by 2009.

Before 1990, the communist state made hardly any investments in communal infrastructure or services in the suburban areas, consequently those areas were not considered desirable at all by the better off households. From the middle of the 1980s a new migration tendency started in the Budapest urban region, which could be labelled as initial, ‘low intensity’ suburbanization, marked by the change of the balance of migration of Budapest against the surrounding Pest county into negative. The loss was not significant for several years and was still counterbalanced by a positive migration balance to Budapest from other parts of Hungary. From the early 1990s, however, the period of intense suburbanization started. Due to suburbanization the loss of population of Budapest increased rapidly and almost reached the level of 18 thousand persons a year. This trend changed again after 2007 and the inflow of people from the countryside outnumbered those who left Budapest.

The selective deconcentration of the population resulted in radical changes of the social and demographic characteristics of the local society. Generally, the social status of the agglomeration increased. This is confirmed by the growing presence of highly educated residents, the proportion of people with university education (within the age group above 15) increased from 3.2 to 12.7 percent between 1990 and 2001. Looking at the individual zones tremendous shifts could be also figured out *(Figure 11)*.

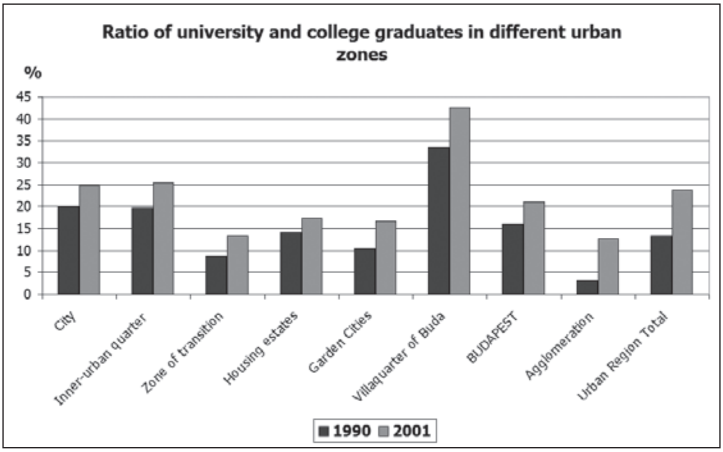

Figure 11: Changes of social status in the different urban zones
Source: edition of ZOLTÁN KOVÁCS – BALÁZS SZABÓ

Regarding the different urban zones we can also figure out the following socio–spatial processes in the post-1990 period. In the following the up- and down trajectories of the different ecological zones are briefly characterized.

II.5.1. City centre – explosion of business functions

The post-socialist urban development in the centre of Budapest was signalised by rapid and intensive reinvestment at the urban core, which resulted in the spectacular regeneration and expansion of the city centre (KOVÁCS, Z. – WIESSNER, R. 2004). The reasons should be sought in the wider restructuring of the economy, which brought about high dynamism of tertiary activities especially in the field of business services, commerce and tourism. Generally, this led to a growing demand for non-residential (business, office etc.) space in the city centre. The re-establishment of real estate market, based upon land-rent, made the rapid functional conversion in the centre of Budapest possible. Many new firms bought flats in the centre of the town for office purposes, and gradually changed the function of the buildings.

As a consequence, the city centre is losing its earlier residential profile, which is also justified by the fact that the population number of the core has decreased by 29 percent between 1990 and 2001. This was the highest rate among the ecological zones. In addition to that the composition of the population is also changing. The proportion of elderly (above 60) decreased from 29.6 to 27.2 percent, whereas the proportion of college educated increased from 20 to 25 percent between 1990 and 2001. These changes are clear signals of gentrification in the city centre. The volume of commercial and business investment has also been growing in the city centre. Large part of the headquarters of foreign companies and newly established domestic enterprises are also concentrated in the centre of Budapest which directly contributes to the physical upgrading of the city-centre. The weight of the CBD in the new form of capital accumulation is well demonstrated by the mushrooming of new office buildings, large-scale commercial and tourist investments. There is an obvious connection between the functional change and revitalisation of inner city neighbourhoods and the growing integration of Budapest to the world economy.

II.5.2. Inner-urban residential quarters – up- and down-grading

Deregulation of the housing market and the growth of income differentials are automatically producing new forms of polarisation in the urban space. In Budapest this process is most visible in the inner-urban residential quarters.

In the densely built-up inner quarters of Budapest state ownership of housing used to be extreme high (above 95 percent) before 1990. In terms of social composition, neighbourhoods along the Danube and inside the arc of Nagykörút (Grand Boulevard) have always had better-quality housing and thus higher social status. Moving outwards from the line of Grand Boulevard the quality of housing stock and the status of residents rapidly declined. The traditional working class districts of Budapest were stretching east and south–east of the city centre. Due to the neglect and the lack of maintenance during communism this densely built up residential zone deteriorated to a great extent and became a slum area by

1990. These areas were stuck in a vicious circle of social erosion and further physical decline after 1990.

The worst slums are located in Józsefváros (8th District) where a high proportion of the population is Gipsy, and that part of Erzsébetváros (7th District) where the Jewish ghetto was located in the final stages of World War II. Migration trends after the fall of communism further intensified the ethnic character of these districts (Kovács, Z. 1998). As economic restructuring hit hard the north–eastern regions of Hungary, the traditional stronghold of Gipsy minority, a gradual migration of poor, unemployed Gipsy could be observed from these regions towards the larger cities and Budapest. Most of the newly arriving Gipsy concentrate in the two above-mentioned neighbourhoods.

On the other hand, also positive examples could be already found for urban regeneration in these dilapidated inner-city residential neighbourhoods. Perhaps the earliest and most successful example is the SEM IX. project, which aimed at the comprehensive rehabilitation of the Middle Ferencváros (9th District). The long years of communism brought a substantial physical decay and a social downgrading in Ferencváros as well, which in turn resulted a severe social exclusion already by the late 1980s. In 1992 the local government has started here the first large-scale rehabilitation programme in the history of Budapest including housing renovation and construction of new dwelling units (partly public rentals), improvement of the green environment and public spaces etc. The project was designed according to the French SEM model (Societé d'Économie Mixte) which is a public–private partnership by the local government (with 51 percent) and a Hungarian–French consortium of investors (OTP Bank from Hungary and the French Caisse des Depôts Consignations with altogether 49 percent). The first ten years of the rehabilitation project has proved to be very successful and innovative under Hungarian and East Central European circumstances. Roughly 100 buildings with obsolete conditions with 700 dwellings were torn down. In their place, new buildings were constructed with over 1000 dwelling units, and almost as many apartments have been completely renovated. The project created an attractive residential environment with green inner-courtyards and a small pedestrian zone, and it can be seen as the flagship project of urban rehabilitation in Budapest (Kovács, Z. – Wiessner, R. 2004).

II.5.3. Zone of transition – slow conversion

Due to the lack of investment the industrial and commercial belt (the so-called zone of transition), that was established in the late 19th century between the inner residential quarters and the outer zone, became and industrial blight area by the early 1990s. The decline of the zone started already in the 1970s and 1980s when many heavily polluting industrial plants were either closed down or removed to the country-side by the communist power. The expansion of derelict industrial spaces was further intensified by the economic restructuring and the collapse of state socialist industry after 1989–1990.

Among the derelict industrial and commercial spaces low quality housing can also be found mainly in the form of single blocks of flats or small-scale housing estates built typically for the workers. The proportion of dwellings without bathroom is the highest here among the ecological zones of Budapest with 12 percent in 2001. Consequently, the social status of the belt is also traditionally low, in 1990 only 8.7 percent of the inhabitants held university or college degree, which increased to 13.3 percent by 2001, nonetheless this is still the lowest figure among the functional zones.

As a new phenomenon, economic transition has brought about new investments in the zone of transition since the late 1990s. Over the last few years more pronounced developments could be seen in the belt that are targeted mainly at locations with good accessibility and transport connections. Geographically, the investments concentrate mainly along the radial main roads (e.g. Váci út, Üllői út). Once again, international companies are the front-runners among the developers, and the purpose of investment is mainly office and retail outlets. There are several mega-projects in the zone, like the Duna Plaza, a large shopping centre in the 13th District along the Váci út, or the InfoPark project in the 11th District near the Danube. Latter can be considered the first technopolis of Hungary with altogether 100 thousand m^2 office space. The Hungarian state is also among the major investors, with the new campus of the Faculty of Science of the Eötvös Loránd University and the new National Theatre located on either side of Danube, south of the city centre.

II.5.4. Housing estates – time bomb of communism

Housing estates can be considered generally the losers of the transition. The popularity of housing estates in Budapest was at its peak in the 1970s, when large-scale estates were developed at peripheral locations by the central government. On the eve of political changes already 36 percent of the population lived on housing estates in Budapest, which comprised altogether 268 thousand dwelling units (typically 2 roomed flats). After 1990 there was no new housing estate project developed in Budapest. Existing housing estates lost their popularity rapidly because of their architectural monotony, lack of green spaces, decreasing security and relatively high costs of amenities (especially heating). This reflected very well in the mass out-migration of younger and better off people from these estates. As a consequence more than 110 thousand people left the housing estates and the total population of housing estates decreased by 15.2 percent between 1990 and 2001. The pace of population loss at housing estates was similar to that of the city centre. Due to the highly selective out-migration the social composition of housing estates has also been changing, the ratio of elderly is increasing, just like the socially disadvantaged families.

II.5.5. Zone of garden cities – new dynamism

This is the only zone within the administrative boundary of Budapest where a population growth has been observable since 1990. The most important advantages of this formerly socially mixed and rather insufficiently developed zone are: its low rise character with lots of green spaces, the relatively good accessibility and the unlimited quantity of plots for new developments. These factors made the zone attractive both for individuals and some major real estate developers who realised their housing projects in this belt increasingly. A new phenomenon under the Hungarian circumstances is the mushrooming of the so-called residential parks *(‘lakópark’)* (Hegedűs, G. 2009).

These residential parks are very similar to the North American ‘gated communities’, as they are perfectly cut off from the surrounding areas and provide lots of additional services for the residents (e.g. guard and security system, parking facilities, playground). Most of the residential parks are located on the Buda side and at the periphery of Pest, fitted into green. Dwellings of such residential parks are sold by the developer on the free market at a price level which is 2–3 times higher than the average. Since these dwellings are affordable only for better off Hungarian households and foreigners the construction of residential parks resulted in the growing status of the zone of garden cities. The ratio of inhabitants with higher education grew from 10.5 to 16.6 percent between 1990 and 2001, and at the same time the society of this belt became also younger. The recent take off of the garden city belt can be considered a kind of ‘internal suburbanization’ in Budapest.

II.5.6. Villa quarter of Buda – ageing wealth

The villa quarter of Buda is the traditional enclave of upper–middle class households. The attractive Buda Hills preserved, or even strengthened their upmarket position after the political changes of 1990. With the division of existing plots or creation new ones on the expenses of green areas, and the extension of former residential buildings the housing stock of the Buda Hills grew dynamically by 11.7 percent between 1990 and 2001. Despite the expansion of the housing market the population of the quarter did not grew, but even a modest (4.8 percent) population decrease was observable between the two censuses. This already indicates the ageing process what hit the quarter in the last decade. This is also confirmed by statistics, the ratio of age group above 60 increased from 20.7 percent to 23 percent between 1990 and 2001.

Despite the accelerating ageing the social status of the zone has not changed, and it is still the highest status belt in Budapest. In 1990, already 33.5 percent of the inhabitants held a university or college diploma in the quarter which grew to 42.6 percent by 2001. This figure was twice the Budapest average in both years. In the future a further population decrease and concomitant ageing process is expected in the Buda Hills. The availability of sites for new housing construction has in the meantime strongly diminished, on the other hand the popularity of the suburban belt or the zone of garden cities with the residential parks is clearly higher among young and affluent families.

II.5.7. Zone of agglomeration – limitless urban sprawl

As it was pointed out earlier, one of the most spectacular features of the post-socialist development in Budapest is the excessive growth of the suburbs. As in the western countries suburbanization was fuelled here both by residential mobility and the relocation of business functions from the city to the periphery. In this process two stages of suburban development is observable after 1990. First the wave of residential suburbanization took off on the eve (or even before) the political changes (Kovács, Z. – Tosics, I. 2014).

The main thrust of residential suburbanization affected mainly villages located to the north and west of Budapest, which is a hilly landscape offering very attractive environment for the newcomers. The housing construction in these villages reached its peak by the end of the 1990s beginning of 2000s, above all in the form of detached family homes, terraced housing and some residential park projects. According to empirical research most of the new households are younger families with children (Kok, H. – Kovács, Z. 1999). However, a specific feature of suburbanization around Budapest is that not only the middle-class families, but also lower class and elderly people are leaving the city, who are suffering from rising living costs what they can hardly afford. Their main destinations are however, the municipalities located to the east and south of the city, where the plain landscape offers less attractive residential environment. In spite of these tendencies the average social status of the suburban belt is clearly growing, the new suburbs with their luxurious environment are in sharp contrast with the decaying inner urban neighbourhoods or high-rise housing estates.

In addition to residential suburbanization clear sings of suburbanization of commercial functions could be also distinguished from the late 1990s. However, we should note that the suburban companies are less frequently relocations from the centre of the city, although there are several examples (e.g. Pannon GSM) also for that, but more often new commercial investments, mainly by foreign companies. The newly erected shopping and leisure centres, as well as office complexes are mostly in the form of green field investments. This process of the de-concentration of the economy led to the emergence of new economic growth poles, kind of edge-cities in the agglomeration zone of Budapest of which perhaps the most pronounced is the Budaörs–Törökbalint concentration at the western gate of Budapest, along the motorway leading to Vienna (Burdack, J. et al. 2004).

The growing relocation of work places and the dynamic increase of car ownership created new pattern of daily commuting around Budapest. On the whole the relative de-concentration of the population and firms resulted in a new spatial pattern of the agglomeration of Budapest *(Figure 12)*.

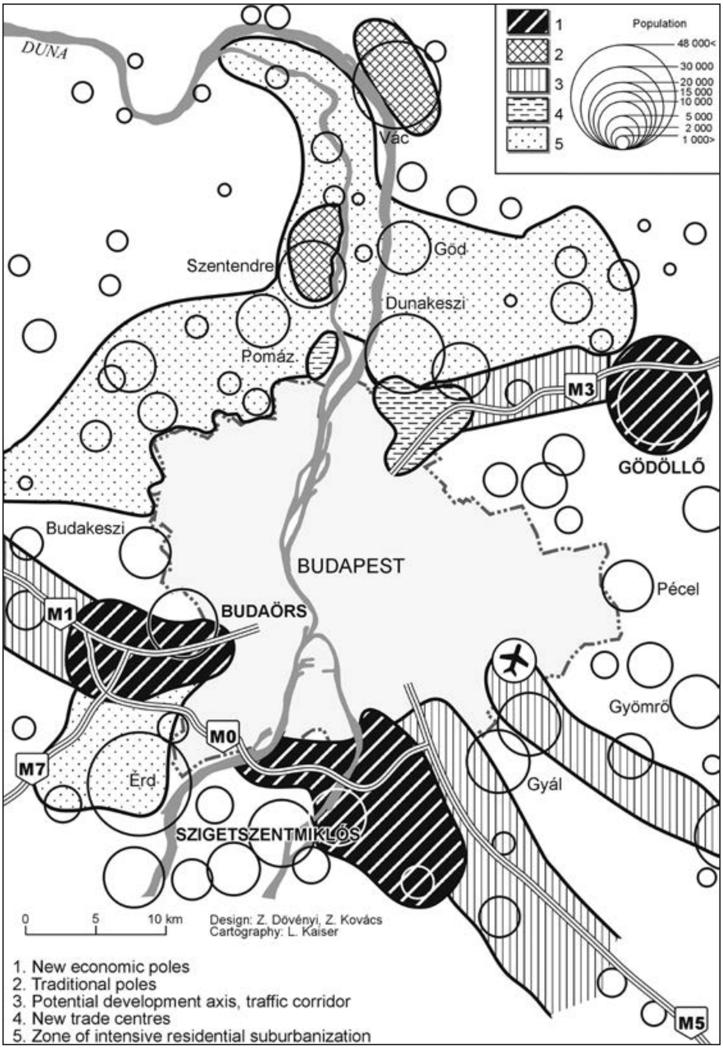

Figure 12: New spatial structure of the suburban belt around Budapest
Source: edition of Zoltán Dövényi – Zoltán Kovács – Lívia Kaiser

II.6. Conclusions

Budapest as the capital city of Hungary and a major hub of international business corporations is a rapidly transforming city. The transformation process was launched by the political and economic changes of the early 1990s. The different zones of the urban region were affected differently by the transformation, which is market-led and generates both up- and down-grading processes in the city. There are two major areas where upward processes are most evident in metropolitan Budapest: the central business district and the suburbs. Neighbourhoods lying between these two dynamic zones reveal some more controversial development. In most of the inner urban residential neighbourhoods that were severely neglected during the communist era a further decline can be observed. In some of these neighbourhoods physical deterioration is accompanied by extreme forms of social segregation and social exclusion. Only a limited number of neighbourhoods provide examples for upward trajectory, these are mostly the core areas of urban rehabilitation actions. Neighbourhoods affected by rehabilitation programmes are going through rapid population change, the old and less affluent population is being displaced in a gentrification process that resembles very much the western cities. The biggest challenge for the future development of the city is caused by the high rise housing estates. These large-scale monotonous housing estates are becoming more and more the shelter of the urban underclass.

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III. Major issues of spatial structure planning of Minsk

Ivan Pirozhnik – Henryk Oziem – Vladimir Korotayev

Abstract

This article deals with the transformation of the urban planning strategy of Minsk analysed on the background of the abandonment of the previous socialist planned economy concept. The trends in the development of the city are analysed in comparison with other European capitals together with the spatial characteristics of the population of Minsk. Due attention is given to the dynamics of the Minsk Master Plan and to the evolution of the spatial structure of Minsk observed in transition in the post-industrial social order.

Keywords: urban planning strategy, urban space, development, socio–spatial types of population, Minsk Master Plan

III.1. Introduction

With the abandonment of the previous socialist economic system, which was based on rigid planning and regulation of the economy and the social order by the state, and with the transition to the new socio–political system, the capital cities of Eastern Europe introduced new principles of spatial organization of the urban environment.

New tendencies in the modern development of post-Soviet cities became apparent, such as transition to the regulation of price and property by the market, minimization of the role of industry and emergence of new social values. These changes of spatial character enhanced mosaicism and diversity of the urban environment.

However, the character of the current socio–economic transformation observed in Minsk is different from the other capital cities of the former Soviet Union. This is due to a more moderate policy of socio–economic and political transformations in the late 20th – early 21st centuries and the specific economic model exercised in Belarus. This peculiarity can be observed in the present socio–political system in the country characterized by the state regulation of production, employment, remuneration and land market.

Among the new factors which led to the transformation of the previous system of territorial organization one may refer to the developing property and land market, commercial regulatory mechanisms of the service sector, socio–structural changes in the population and especially the emergence of a creative environment. Market development in many cities goes hand in hand with accelerating deindustrialization in capital centres, transition of industry from metropolitan areas and the extension of post-industrial features. Due to these features the process which was accomplished in capital cities of Western Europe in a period of 40–50 years, in many capital cities from Eastern Europe took place in a period of only 10–15 years. Quite naturally, the changes of economic and social character are vivid in the territorial organization of space in large cities and primarily in the decentralization of urban space, gentrification, property development and extension of the number of functions in the cities themselves.

III.2. Minsk – a basis of economic power of the country

Minsk, the capital of Belarus for the last 100 years, has a history of 900 years *(Figure 13)*. It is a major transport, political, economic, cultural and scientific centre of the country. Its contribution to the GDP of the country was 24.8 percent (2011). In 2011, GRP in Minsk increased by 17.6 percent in comparable prices as compared to the corresponding period in 2010, in production by 16.8 percent and services by 18.1 percent. GRP growth in Minsk was 2–2.5 times higher than in other regions of the country (Glavnoe Statisticheskoe Upravlenie Goroda Minska 2012, p. 3).

Figure 13: General view of ‘Troetskoe precinct’

This status of Minsk in the national economy was achieved in a very short period of time. The post-war period in the 20th century was unique for the city. Because of the lack of a balanced spatial planning policy in the post-war period, emphasis on industrial urban expansion in the Soviet Union enhanced urban population growth associated with the disregard of natural demographic growth in urban centres. Minsk was no exception. The restoration of the city destroyed by war, renovation, reconstruction and enhanced industrial expansion promoted rapid population growth. Among the factors which contributed to this growth, immigration accounted for two thirds of the total population growth for the given period (Polskiy, S. A. 1976, p. 12). The population growth was not uniform *(Table 1)*.

Year	Pop., 1000 people	Period	Average annual pop. growth rate, %	Features of economic development
1945	120.0	–	–	Post-war recovery of industry, beginning of industrialization
1947	240.0	1945–1947	50.00	
1950	273.6	1947–1950	4.67	
1955	401.7	1950–1955	9.36	Period of rapid industrialization, focus on the development of mechanical engineering and metalworking. Concentration of industrial production in Minsk and its transformation into a powerhouse of the industrialization of the Byelorussian Soviet Socialist Republic (BSSR).
1959	509.5	1955–1959	6.71	
1965	721.5	1959–1965	6.93	Intensive development of industrial production on the basis of cooperation with existing enterprises of mechanical engineering. Elimination of imbalances in the economic development of the city resulting in the rapid development of the service and support industries (food, light industry, the scope of social and community services). Beginning of the policy of restricting the construction of large industrial units in the city.
1970	916.9	1965–1970	5.42	
1974	1094.6	1970–1974	4.85	
1979	1273.5	1974–1979	3.27	
1985	1472.1	1979–1985	2.60	Slowdown and extensification of industrial production, focus on accelerating development of housing, health, science and education.
1989	1607.1	1985–1989	2.29	
1995	1665.6	1989–1995	0.61	The period between 1990 and 1995 is referred to as depression with a sharp drop in industrial output and stagnation of services. The sustainable trend of economic growth began from 1996.
1999	1680.6	1995–1999	0.23	

Year	Pop., 1000 people	Period	Average annual pop. growth rate, %	Features of economic development
2006	1758.8	1999–2006	0.78	Deindustrialization of the economy of the city was enhanced. The accelerated development of high-tech and innovative industries and the service sector began.
2010	1843.7	2006–2010	1.21	
2011	1864.1	2010–2011	1.11	

Table 1: The dynamics of population growth of Minsk in 1945–2011 and features of economic development
Source: compilation of the authors

III.3. Minsk – the heritage of socialist era industrialization

Despite the trends in the early years of the 21st century, the modern economic profile of Minsk is quite typical of any industrialized city with an impressive concentration of industrial output *(Table 2)*. This is supported by the structure of residential employment and the profit factor of the urban economy. This factor affects the economic image of Minsk as a typical Soviet city of the bygone Soviet era.

In 2012, industrial production accounted for 23.9 percent and services for 61.1 percent of the structural gross product of Minsk, with a notable decrease in industrial production and the growth of the service sector by 65.4 percent in 2011 *(Table 2)*. The instability of the domestic market contributed to the downfall.

The branch structure of industry in Minsk is represented by enterprises of engineering and metalworking (53.9 percent of the value of industrial production), food (12.9 percent), electricity (12.5 percent), production of building materials (6.0 percent), chemical and petrochemical (5.2 percent), light industry (3.7 percent), forestry and wood (2.4 percent). Businesses from Minsk provide one fifth of the total industrial output in Belarus. The entire volume of the production of trolley buses, motorcycles, household refrigerators and freezers, internal combustion engines, power transformers, tractors and bicycles is concentrated in Minsk. 90 percent of the total production of trucks, 86 percent of buses, 81 percent of bearings, 35 percent of TVs and 88 percent of wool fabrics were manufactured in the city of Minsk (Glavnoe Statisticheskoe Upravlenie Goroda Minska 2012, pp. 35–39).

City (metropolitan region)	Industrial share in employment, %	Industrial share in the structure of added value, %
Berlin	9.0	14.0
Budapest	16.8	22.1
Copenhagen	8.9	13.9
Hamburg	10.9	12.0
Helsinki	12.3	23.3
Minsk	37.4	23.9
Moscow	24.6	15.0
Riga	13.0	9.0
Oslo	7.5	7.0
St. Petersburg	33.0	24.3
Tallinn	17.0	17.5
Vilnius	16.0	20.0
Warsaw	16.5	16.0

Table 2: The role of industrial production in the economy of some selected European cities (at the beginning of 2010)
Source of data: homepage of Eurostat[3]

Despite the impact of the global financial crisis, the industrial enterprises of the city achieved high growth rates of production. The growth rate of industrial production from 2006 to 2010 amounted to 162.7 percent. However, the crisis of the global economy and price fluctuation in the global and regional markets in the last quarter of the 20th century and the beginning of the 21st century led to a sharp decrease in the technological capacity of enterprises. Modern

3 http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/themes – 2014. 06. 30.

technological efficiency of the Minsk Automobile Plant (MAZ) is 40–45 percent, the tractor plant (MTZ) 70–75 percent, the Minsk Bearing Plant (MPZ) 18–20 percent, machine-tool plants 25–30 percent and the production of television sets 35–40 percent. The high amount of raw materials used in modern production reduces the economic efficiency of production. The industry of the city is in the process of radical technological modernization and industrial restructuring.

As industrial development is, in many ways, the foundation of the socialist city, the realities of post-industrial market capitalism are directly related to changes in determining the face of post-socialist cities. Deindustrialization as the long-term process of reducing the share of industrial production in the structure of the urban economy, accompanied by the growing share of services *(Table 3)* took place in the European cities in the late 1970s – early 1980s. It started in Belarus only in the second half of the 1990s. About 585 thousand people are engaged in the service sector of the city. Over the period from 1990 to 2010, employment in this sector grew by 1.4 times, increasing the share in employment from 46 to 54 percent. The most rapidly growing sectors of employment are trade and catering (3-fold increase). A negative factor is the decline in employment in science and scientific services (by more than 3.5 times). The other sub-sectors of services experience insignificant increase in their share in the employment structure (by less than 1.2 times).

City (metropolitan region)	Share of services in employment, %	Share of services in the structure of added value, %
Berlin	86.1	82.1
Budapest	83.0	77.7
Copenhagen	88.1	83.1
Hamburg	85.3	85.4
Helsinki	81.0	72.0
Minsk	54.1	61.1
Moscow	51.2	80.9
Riga	79.1	82.2
Oslo	87.2	90.1
St. Petersburg	45.2	69.8
Tallinn	72.4	76.0
Vilnius	72.0	73.0
Warsaw	73.0	80.0

Table 3: The role of services in the economy of cities in Europe (at the beginning of 2010)*
Source of data: homepage of EUROSTAT[4]

Among the features of post-industrial cities are innovation and restructuring, the creation of enterprises working with new technological processes based on knowledge-intensive production with maximum added value, low consumption of materials and high labour productivity. There were 468 organizations (including small ones) in Belarus in 2010 engaged in scientific innovation. The largest number of research organizations (303) is located in Minsk, which include the scientific institutions of the National Academy of Sciences, industrial research institutions and institutions of higher education. By 2010, their number in Minsk increased by 89 units since 2006. In other regions of the country the increase in the number of research organizations was 41 units.

4 http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/themes – 2014. 06. 30.

III.4. Social diversity of Minsk

The economic potential of Minsk, its functional role in the economic space structure of the country as the dominant socio–economic and political centre determines the territorial organization of urban space. Minsk is the capital of the country. From the political–administrative point of view the city is divided into nine districts, which have a specific functional and territorial structure. This fact explains the dominance of the peculiar social structure of the population in these areas.

In general terms, three major types of urban areas can be distinguished in Minsk regarding the social structure of the population, based on an analysis of census data in 2009 (level of education, employment, age, marital status, scope of professional activity and employment, availability and characteristics of housing). Conventionally, they can be characterized as 'industrial', 'post-industrial' and 'mixed' *(Figure 14)*.

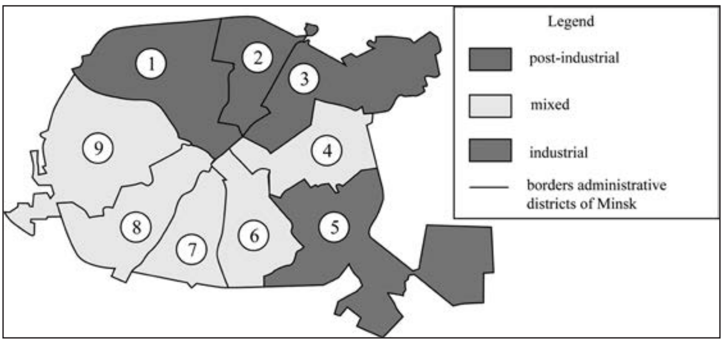

Figure 14: The functional district-types of Minsk (Numbers denote administrative districts of Minsk: 1. Tsentralny, 2. Sovetsky, 3. Pervomaisky, 4. Partizansky, 5. Zavodskoy, 6. Leninsky, 7. Oktyabrsky, 8. Moskovsky, 9. Frunzensky)
Source: homepage of Institute of Regional and Urban Planning[5]

The first type of social structure ('industrial') is most actively present in the Zavodsky district of Minsk. The 'post-industrial'

5 http://www.irup.by/en/ – 2014. 06. 30.

type can be observed in three districts: Tsentralny, Pervomaisky and Sovetsky. The rest of Minsk is characterized by the 'mixed' type.

In the industrial Zavodskoy district the industrial giants of the country are located: the former enterprises of all-Union importance such as the Minsk Automobile Plant (MAZ), the Minsk Bearing Plant (MPZ) and the Minsk Wheel Tractor Plant (MZKT). The social group of 'plant workers' forms the main segment of the inhabitants in this area. The population of the Zavodskoy district has special secondary education (26 percent of residents) and general secondary education (25 percent). In comparison with other areas it also has a large percentage of people with vocational technical training (9 percent), while the proportion of people with higher education is the lowest in this district (21 percent). The Zavodskoy district has the largest number of married and divorced residents in the city.

The average age of residents is 38.5 years (male – 36 years, female – 41 years). The high proportion of residents over working age is due to the tendency for young people to move to other areas of Minsk. The main reasons are the poor employment opportunities and the lack of entertainment and leisure facilities. The bulk of the population is employed in industry, construction, trade and consumer services, associated with preferential development of residential housing for workers built in the 1950s–1960s (when the plants were constructed).

The 'post-industrial' areas are characterized by the dominance of intellectuals and civil servants. This category of the population lives in the Tsentralny, Pervomaisky and Sovetsky districts. The proportion of people with higher education in these areas is 36 percent, 34 percent and 36 percent respectively, partly due to the concentration of research institutions, universities and student hostels. These are the National Academy of Sciences, research institutes, design and construction organizations, the Belarusian Film Studio, the new building of the National Library *(Figure 15)*, High-Tech Park.

Figure 15: The National Library – the new symbol of Minsk
Source: photo of Vladimir Korotayev

High-tech production plants dominate in industry (Minsk Technological Design Institute of the pilot car industry, 'Horizont', 'Atlant', computer firms). Besides Soviet era buildings there are the most prestigious high-rise apartment blocks as well as cottage *(kottedzh)* villages on the periphery. It should be noted that rents are slightly higher here.

There is a large proportion of working age people (67 percent) in the Pervomaisky district. The highest percentage of people over working age (25 percent) lives in the Sovetsky district, where the number of unmarried people is also the largest. This indicates that for men these areas are associated with success, career growth, and financial stability.

Areas with a 'mixed' social structure of population include the other five districts: Leninsky, Oktyabrsky, Frunzensky, Moskovsky and Partizansky. They are characterized by a combination of these two social and professional groups of people. The share of population with higher education does not exceed 29 percent. The Moskovsky district is distinguished by the highest proportion of working-age people (70 percent). Large industrial enterprises are concentrated in these areas (Minsk Aircraft Repair Plant, 'Integral', 'Keramin', Minsk Meat-packing Plant, machine tool plants, Minsk

Heating Equipment Works) and also cultural facilities (Concert Hall 'Minsk', the National Art Museum, and The Yanka Kupala National Academic Theatre). Here are the main government establishments: President's Residence, ministries, the Presidential Academy of Management, the courts, the CIS Executive Committee headquarters.

III.5. History and Perspectives of the Minsk Spatial Structure

The expansion of Minsk districts *(Figure 16)* is carried out in accordance with the Master Plan. The first plan to optimize the planning system of the city within the Soviet Union was worked out in 1926. Its primary aim was to build pedestrian crossings and subways and to set up traffic lights, which improved the sanitary and safety conditions of the city. The 1930s were marked by the intensive construction of certain complexes in new areas, such as the Belarusian State University (BSU) campus and the City Hospital. In terms of planning and architecture, a major event was the construction of the House of Government (1929–1934). This was the beginning of a new historical stage in the spatial structure of Minsk with its administrative centre.

The Master Plan took into account the prospective growth of the population of the city. Thus, the pre-war Master Plan (1940) was designed for a population of 250–500 thousand people, while the first post-war Master Plan (1946–1960) counted on a population of 450–500 thousand people. The growth of the population in the period of 1944–1946 was more than planned. In the 1990s, however, the growth slowed down, but the expansion of the city continued causing a low population density (6.1 thousand people per km^2; while in Moscow and Warsaw it was twice as high).

The post-war urban development essentially aimed at creating a new city with great industrial complexes, wide avenues, architectural ensembles and large squares. The plan (1944–1946) was aimed at converting the main avenue (now Independence Avenue) into a traffic highway across the city. It also necessitated the construction of a second road junction (known as Pobediteley Avenue). These two lines now form the main planning framework of the city. A whole system of parks along the river Svisloch was designed and also two ring-roads were built, which was the implementation of the pre-war Master Plan (1938).

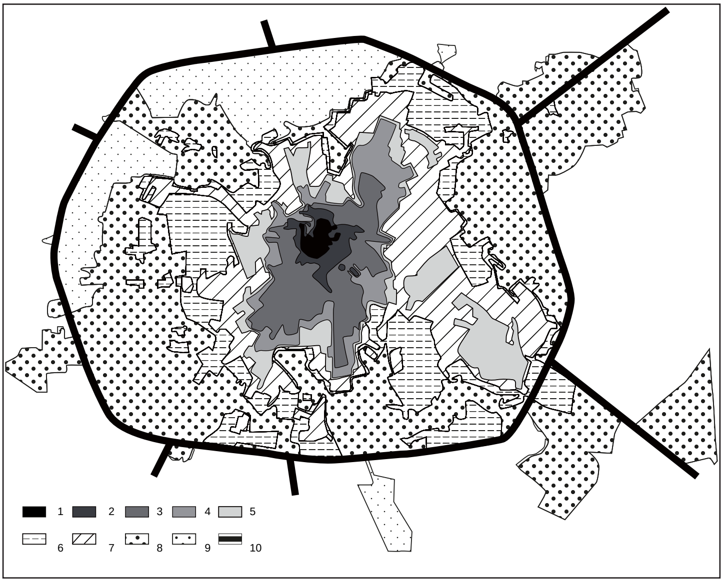

Figure 16: Territorial evolution of Minsk (the boundary of urban areas in certain years: 1. 1800, 2. 1850, 3. 1900, 4. 1940, 5. 1950, 6. 1965, 7. 1980, 8. 2001, 9. 2009, 10. the Minsk encircling highway and exit roads)
Source: edition of the authors

The latter was revised twice. Within the period 1951–1952 residential areas were set up taking into account a more economical use of urban territories. In 1958 Minsk was completely restored and the spatial structure considerably exceeded the pre-war size. The city expanded south, southeast and northeast so that the distances between the employment areas and the residential districts were substantially reduced. The latter became a basic structural element of the spatial planning of the city. Since 1970 the outskirts of Minsk have gradually been included into the Minsk metropolitan area. New radial highways, semi-ringroads and motorways were constructed.

In 1965, after the renewal and reconstruction of the city a new general plan was worked out. Keeping to the principle of continuity it was aimed at the accumulation of industrial enterprises and works, which stimulated the growth of the city territory and of the population. From 1961 to 1972 the population doubled (from 570 thousand to 1 million people). People tried to move closer to the industrial areas of the city, forming industrial districts within the city (in its western and southeastern part: Drazhnya and Shabany).

Simultaneously, the foundation of administrative (in the historical centre of the city) and residential areas was very actively carried out. The planning structure of the city was changed from the classical simple concentric model by Burgess onto the sectoral model by Hoyt.

The rapid growth of the population and the excessive concentration of industrial enterprises, research and educational institutions and other city-forming establishments led to a disproportionate development of the city economy. Developing new strategies restricting the population growth mainly at the cost of the restriction of new industrial construction was one of the main objectives of the new general plan. The concept of monitoring the development of Minsk presented in the Master Plan of 1982 was realized at the following spatial hierarchic levels:

- in the population structure of country Minsk was specified as a dominating centre of a spatial and economic settlement;
- at regional level Minsk was considered as the centre of the Minsk agglomeration based on the location of industrial enterprises which belonged to cooperative and technological clusters (including such towns as Borisov, Molodechno, Soligorsk, Bobruisk and Baranovichi);
- at micro level it was viewed as a centre of group settlement, as a territorial and production complex, which consisted of the city and its outskirts.

In the 1980s–1990s Minsk expanded southwest and west within the external ring road and also northeast beyond it (Uruchye residential district). New housing construction was performed both in vacant areas and the areas occupied by small bungalows built between 1945 and 1960.

The current plan made in 2009 provides development of the functions of the capital, which includes regeneration and reconstruction of the historic areas and further expansion of the territory of the city from 30.6 hectares to 54.2 hectares. The plan also counts on the growth of the population from 1.8 to 2.0 million people, which will lead to the optimization of the service and industrial sectors from the present 60:40 % rate to 75:25 % in the future (Rubanov, A. V. 2005, pp. 5–15.).

The historical centre of Minsk occupies about 10 percent of the territory of the city and it is the primary area where administrative and public institutions are located. At present, this area undergoes an intensive functional transformation being a multipurpose city centre, such as an administrative and business centre. The main buildings of government and executive administration are located here, gradually transforming it into the main office centre of the city with banks, restaurants, cafes, luxury retailers, leisure and entertainment sites (night clubs, casinos etc.).

The effective spatial and functional development of the city is provided by the formation of four concentric zones: zone I – the centre of the city within the first ring road, zone II – the central area within the second ring road, zone III – middle zone within the Minsk encircling highway and zone IV – the peripheral zone within the boundaries of the perspective planned metropolitan boundary (Rubanov, A. V. 2005, p. 114.). According to this strategy, the main avenues of each district will form the structural framework of the urban planning of the city *(Figure 17)*. Each direction of the territorial growth of the city is expected to have one main avenue. Depending on the nature and intensity of land use 100, 400 and 1000 metre areas of planning framework are to be set up with an outside zone of 2500–3000 metres. The most usable part for urban life is the territory located in the 400 metre strip on either side of the main avenues. They will be actively used for public facilities units – offices, banks, restaurants, cafes, businesses, trade, culture and recreation, scientific and educational institutions, etc. Special attention is paid to the Master Plan for the comprehensive development of the city centre. Today it is a residential, administrative and industrial area. Under the new concept of the general plan of Minsk the city centre will not be multifunctional. This will require changes in the socio–economic profile with the elimination of industrial and environmentally unhealthy objects and thus making it a business, trade and service centre with a high density of competing economic units. Special attention will be given to the reconstruction of historic buildings and the establishment of important public facilities. Other important issues determined by the Master Plan are the isolation of the urban centre from transit traffic and the organization of parking. The territorial growth of the city will be affected due to the demolition of buildings in the central and middle zones, increasing the density of the urban area, especially in the centre and in the kilometre zone along the main avenues. Simultaneously, the industrial enterprises that are located in this zone will be removed beyond the city perimeter by 2030 *(Figure 17)*.

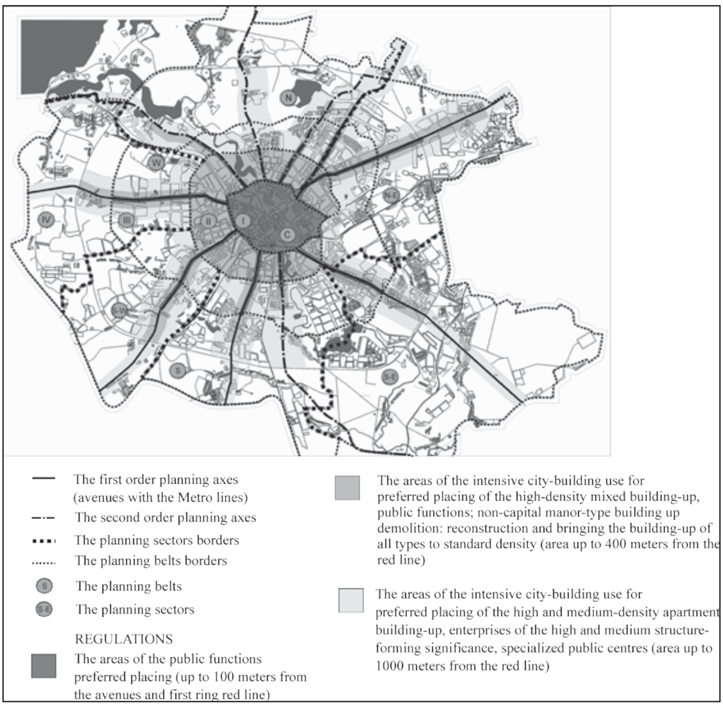

Figure 17: A sketch of the perspective Minsk scheme in 2020
Source: Rubanov, A. V. 2005, p. 114.

Special attention is paid to the reconstruction of historical buildings in the nucleus. A new system of historical symbols of the city is planned with town halls, hotels, European type malls, etc.

Setting the borders of compact spatial development of Minsk counts with an area of one-hour access to the city centre with passenger transport routes to suburban residential areas across the following sectors: the northeast – Leskovka, Kolodishchi, east – Privolny, Obchak, southeast – Korolischevichi, south – Gatovo, Machulishchi and Priluki, southwest – Bogatyrev, Ozertso and Volchkovichi, west – Tabora, Hatezhino and Ratomka – and northwest – Semkov–gorodok, Bolshevik.

The strategy to improve the ecological state of the urban environment will be continued with the formation of an interconnected system of recreational landscape areas, including water and green city zones along the River Svisloch and a water park in the flood areas of its tributaries (Loshitsa, Stepyanka) linked with green wedges in undeveloped areas with woodland parks in the suburban zone.

The program for the removal of industrial enterprises from the vacant land of industrial complexes in the suburbs is expected to reduce the industrial and human impact on urban areas. This statement is debatable, however. Efforts to remove industry beyond the city boundaries have been made in the last 10 years. Although economic assessments and calculations had been made, no actual steps have been implemented. This is due to the enormous economic costs (estimated at more than 6 billion US dollars), and also because of the eagerness of investors and industries to retain the right to use the vacated buildings and land within the city according to their will and with potential further development concepts.

The removal of industries outside the city will be implemented in the scope of a Belarusian–Chinese investment project, by establishing an industrial park, which will be built near Smolevichi and the National Airport by 2025. The 80 km² area will site high-tech export products of mechanical engineering, biomedical, consumer electronics, etc. The Chinese partners estimate the cost of the project to be in the region of 30 billion US dollars.

The complex solution of territorial development issues in Minsk, as it is viewed by architects and urban planners (Semenkevich,

D. I. 2011, p. 20.), requires transition to the concept of intensive suburbanization and formation of the Minsk polycentric metropolitan agglomeration together with the development of satellite cities along the railways and highways in the agglomeration zone of Minsk (Zaslavl, Fanipol, Dzerzhinsk, Rudensk, Smolevichi, Logoisk). The population of the satellite cities should be at least 30 thousand to enable them to perform some functions of the central city.

In the second half of the 20th century the architectural design in the Soviet cities was characterized by the standardization of housing estates. Minsk was no exception. Styles and eras were not typically mixed, some architectural tendencies, however, can be observed in:

- ⊕ the Stalin era empire style in the centre of the city, almost covering the territory within the first ring road; *(Figure 18a)*
- ⊕ the five-storey apartment blocks built in the 1960s *(Figure 18b)*. In the west they can only be seen within the second ring road. In the south and to the east of the railway they are located as far as the Minsk encircling highway and near the industrial enterprises *(Figure 18c)*. In the east and the southeast, where the industrial zones were formed (MAZ, MTZ, MZKT), housing meant filling existing gaps, therefore the arrangement of 'five-storey apartment blocks' was very irregular.
- ⊕ the housing of the 1970s and 1980s in the Brezhnev era are characterized by buildings with more than nine storeys *(Figure 18d)*. They form residential districts which are independent and have the minimum social infrastructure. Such 'autonomy' required considerable areas for construction. Therefore this type of construction corresponds to a new territorial extension in city growth. A specific feature of areas with such buildings is that the new housing estate doesn't mix up with residential areas of the earlier period and with other functional zones. Thus, these buildings surround the city, occupying areas between the second ring road and the Minsk encircling highway.
- ⊕ new apartment buildings of the post-Soviet period on vacant plots in the city, typically situated in the western sector of the city and in the suburbs, with more than 16 storeys.

(18a)

(18b)

(18c)

(18d)

Figure 18: Typical Stalin-era buildings *(18a)*, Plekhanova Street – traditional building scheme of the 1950s–1960s *(18b)*, Industrial Zone of Minsk near Minsk Tractor Works (MTZ) *(18c)*, Residential buildings of the Brezhnev era – Minsk, Serebryanka *(18d)*
Source: photos of Vladimir Korotayev *(18a)* and Dávid Karácsonyi *(18c–18d)*

III.6. The beginning of a new transformation of Minsk

The post-industrial transformation of the city was most explicit in trade and commerce. The shift of the territorial organization of trade and commerce in Minsk was due to a shift from planning strategy to giving priority to competitive outlets. Over the last ten years the number of retail outlets in Minsk increased from 3.3 to 4.9 thousand units. Considering the fact that the city has a population of over 1.9 million, the number of multipurpose shopping centres remains insignificant. Nevertheless, the new tendency to give priority to modern multi-storey structures is obvious. This is evident in the construction of a new shopping centre near the sports complex – the Minsk Arena. This area is situated on Pobediteley Avenue between the second ring road and the Minsk encircling highway and is characterized by the modern residential estate of the last ten years.

Minsk continues to maintain the traditional country market. The markets are located in all districts of the city, both in the centre and beyond the second ring road. The largest market of Minsk – 'Zhdanovichi' is located in the northwestern part of the city near the Minsk encircling highway. It was constructed during the post-Soviet period and now it is a shopping mall, as trading has gradually moved from the open air to indoor pavilions formed on the basis of the product types (grocery, commodities, building materials). The Komarovka market is the main food market in Belarus, and it is situated within the second ring road near the historical city centre. The covered market was constructed in 1979, but subsequently it was considerably rebuilt and became a closed pavilion with a parking lot. Following the example of the reconstruction of commercial centres in other post-Soviet cities such as St. Petersburg, these markets can be transformed into traditional malls.

In the service sector of Minsk there is a shortage of hypermarkets. The most popular are the 'ProStore' complexes located near the Minsk encircling highway and 'Crown'. The majority of goods and commodities are purchased in easily accessible shops typical of the Soviet period. Today the most popular commercial centres are the 'Gippo', 'Evroopt' and the 'ProStore' complexes.

III.7. Conclusion

Post-Soviet and post-industrial renovations in Minsk are in full swing. The dynamics of transformation at the present stage substantially depend on the degree of restrictions of market regulation mechanisms which may considerably 'soften' the extent of spatial differentiation of the urban environment.

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IV. Spatial and temporal differentiation of demographic development of Minsk

Ekaterina Antipova – Liudmila Fakeyeva[6]

Abstract

This chapter is devoted to the demographic development of Minsk in the late 20th and early 21st century. The state of Minsk in the demographic pattern of Belarus and the factors of population dynamics are analyzed. Spatial and structural shifts in population dynamics, fertility, mortality, age structure and migration are identified, characterized and typified in the various Minsk administrative districts for the period of 1990–2010 years. The complex geodemographic typology of Minsk is worked out and three types of districts are differentiated: progressive with natural increase and stationary age structure (Moskovskiy, Frunzenskiy), stable with natural increase and regressive age structure (Leninskiy, Oktyabrskiy, Partizanskiy, Pervomaiskiy), regressive with natural decrease and regressive age structure (Zavodskoy, Sovietskiy and Tsentralny).

Keywords: Minsk, Belarus, spatial and structural demographic dynamics, demographic balance, age structure, factors of demographic development, geodemographic typology

IV.1. Introduction

Under globalization conditions the sharp increase in the role of large cities in the socio–economic and cultural life of the society is one of the typical and distinctive features of modern urbanization. The growth and development of large cities is caused by newly established businesses and the extension of already working industrial units and service industry firms, the presence of administrative establishments, higher education institutions and colleges and other enterprises along with transport development.

6 The research presented in this chapter was conducted with the support of International Visegrad Fund: 2012–2013 'Migration factor in spatial development of the metropolitan area in the postsoviet period (on the example of Minsk and Budapest)', 2013–2014 'Comparative analysis and economic-geographical prognosis of demographic development of Hungary and Belarus'.

The development of many large cities has its peculiarities. Scientific and technological advances, modernization and restricting of enterprises influence the rapid development of service and industry as main city forming factors. That is why such types of cities develop rather more quickly. However, the faster a city grows, the more problems and imbalances it will have in terms of its socio–economic development.

The state of Minsk in the demographic pattern of Belarus is unique and different from other cities due to:

1.) positive dynamics of the population size during the twentieth century, except for the years of the World War II;
2.) high annual growth rate of the population in contrast to all other urban settlements;
3.) predominance of the migration factor in the formation of the population size for a long time;
4.) active commuting and links to satellite towns;
5.) the highest level of concentration of the urban population;
6.) the spatial differentiation of demographic processes within administrative districts.

The spatial and structural dynamics of demographic and migration development of Minsk over the period of industrialization and the 'Belarusian urban boom' in 1960–1970 attract the scientific interest of Belarusian geographers (Polskiy, S. A. 1976). There was a gap in the research during the period of social and economic transformations caused by the collapse of the socialist economic system and the Soviet Union. New economic and social trends of the early 21st century during the stage of transition to the post-industrial development give rise to changes in the growth rate, structure, spatial distribution and function of the city, which required a detailed study to identify the factors and patterns of development and the new image of the capital city.

The main methods used in this research were: factor analysis and GIS mapping (Antipova, E. et al. 2012). The information base of the research is the results of the population censuses of the USSR and Belarus and current demographic records of the National Statistical Committee of Belarus for the period of 1989–2011.

IV.2. Dynamics and factors of demographic development of Minsk

The population increased by more than 5 times during the active period of industrialization of the capital from 1950 to 1985. Minsk contributes 30 percent of the total growth of the Belarusian urban population, accounts for 25 percent of all urban population and one-seventh of the total Belarusian population. The Minsk region increased its share in the country's population by up to 30 percent due to the capital city in the mid-1980s, and the city of Minsk has surpassed such regions as Vitebsk, Brest, Grodno and Mogilev in the number of its population. It is clearly defined as the major demographic centre with the densely populated environment of the city and its agglomeration (POLSKIY, S. A. 1976, BELSTAT 2012).

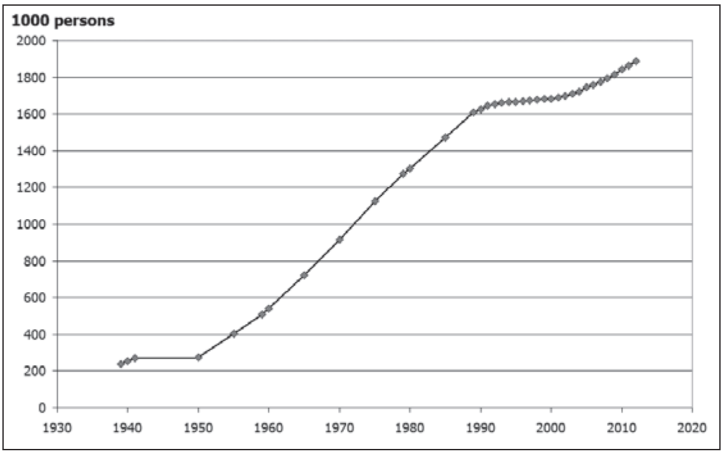

Figure 19: Minsk population dynamics within the period of 1939–2011
Source of data: BELSTAT 2011, BELSTAT 2012

As a result, one of the main features of the urbanization process in Belarus is the primate city effect – the dominant role of Minsk and the Minsk metropolitan area, where 27 percent of urban population is concentrated and weak agglomeration processes in other regions. The slow-down of the growth of large cities as a result of the socio–economic crisis in the second half of the 1990s led to a reduced share of cities from this group in the population relative to the extra large cities (Minsk) from 1.77 in 1999 to 1.65 in 2010. The share of the metropolitan area in the total population increased from 16.7 percent in 1999 up to 19.9 percent in 2010.

Minsk belongs to those European capitals which had the highest population growth rate in the second half of the 20th century. During the period from 1950 to 2010 the population size increased almost sevenfold and almost reached the level of 2 million – 1.883 thousand people *(Figure 19)*.

Minsk increased its demographic potential in the post-war period, primarily due to migration and natural increase with relatively small increase in population due to the integration of rural settlements to the city territory.

The industrialization development during the Soviet era, the rapid growth of new industrial branches (such as auto and tractor construction, machine-tool construction, radio-electronic industry, and electronic mechanical engineering) turned the Belarusian capital into the 'assembly shop' of the Soviet Union. A distinctive feature of Minsk is that it has retained the role of a major industrial centre even in the current transitional stage to post-industrial development.

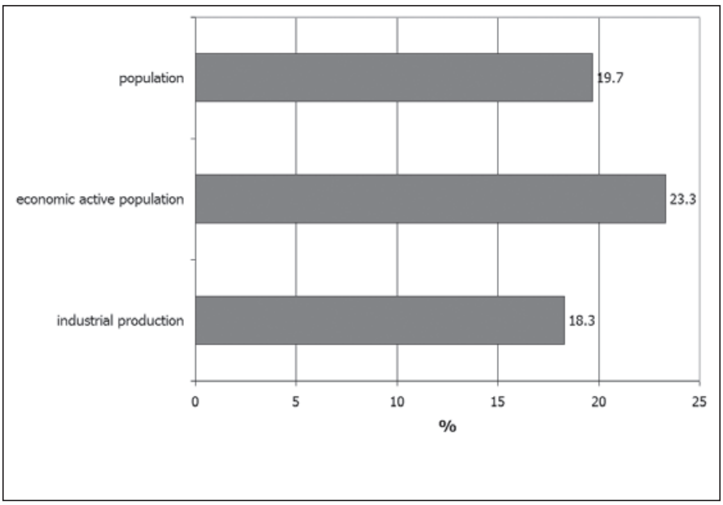

Figure 20: Industrial role of Minsk City in Belarus
Source of data: Belstat 2012

Almost a quarter of the country's industrial output is produced in the capital at present *(Figure 20)*.

The territory of modern Minsk is divided into 9 administrative units/districts. The population of the city has an uneven distribution: Moskovskiy, Zavodskoy and Pervomaiskiy districts have the largest, while Parthizansky, Tsentralny and Oktyabrsky districts have the smallest shares in the population *(Table 4)*.

District	Population, thousand people			Share of district in population, %			Population dynamics index		
	1989	1999	2009	1989	1999	2009	1999/1989	2009/1999	2009/1989
Moskovskiy	169.2	224.8	261.9	10.5	13.5	14.4	1.33	1.17	1.55
Tsentralny	74.6	64.8	112.1	4.6	3.9	6.3	0.87	1.73	1.50
Frunzenskiy	297.2	346.8	353.8	18.4	20.6	19.5	1.17	1.02	1.19
Pervomayskiy	183.3	208.6	216.7	11.4	12.4	11.9	1.14	1.04	1.18
Leninskiy	189.2	180.8	210.3	11.7	10.7	11.5	0.96	1.16	1.11
Oktyabrskiy	159.6	150.4	155.5	9.9	8.9	8.6	0.94	1.03	0.97
Zavodskoy	251.6	248.5	236.8	15.6	14.8	13.0	0.99	0.95	0.94
Sovetskiy	181.2	160.5	168.4	11.2	9.6	9.3	0.89	1.05	0.93
Partizanskiy	108.8	94.6	99.3	6.7	5.6	5.5	0.87	1.05	0.91
Minsk total	1614.7	1679.8	1814.8	100	100	100	1.04	1.08	1.12

Table 4: Minsk population dynamics by administrative districts, 1989–2009
Source: calculation of the authors based on the data of Belstat 2011

Minsk, as a large geographical unit, is a complex system consisting of 9 administrative districts with different socio–economic functions and structure. The formation of the demographic spatial structure of the city is connected with the historical formation of administrative districts and their socio–economic role, in the Soviet (BSSR) era as well as at the present stage.

Moskovskiy and Tsentralny are the fastest growing districts, which have increased the size of their population by 50 percent or more since 1989. Leninskiy, Pervomayskiy and Frunzenskiy districts also show a positive trend with an increase of 10–20 percent. In Sovetskiy, Partizanskiy and Zavodskoy districts the population has declined by 6–9 percent during the period of 1989–2009. The situation is relatively stable in the Oktyabrskiy district – its population has not changed significantly in 20 years.

In different periods of time migration and natural movements of population played various roles in forming the population of Minsk. Before 1994 the population growth was due to natural increase as well as migration, while from 1995 it was only because of migration growth and administrative territory changes. Since 2006 the tendency of population growth has been again partly attributed to natural growth.

IV.3. The natural increase in the population dynamics and spatial structure formation in Minsk

The nature of vital development of Minsk reflects European demographic tendencies, but has its local features and peculiarities. In 1989, the total fertility rate was 16 ‰, higher than in many European capitals. The subsequent period up to 2002 was characterized by the progressive trend of fertility decline to the level of 9 ‰, which is consistent with trends in most European cities.

The birth rate in the capital has been increasing since 2002 onwards and currently amounts to 11.3 ‰, which corresponds to the figure in 1992, i.e. the pre-crisis and pre-transformation period. The main causes of the increasing birth rate in the capital are institutional (an active state policy to support young families) and demographical (the large number of women born in the late 1980s are coming into childbearing age) *(Figure 21)*.

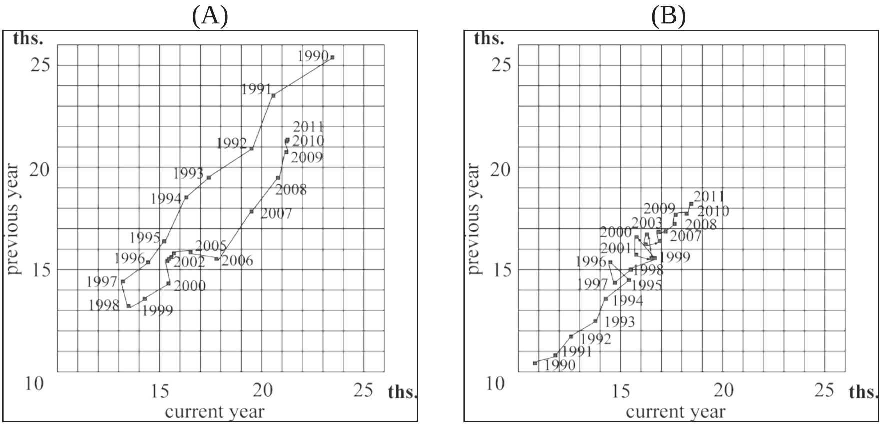

Figure 21: Demographic trajectories of fertility and mortality, 1989–2011
Source: compilation of the authors based on the data of BELSTAT 2011; PARYSEK, J. J. – MIERZEJEWSKA, L. 2012

There are differences in the character of natural movement between the administrative districts of Minsk. The highest birth rate is in the Frunzenskiy and Oktyabrskiy districts – 12.8 and 12.3 ‰, respectively. It increased by 1.5 times in the Frunzenskiy district, located in the western part of the capital, compared with 1999. There is a high proportion – 18.9 percent – of the female population at active reproductive age (20–29 years) in this district. The population can be considered as relatively young, with an average age of 34.5 years. It is the largest and most active residential development area of the capital. About 40 percent of urban housing in the capital was put into operation in this district, with sleeping areas under construction, such as ‘Zapad’, ‘Suharevo’, ‘Kuntsevshchina’, ‘Krasny Bor’, ‘Masyukovschina’.

There is a high proportion – 20.4 percent – of women at active reproductive age also in the Oktyabrskiy district, which is one of the oldest in the city, and a major industrial, transport, scientific and cultural centre, located in the southern part of the city *(Table 5)*.

The third highest level of fertility is in the Partizanskiy district. Over the last decade, this figure has increased by 1.4 times. Today the Partizanskiy district is one of the most important areas of the construction industry and housing development.

Year		Minsk City	Zavodskoy	Leninskiy	Moskovskiy	Oktyabrskiy	Partizanskiy	Pervomayskiy	Sovetskiy	Frunzenskiy	Tsentralny
			District								
persons											
1989	A	25639	4128	2900	2610	2599	2212	2771	2741	4469	1209
	B	10360	1489	1095	912	836	710	1152	1255	2274	637
	C	15279	2639	1805	1698	1763	1502	1619	1486	2195	572
1999	A	14288	1980	1743	1908	1365	831	1534	1293	2980	654
	B	16787	2591	1688	1841	1345	1092	1965	1720	3675	870
	C	–2499	–611	55	67	20	–261	–431	–427	–695	–216
2009	A	21190	2653	2401	3205	1991	1226	2115	1588	4737	1274
	B	17719	2755	2034	2147	1448	1206	2030	1777	3159	1163
	C	3471	–102	367	1058	543	20	85	–189	1578	111
2011	A	21123	2507	2364	3224	1912	1181	2151	1449	5047	1288
	B	18325	2811	2073	2135	1503	1227	2073	1770	3435	1178
	C	2798	–304	291	1089	409	–46	78	–321	1612	110
‰											
1989	A	15.9	16.4	15.3	15.4	16.3	20.3	15.1	15.1	15	16.2
	B	6.4	5.9	5.8	5.4	5.2	6.5	6.3	6.9	7.7	8.5
	C	9.5	10.5	9.5	10	11	13.8	8.8	8.2	7.4	7.7
1999	A	8.5	8	9.6	8.4	9.1	8.8	7.3	8.1	8.5	10.1
	B	10	10.5	9.3	8.1	8.9	11.6	9.4	10.7	10.5	13.4
	C	–1.5	–2.5	0.3	0.3	0.2	–2.8	–2.1	–2.7	–2	–3.3
2009	A	11.7	11.1	11.3	12.3	12.9	12.7	9.9	9.8	13	11.4
	B	9.8	11.5	9.5	8.3	9.4	12.5	9.5	11	8.7	10.4
	C	1.9	–0.4	1.7	4	3.5	0.2	0.4	–1.2	4.3	1
2011	A	11.3	10.5	10.9	11.8	12.3	12.0	10.0	9	12.8	11.7
	B	9.8	11.8	9.6	7.8	9.7	12.5	9.7	11.0	8.7	10.7
	C	1.5	–1.3	1.3	4.0	2.6	–0.5	0.4	–2.0	4.1	1.0

A. births, B. deaths, C. natural increase/decrease

Table 5: Components of population natural movement dynamics in Minsk, 1989–2011
Source: BELSTAT 2011

A higher than average birth rate characterizes the population of the Moskovskiy district – 11.8 ‰. There is a high proportion of the female population at active reproductive age (20–29 years) with 21.3 percent. Active residential development is under way in this district, too. In the Tsentralny, Leninskiy, Zavodskoy, Sovietskiy and Pervomaiskiy districts a lower than average birth rate is typical. The population in these districts is characterized by demographic ageing. In the Tsentralny district more than 25 percent of the population is of retirement age, while 18.9 percent of the population is at reproductive age. In the Sovietskiy district up to 25 percent of people are of retirement age. Despite the fact that at the moment the lowest share of people in childbearing age (17.7 percent) live in the Leninsky district, there is a tendency of changing this indicator. A new residential area called 'Loshitsa' is currently being built in the territory of the district that can lead to an increase in the birth rate in the long term. The birth rate in the Zavodskoy district is lower than the city average level, but this figure is increasing.

Thus, a high fertility rate characterizes the south–western areas in Minsk, i.e. the Moskovskiy, Oktyabrskiy and the Frunzenskiy districts, a low fertility rate is typical of the north–eastern zone of the Partizanskiy and Pervomayskiy districts, while the south–eastern zone including the Zavodskoy and Leninsky districts show a medium birth rate.

The zone of high fertility comprises a residential area with intensive construction activities, whereas the zone of low fertility is formed by areas used by the rapidly developing industrial sector.

The main trend of mortality in Minsk is slow growth. In 1989, the overall mortality rate was 6.4 ‰. By 1999, it increased to 10 ‰, and it currently stands at 9.8 ‰. The main factor of mortality dynamics in the capital is demographic ageing, which is typical of all the economically developed countries.

Among the causes of death cardiovascular diseases have been the primary factor for a long period of time, which are dominated by ischemic heart disease. Cancer is the second most common fatal disease. The implementation of measures aimed at reducing the mortality rate in occupational accidents, poisoning, injuries and other external causes has reduced the share of mortality of this group, from 9.8 percent in 2008 to 9.6 percent in 2009. However, this figure is still high and takes the third place in the mortality structure.

There are differences in the mortality rates among the administrative districts of Minsk. The highest level of mortality is in the Partizanskiy district – 12.5 ‰. Over the last decade, this figure has increased by almost 1 ‰. Most workers live in the Partizanskiy district of Minsk and it takes the first place by the prevalence of alcoholism in the capital city. Liver diseases are three times more frequent in this district than the city average. Liver and gastro-intestinal diseases and cancer take joint 3rd and 4th places in the structure of causes of death among people of working age during the last two years.

The same situation can be observed in the Zavodskoy district. A higher than average mortality rate can be observed in the Tsentralny and Sovietskiy districts. In both districts about 25 percent of the population is of retirement age, and they are in the process of demographic ageing.

The areas with the lowest mortality rates are the Frunzenskiy and Moskovskiy districts with 7.8 and 8.7 ‰, respectively. This index has been declining over the last decade, which can be explained with the young age structure of the population.

Thus, in Minsk the south–western zone including the Moskovskiy and Frunzenskiy districts with a young population structure shows a low mortality rate, the south–eastern zone of the Zavodskoy and Partizanskiy districts with the highest share of industry shows a high mortality rate, while the southern and north–eastern zone formed by the Leninsky, Oktyabrskiy, Pervomayskiy districts shows average mortality rates.

There are some differences in natural movements between the various districts of Minsk. Three types of districts have been identified on the basis of the natural movement of the population:

1.) districts with progressive dynamics, where a consistent natural population growth is observable since 1999 (Moskovskiy, Leninsky and Oktyabrskiy districts),
2.) districts with a steady natural growth, where a natural

population growth has been observed since 2009 (Frunzenskiy, Partizanskiy, Pervomayskiy and Tsentralny districts),

3.) districts with regressive dynamics and natural decrease in population (Zavodskoy and Sovetskiy districts) *(Figure 22)*.

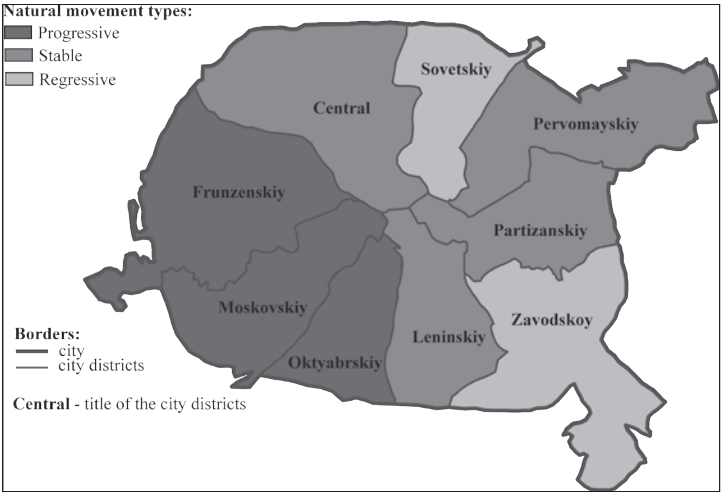

Figure 22: Types of natural population movement in Minsk, 1995–2009
Source of data: Belstat 2011

The modern age population structure of Minsk is the result of its demographic development for the past 100 years. It was formed by wars and other political and social changes of the 21st century. The main tendency in the evolution of the population is its ageing. While in 1999 the share of people of employable age was 15.9 percent, in 2006 it was 17.6 percent, and at the beginning of 2009 it was 19.6 percent. As a result, every fourth citizen of the city is at the age of retirement. In 2009 the share of people in this category was 5.3 percentage points higher than the share of children under the age of 16. It is important to note that in 1999 the share of children was 4 percentage points higher than the share of the people older than working age. In spite of the ageing character of the demographic structure of Minsk, the share of people of employable age has increased in the past few years, now its share is over 67 percent *(Table 6)*.

	1999	2000	2006	2007	2008	2009
Including the age						
0–4	4.1	4.1	4.4	4.5	4.7	5.2
5–9	6.0	5.5	4.0	4.0	4.4	4.2
10–14	8.1	7.8	4.9	4.5	4.2	3.9
15–19	9.6	9.7	9.0	8.4	7.8	7.7
20–24	8.7	9.1	10.8	10.9	11.0	10.7
25–29	7.3	7.4	9.2	9.5	9.7	9.5
30–34	7.1	6.9	7.4	7.5	7.7	7.9
35–39	8.9	8.7	6.6	6.6	6.7	6.8
40–44	8.9	8.9	7.8	7.3	6.9	6.3
45–49	7.8	7.9	8.5	8.4	8.3	7.8
50–54	5.6	6.1	7.4	7.6	7.6	7.8
55–59	4.4	4.0	6.1	6.4	6.5	6.6
60–64	4.8	5.1	3.2	3.3	3.6	4.8
65–69	3.4	3.4	4.4	4.3	3.8	3.1
70 and more	5.3	5.4	6.3	6.8	7.1	7.7
Age groups by working capacity						
0–15	19.8	19.1	14.6	14.2	14.0	14.3
15–55/60	64.2	64.8	71.9	67.8	67.4	66.1
55/60 and more	16	16.1	13.5	18	18.6	19.6

Table 6: Distribution of Minsk population by age groups, %
Source of data: BELSTAT 2011

At district level the youngest population structure is in the Frunzenskiy, Moskovskiy and Leninskiy districts. This is due to the fact that these are the newest districts with new territories being built in. The only district where the population is younger than employable age is the Moskovskiy district. There are inconspicuous differences in the shares of these population groups in the Frunzenskiy district. In the Sovetskiy district the share of people at the age of 65 and older is twice as high as the share of children as this area is originally the oldest in the capital. A similar tendency is observable in the Zavodskoy, Leninskiy, Oktyabrskiy, Partizanskiy and Pervomaiskiy districts *(Table 7)*.

District	Share of age groups in total population, %		
	0–14	15–55/60	55/60 and more
Zavodskoy	13.7	65.8	20.5
Leninskiy	15.3	64.7	20.0
Moskovskiy	15.4	69.5	15.1
Oktyabrskiy	13.5	66.3	20.2
Partizanskiy	13.5	66.2	20.3
Pervomayskiy	12.5	67.3	20.2
Sovetskiy	12.7	62.7	24.6
Frunzenskiy	16.2	66.1	17.7
Tsentralny	13.0	63.6	23.4
Minsk City, total	14.3	66.1	19.6

Table 7: The age structure of the population of Minsk in 2009
Source of data: Belstat 2011

Generally speaking, the districts of Minsk show considerable differences as far as their age structure dynamics is concerned, outlining two types of districts: 1 – the districts with conventionally stable, aligned structure and low demographic load; 2 – the districts with regressive structure. The latter has three subtypes: 2a – regressive type with relatively aligned structure and low demographic load, 2b – regressive type with strained structure and medium demographic load, 2c – regressive–stagnating structure with high demographic load *(Figure 23)*.

Analyzing the spatial and temporal trends of natural movement and age structure the geodemographic typology of Minsk has been developed. A positive development can be observed in the two districts of Moskovskiy and Frunzenskiy, characterized by a progressive trend of natural growth and stationary age structure of the population *(Figure 24*, *Table 8)*.

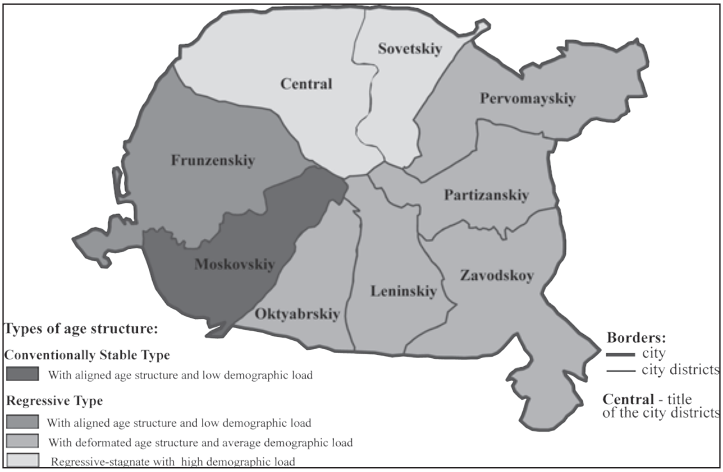

Figure 23: The typology of administrative districts of Minsk according to the character of population age structure
Source: compilation of the authors based on the data of Belstat 2011

Types	Parameters of demographic development					
	A	B	C	D	F	G
Type 1. Progressive with natural increase and stationary age structure	4.3	16.4	1.03	24.3	Moskovskiy, Frunzenskiy	2/22
Type 2. Stable with natural increase and regressive age structure	1.5	20.2	1.5	30.6	Leninskiy, Oktyabrskiy, Partizanskiy, Pervomaiskiy	4/44
Type 3. Regressive with natural decrease and regressive age structure	–0.3	22.8	1.7	35.7	Zavodskoy, Sovietskiy, Tsentralny	3/34

A. natural increase/decrease, ‰, B. share of persons aged 55/60 and more, %, C. index of age structure regression, D. demographic load, %, F. districts, G. number of districts, %

Table 8: Geodemographic typology of Minsk
Source: compilation of the authors based on the data of Belstat 2011

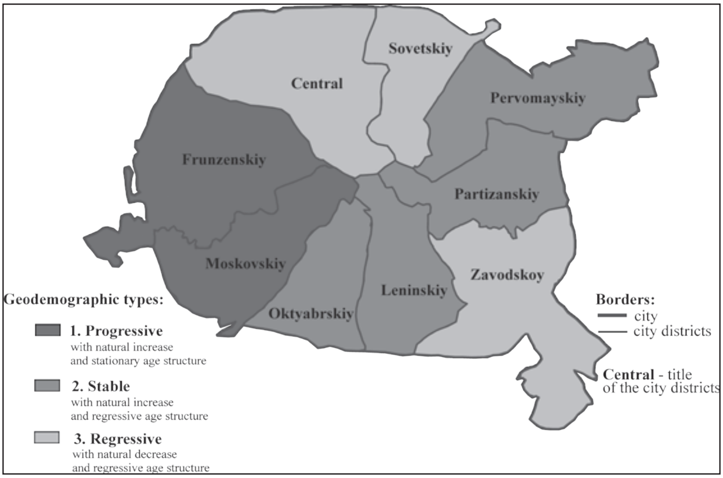

Figure 24: Geodemographic typology of Minsk
Source: compilation of the authors based on the data of Belstat 2011

The most common is a stable type with natural growth and regressive age structure, which includes the Leninskiy, Oktyabrskiy, Partizanskiy, Pervomaiskiy districts. Three districts are characterized by negative trends that are relevant to the type of regression with the natural decrease and regressive age structure: Zavodskoy, Sovietskiy and Tsentralny.

IV.4. Migration factor in the population dynamics and spatial structure of Minsk

The intensive population growth in Minsk is still determined by the migration factor, however, its significance was decreasing during the post-Soviet period .The volume of migration in Minsk showed a positive trend in the last decade (from 121.8 thousand in 2001 to 146.1 in 2011), with an increase in the number of both arrivals and departures. Most incoming migrants come to the capital from small towns and villages in the Minsk region in order to find high-paid jobs as, at present, there is a shortage of employees in services and construction in the city.

At district level, there has been a substantial majority in the number of immigrants in the Moskovskiy and Frunzenskiy districts – the number of arrivals per year is more than 10 thousand people in each of these two districts. This phenomenon is due to the construction of new residential ('sleeping') areas, such as Malinovka, Kuntsevshchina or Kamennaya Gorka. In the Leninsky district the number of arrivals has been about 11 thousand people every year since 2002. This is also attributed to the development of entire microdistricts (Loshitsa). In the other administrative districts the annual number of people arriving does not exceed 6 thousand *(Table 9)*.

The Sovetskiy district shows the highest emigration figure, with more than 7 thousand people leaving this administrative district annually. The main reason for this is the fact that this district is one of the oldest in Minsk locating a significant share of the private sector. The residents of the district have been looking for improved housing facilities in other parts of Minsk since 2000.

The following regularities can be observed when analyzing the volume of migration in the various districts and net migration figures. The Frunzenskiy, Leninskiy and Moskovskiy districts have positive net migration figures with an excess of 3000 people annually. In contrast, the Zavodskoy district is characterized by significant negative net migration (–300 to –1800 people annually), showing positive indicators only in 2008, 2009 and 2011. Thus, the old central districts of the city (Leninskiy, Moskovskiy, Sovetskiy and Tsentralny) show negative migratory trends (the negative dynamics indices for the study period of 1989–2011 are –0.08; –0.26; –0.05 and –0.04 respectively). Positive migratory trends are observed in young districts with good infrastructure and active housing development. In 2011, the intensity of arrivals was the highest in the Frunzenskiy (58.7 ‰), Sovetskiy (53.6 ‰), Partizanskiy (50.8 ‰) and Oktyabrskiy (47.8 ‰) districts, while in the same year the intensity of departures showed the highest figures in the Sovetskiy (46.0 ‰), Tsentralny (43.5 ‰), Partizanskiy (43.0 ‰) and Oktyabrskiy (41.4 ‰) districts.

Thus, in 2010 net migration reached the highest value in the Frunzenskiy district (36.8 ‰) and the lowest in the Tsentralny district (–11.1 ‰).The latter is the oldest administrative unit in Minsk (it was founded in 1921), which is a push factor for migrants. Secondly, it is characterized by considerable social tensions. The increase in the migration activity in this district has indicated an improvement in the socio–economic welfare of the population in recent years. Relative cheapness of the secondary housing market also plays a role in the increasing migratory flows.

The role of the Moskovskiy district in the volume of migration considerably increased compared to the beginning of the studied period. The absolute value of migration in this district reached 21 thousand people, representing about 14 percent of the total migration in the city. The increase in migration in the Moskovskiy district is primarily due to socio–economic factors, as the functional role of this district was changed in the late 1990s. Today it is a cultural and educational centre of the capital, with many educational and research institutions, as well as cultural and recreation centres.

Year		Minsk City	District								
			Zavodskoy	Leninskiy	Moskovskiy	Oktyabrskiy	Partizanskiy	Pervomayskiy	Sovetskiy	Frunzenskiy	Tsentralny
persons											
1989	A	109948	12859	10352	8767	12402	8811	19031	12759	20131	4836
	B	91173	11671	11798	9215	9498	7774	9610	14765	10996	5846
	C	18775	1188	–1446	–448	2904	1037	9421	–2006	9135	–1010
1999	A	58162	4736	5330	8469	5177	3380	7252	7128	13518	3172
	B	47340	5299	5650	5904	4771	3385	6097	6645	6755	2834
	C	10822	–563	–320	2565	406	–5	1155	483	6763	338
2009	A	92681	8335	10923	19520	6800	6382	8192	10044	18462	4023
	B	66834	8069	7947	9639	6946	4861	7845	8917	8055	4555
	C	25847	266	2976	9881	–146	1521	347	1127	10407	–532
2011	A	82142	7597	7140	11239	7416	4988	8343	8650	23192	3577
	B	63963	7459	7720	10157	6422	4218	7130	7415	8636	4806
	C	18179	138	–580	1082	994	770	1213	1235	14556	–1229
D	A	0.75	0.59	0.69	1.28	0.60	0.57	0.44	0.68	1.15	0.74
	B	0.70	0.64	0.65	1.10	0.68	0.54	0.74	0.50	0.79	0.82
	C	0.97	0.12	0.40	–2.42	0.34	0.74	0.13	–0.62	1.59	1.22

Year		Minsk City	District								
			Zavodskoy	Leninskiy	Moskovskiy	Oktyabrskiy	Partizanskiy	Pervomayskiy	Sovetskiy	Frunzenskiy	Tsentralny
		‰									
1989	A	68.1	51.1	54.7	51.8	77.7	81	103.8	70.4	67.7	64.8
	B	56.5	46.4	62.4	54.5	59.5	71.5	52.4	81.5	37	78.4
	C	11.6	4.7	–7.6	–2.6	18.2	9.5	51.4	–11.1	30.7	-13.5
1999	A	34.5	19.1	29.5	37.5	34.4	35.8	34.7	44.4	38.6	49
	B	28.1	21.4	31.3	26.1	31.7	35.8	29.2	41.4	19.3	43.7
	C	6.4	–2.3	–1.8	11.3	2.7	–0.1	5.5	3	19.3	5.2
2009	A	51.1	34.9	51.3	75.1	44	66.3	38.3	62.2	50.7	35.9
	B	36.8	33.8	37.3	37.1	44.9	50.5	36.7	55.2	22.1	40.7
	C	14.2	1.1	14	38	–0.9	15.8	1.6	7	28.6	–4.8
2011	A	44.1	31.9	32.9	41	47.8	50.8	38.9	53.6	58.7	32.4
	B	34.3	31.3	35.6	37.1	41.4	43	33.2	46	21.8	43.5
	C	9.8	0.6	–2.7	3.9	6.4	7.8	5.6	7.7	36.8	–11.1
D	A	0.65	0.62	0.60	0.79	0.62	0.63	0.37	0.76	0.87	0.50
	B	0.61	0.67	0.57	0.68	0.70	0.60	0.63	0.56	0.59	0.55
	C	0.05	0.14	-0.08	-0.26	0.04	0.06	0.01	-0.05	0.02	-0.04

A. arrivals, B. departures, C. net migration, D. dynamics index 1989–2011

Table 9: Dynamics of main indicators of migration in Minsk, 1989–2011
Source of data: Belstat 2011

Intensive construction and infrastructural development in the early 2000s are key factors in the spatial changes in migration. Due to this factor the Frunzenskiy district has been a leader in the number of arrivals and departures for more than 10 years. In 2011, the volume of migration reached 32 thousand people (including 23 thousand arrivals) or 22 percent of the total migration in Minsk, which is primarily attributed to the commissioning of the new microdistrict Kamennaya Gorka.

№	District	Pull factors	Push factors
1.	Zavodskoy	Cheap secondary housing market	Poor infrastructure, poor environmental conditions, crime situation
2.	Leninskiy	Intensive construction	Poor infrastructure
3.	Moskovskiy	Availability of education as a factor in the attraction of young people, infrastructure,	High traffic load
4.	Oktyabrskiy	Cheap secondary housing market	Crime situation
5.	Partizanskiy	Cheap secondary housing market	Poor infrastructure, poor environmental conditions, crime situation.
6.	Pervomayskiy	Favourable ecological conditions, rapidly developing infrastructure, availability of new residential ‘bedroom communities’	High cost of housing
7.	Sovetskiy	High level of infrastructure development	High cost of housing
8.	Frunzenskiy	Cheap secondary housing market	Poor environmental conditions
9.	Tsentralny	The highest level of infrastructure development	High cost of housing

Table 10: Factors of spatial differentiation in migratory movement among administrative districts of Minsk
Source: compilation of the authors

The highest intensity of migration during the post-Soviet period is observed in the Sovetskiy and Oktyabrskiy districts. It can be explained by the fact that the population which is concentrated here has been living in the capital for a relatively long time mostly in old-type residential buildings. The resettlement of the population from these two districts to other administrative units of Minsk started at the end of the 1990s. The lowest intensity of migration is typical of the Zavodskoy and Pervomayskiy districts. These are characterized by a relatively low cost of housing (more than 10 percent below the average for the city of Minsk). Thus, the factors determining the spatial differentiation of migratory movements in Minsk show significant differences between the various districts *(Table 10)*.

Minsk, as the largest cultural and economic centre of Belarus, has an increasing role in the internal migratory movement of the population. It is characterized by a positive balance of migration, with a trend of annual increase and a significant diversification in the distribution of migration flows within the city. There are two distinctive periods in the formation of the demographic balance of the capital at the late 20th and the early 21st centuries in accordance with the role of demographic factors and migration. The first period between 1995–2005 was a period of positive contrast-factor dynamics, with dominance of the migratory factor (migratory inflow > natural decrease), while the second one – from 2006 to the present – has been a period of positive progressive dynamics with dominance of the migratory factor (migratory inflow > natural increase) *(Table 11, Figure 25)*.

Period	Natural increase/ decrease, persons	Migratory inflow, persons	Population dynamics, persons	Structure of demographic balance, %	
				Natural movement	Migratory movement
1995	–163	581	418	–38	138
2001	–541	14012	13471	–4	104
2002	–1447	15211	13764	–11	111
2003	–746	15782	15036	–5	105
2004	–475	15524	15049	–3	103
2005	–395	15320	14925	–3	103
2006	964	15836	16800	6	94
2007	2401	14923	12522	7	93
2008	3206	11056	14262	22	78
2009	2994	25800	28794	11	89
2010	3019	17386	14367	8	92
2011	2798	18179	15381	8	92

Table 11: Dynamics of Minsk demographic balance, 2001–2011
Source of data: Belstat 2011

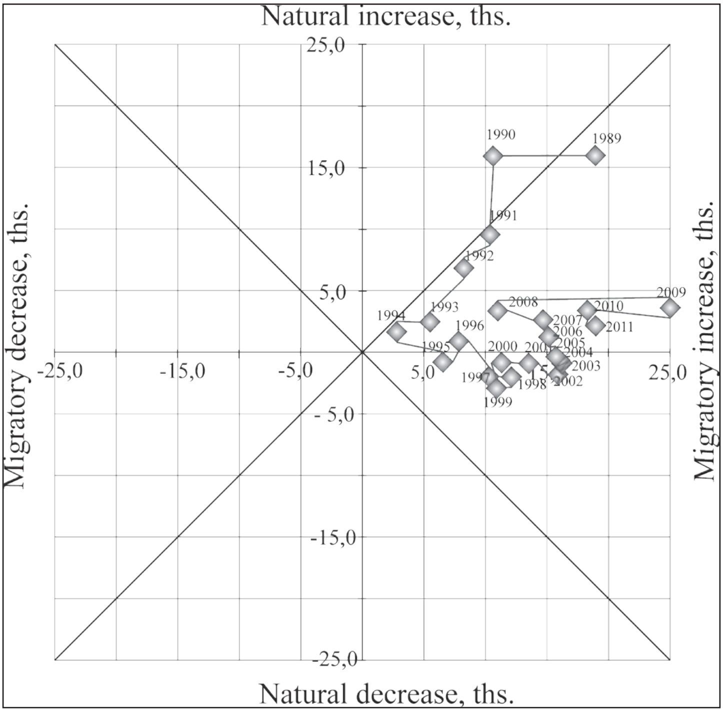

Figure 25: Trajectory of demographic balance of Minsk, 1989–2011
Source: compilation of the authors based on the data of BELSTAT 2011

The population dynamics varies significantly in the different administrative districts *(Table 12)*.

In the Moskovskiy, Oktyabrskiy and Frunzenskiy districts the population is growing due to the positive dynamics of the two components. These are the areas of modern active development with active migratory inflow, younger age structure of the population and stable natural growth. In the Sovetskiy and Partizanskiy districts the migration inflow exceeds the natural decline, and the population continues to grow. In the Zavodskoy, Leninskiy and Tsentralny districts the population is decreasing, in the first district due to natural decrease, while in the other two districts due to migration outflow.

District	Natural increase/ decrease, persons	Migratory inflow/ outflow, persons	Type of demographic balance
Zavodskoy	–304	138	contrast-factor
Leninskiy	291	–580	contrast-factor
Moskovskiy	1089	1082	progressive
Oktyabrskiy	409	994	progressive
Partizanskiy	–46	770	contrast-factor
Pervomayskiy	78	1213	progressive
Sovetskiy	–321	1235	contrast-factor
Frunzenskiy	1612	14556	progressive
Tsentralny	110	–1229	contrast-factor

Table 12: Typology of administrative districts of Minsk by demographic balance, 2011
Source: compilation of the authors based on the data of Belstat 2011

IV.5. Conclusion

Thus, the analysis of the demographic development of Minsk reveals a diversification in terms of time and space as for the formation of the demographic balance factors of the capital and the parameters of the natural movement and the age structure of the population at the level of administrative districts. As for the division in terms of time, the period up to 1994 is characterized by the active role of migration and natural increase in population dynamics, up to 2006 migration inflow dominates, while currently the progressive influence of two factors with dominance of migration prevails. The spatial differentiation is manifested in geodemographic types of districts, characterized by progressive demographic development in areas with intensive housing and regressive development in the industrial areas of the city. A distinctive feature of Minsk is that even during the transition to post-industrial development it has preserved its role as a major industrial centre.

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V. Main features of large housing estates and the results of their rehabilitation in Budapest

Balázs Szabó – Ágnes Erőss

Abstract

At the turn of the millennium about one third of the inhabitants of Budapest lived at housing estates. Those quarters have become an identical part of the cityscape inducing intense scientific discussion in the field of social sciences including human geography addressing such topics as architectural and spatial planning of housing estates, the analysis of society settled in those blocks of flats or even the psychological effects of the uniform environment on individuals. The gradually deteriorating housing stock and environment additionally the unfavourable demographic trends meant a further challenge in case of Budapest. The rehabilitation of large housing estates seems to be the best way to avoid their demographic erosion and social decline. Although examples from the Western European countries provide significant help and information regarding housing estate rehabilitation, nevertheless due to the different scale of the problem, the altering history and the embeddedness of the topic, in post-socialist countries discussion on regional level is not only promising but necessary at the same time. This paper explores the rehabilitation initiatives carried out in Budapest in the last decade, with special attention to their outcomes and effects. We also examine whether renovations resulted in some new socio–spatial differentiations at large housing estates.

Keywords: large housing estate, rehabilitation, segregation, Budapest

V.1. Introduction

The idea to improve the living conditions of working class by building modern housing estates emerged in the early 20th century but primarily the severe shortage of dwellings after World War II together with the rapid growth of population and the increasing pace of urbanization made housing estates a viable and widespread solution offering home for a great amount of people in need for a relatively cheap price (Kempen, R. van 2005, p. 2.). Projects like

Million Programme in Sweden (Borgegård, L. – Kemeny, J. 2004, p. 37.) or state financed house building projects in suburban areas in France were initiated for the similar reason as any other long term housing development plans in the state-socialist countries. As a result of those programmes ten thousands of flats were constructed all around Europe, on both sides of the Iron Curtain. As Murie, A. et al. (2005, p. 85.) points out those blocks of flats share some common features, namely representing the most recent, up-to-date notions on residential construction of the era when they were built, additionally they were financed either by the state, local governments or non-profit organizations. Besides the similarities, substantial differences must be mentioned which define the fate and later development processes in large housing estates in former socialist countries and Western Europe.

In the first part of present chapter we would like to summarize the peculiarities of large housing estates in Europe, with special attention to Budapest. Then we would like to outline some findings of a survey that was designed to collect data about large housing estate rehabilitation.

V.2. Main specificities of large housing estates: comparison of Western and Central European examples

'Concrete jungle', 'rabbit hatches', 'concrete deserts', 'vertical slums' – only a few examples of the numerous, not too flattering phrases referring to housing estates all around in the former state-socialist countries as well in Western Europe. Next to the similarities substantial differences also need to be highlighted.

1.) In the former state socialist countries the ratio of population living in large housing estates reaches 40 percent of urban population. Furthermore, in certain newly established socialist towns or industrial centres housing estates can concentrate 60–80 percent of the population while in the Western European countries typically less than 10 percent of the population lives in such blocks of flats (Kempen, R. van 2005, p. 2.).

2.) In socialist countries housing estates were attractive not only to blue collar workers, but also to middle-class families or even representatives of the socialist elite (Szelényi, I. – Konrád, Gy. 1969). Decades later the large housing estates built to solve housing problems of families with low income and other vulnerable groups turned to be the symbols of social problems. The spatial concentration of poverty in housing estates resulted in growing risk of social (in many cases ethnic) segregation (Kemper, F.-J. 1998) and the decreasing prestige of those quarters (Hastings, A. 2004).
3.) There is a fundamental difference between the most Western and Nordic countries and the former state-socialist countries: while in Western Europe the majority of housing estates are owned by public authorities or cooperatives, in the former state socialist countries the great majority of those dwellings were sold during the privatization process on discount price and now they are owned by private households. In case of Budapest the share of owner occupied flats increased from 50 to 93 percent just over a decade, between 1990 and 2001 (KSH 2004). As a consequence, the local governments can only implement limited and rather indirect tools to improve the living conditions of housing estates, while the condominiums made up by the private owners/tenants usually lack the fund to carry out significant rehabilitation (Kovács Z. – Douglas, M. 2004b, pp. 243–244.; Wassenberg, F. et al. 2004, p. 24.).

Following the collapse of socialist regimes in Central Europe, housing estates suffered from a decline in terms of their market position and reputation while signs of growing socio–spatial segregation also appeared. Nevertheless, unlike in Western Europe, neither influx of immigrants (Bonvalet, Ch. et al. 1995) nor massive depopulation affected housing estates in Central Europe: they still represent a fair option for lower middle-class households and young families with children (Kovács, Z. – Herfert, G. 2012).

However, in case Budapest, one of the most troublesome tendencies in large housing estates is the relatively high and growing proportion of unsatisfied households in comparison to the western examples (Kovács, Z. – Herfert, G. 2012). The high level of comfort was one of the main advantages of panel dwellings before 1990. That very same feature became a disadvantage in the following decade due to the rapid rise of housing (especially energy) costs (Egedy, T. 2000). After privatisation the new owners living at large housing estates found themselves in a novel situation: the value of flats in pre-fabricated houses declined, while the costs of maintenance drastically increased. As a consequence, the lower-status residents of housing estates often became trapped: they could not sell their flats or buy another one of similar quality; thus their housing career ended (Hegedűs, J. – Tosics, I. 1998).

Figure 26: Two faces of block of flats: Before and after renovation (Csepel)
Source: photo of Balázs Szabó

The most problematic part of the rising housing costs is connected with the central heating and the insufficient insulation of the houses (Egedy, T. 2003), thus, rehabilitation programmes were targeted to offer a solution to this problem. Some support encouraging and facilitating the application of energy saving methods became available already in 1997. The first governmental program (called 'Panelprogram') was launched in 2001, however, the highest share of the rehabilitation was implemented only after 2004 (Egedy, T. 2006). One of the main social consequences of the rehabilitation was the improvement of the residential satisfaction of inhabitants (Kovács, Z. – Herpai, T. 2011). The residents of renovated houses were very satisfied with the better insulation, the lower level of noise and the lower costs of heating, besides, the aesthetic view and the higher market value of dwellings were also important aspects *(Figure 26)*. The difference between the satisfactions of residents became significant in the renovated and non-renovated houses but it has not yet affected the residential mobility of dwellers.

Tensions may emerge upon this situation on the housing market and within the local society. In those cases complex rehabilitation procedures aimed to influence living conditions in blocks of flats might help to mitigate the situation and decrease the tension. In the post-socialist cities the rehabilitation programs of housing estates started in the last two decades have strong effects on the image of neighbourhoods (Andrasko, I. et al. 2013). Up to now, we have little information about the renovation of large housing estates in Budapest, neither its physical results nor social consequences. This was the motivation of our research project that aimed to scrutinize this aspect of urban rehabilitation.

V.3. Brief history of large housing estates in Budapest

Housing estates built in the socialist period contain around one third of the housing stock in Budapest. The first buildings were erected in 1947, however during the 1950s the housing construction remained in a low level. In that period the structure of the estates was following traditional schema, they were in harmony with the given urban structure, typically were three–four-storeys building with inner courtyard. The modernist style appears in the 1960s, both concerning the building structure and its physical appearance. In parallel those apartments are of high standard and offer a good comfort level and quality. Next to other factors, this contributes to the growing popularity of such housing estates, especially among middle-class families (Szelényi, I. – Konrád, Gy. 1969). Housing estates built in that era were mainly established in transition zones, where free land connected to public utilities was available. Mass production of housing building blocks from the end of the 1960s brings a new period: the 1970s is the golden age of housing estate building. The large housing estates with 10–15 storeys buildings and hundreds of apartments were raised in that decade (Preisich, G. 1998). Due to lack of available land in the transition zone, and inner parts of settlements, more and more housing estates were located in the edges of the town. In general flats are middle-sized and still mean a reasonably good comfort level, but following certain shifts in social policy and legislation families with lower income are preferred to be housed in the freshly built housing estates. As a result of mass-housing block production, the homogeneity of the housing stock and the changes in the housing policy a slow degradation and loss of prestige of large housing estates' can be detected. In the 1980s a twofold process evolves: on the one hand the continuation of previously started construction of housing estates and on the other hand substantial quality turn took place in designing and implementation of housing estates. Among the factors that place the housing estates built in the 1980s above the earlier era buildings one can mention the return to smaller size buildings with lower floor numbers, the favourable location and more diverse apartment stock *(Figure 27)*. Housing block factories rapidly fall victim to the transition period, which means the end of housing estates building period.

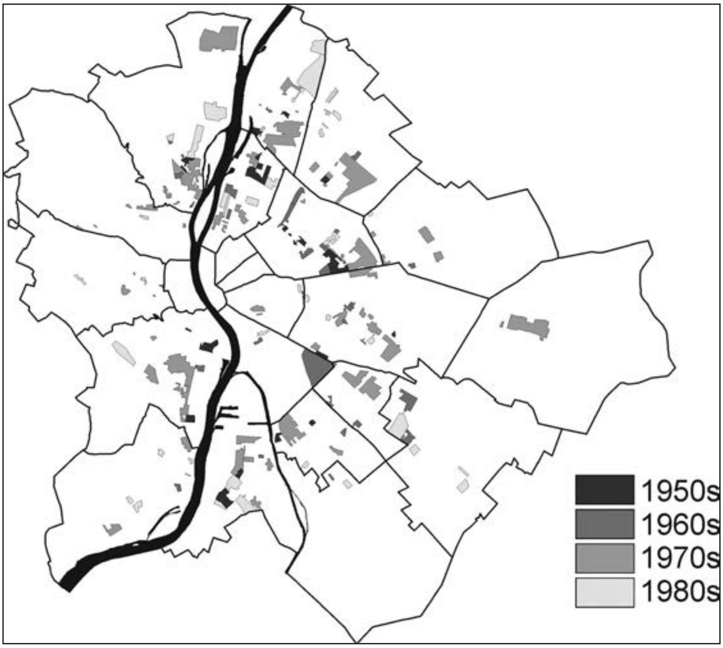

Figure 27: The generations of housing estates in Budapest
Source: compilation of the authors

V.4. Survey method and classification

The survey of 142 housing estates in Budapest[7] was carried out in summer 2012. The students participating in the survey collected information on the field (and after on the internet) on the main features of the buildings (the number of gates, dwellings, storeys) and the characteristics of recognisable renovations. Renovations of buildings at housing estates were divided into four categories: renovated,

7 The list of housing estates involved in the survey was based on a paper of BVTV (1987) and a study of Iván, L. (1996), but we had to complete it with some smaller housing estates ignored by those authors. As a rule, every estate appears as a single item in the database even if it was built during several phases. The only exceptions are Csepel Centre and Káposztásmegyer, because the two parts of those housing estates were not constructed at the same time and they are also spatially separated. The number of dwellings in the housing estates included in our database is 295 thousand. That figure is not far from the one mentioned in the cited papers.

painted, other improvements and under renovation. Renovated meant the insulation of the walls of the house that is the most significant investment of all, because it increases the value of the dwellings and decreases the costs of housing for the inhabitants. The painting of a house has only an aesthetic effect. It is typical in the case of older, not pre-fab (panel) buildings. Being newly painted might suggest a high level of maintenance, but it does not really change the value of the building. The other improvements included either some kind of partial insulation or the change of windows without an insulation of the walls. There were buildings that were under renovation during the survey. Most of them seemed to be insulated, but the exact number only could be roughly estimated.

The typology of renovation is widely used in the analysis of our survey results. Whenever the composition of renovation types is examined, the percentage values are always calculated on the basis of the number of dwellings in buildings which have gone through certain kinds of renovation.

V.5. Dimensions of renovation at housing estates

More than one fifth of the dwelling stock of housing estates have been renovated during the last decade. This is not a low rate, but it is far from the necessary level. The shares of dwellings renovated in one way or another are as follows:

- ⊕ 13.4 percent in completely renovated buildings,
- ⊕ 1.2 percent in buildings under renovation,
- ⊕ 3.1 percent in buildings that were only re-painted,
- ⊕ 5.1 percent in (mostly panel) buildings where other improvements also occurred.

Since the rehabilitation of housing estates began after the last population and housing census in 2001, only indirect information is available about its social consequences.[8] Therefore, we have to

8 In fact, the year of the very last census was 2011 but its detailed data have not become available by the time of our survey.

rely on research materials when trying to explore the connection between renovation and social status. Csizmady, A. (2008) ranked the 30 largest housing estates of Budapest by their social milieu and the housing prices and she classified them into three (low, middle and high status) categories. Using that ranking,[9] it can be assessed whether the occurrence and the intensity of renovation are different among housing estates dominated by distinct social groups *(Table 13)*. The share of dwellings located in buildings completely renovated, painted or under renovation seems to be almost independent from the prestige of housing estates; only the share of 'other improvements' is much higher in the low-status housing estates as compared to the more prestigious ones.

Social status	Proportion of dwellings in somehow renovated buildings	Of which			
		Renovated	Painted	Under renovation	Other improvements
Low	27.6	15.2	0.4	3.0	9.0
Medium	19.0	15.9	0.7	0.6	1.8
High	20.1	14.5	0.0	0.5	5.1

Table 13: Intensity of renovation by the social-status of housing estates, %
Source: compilation of the authors

However, within the status groups there are big differences. In the high-status group only one housing estate could be found (Őrmező on the Buda side) where more than 80 percent of the dwellings were renovated. At the same time the most popular 'elite' housing estates are hardly renovated. In the low-status group housing estates could be observable with poor reputation but with certain renovations because the inhabitants who cannot otherwise finance the full-rehabilitation usually try to renovate their houses in other, cheaper ways (e.g. through insulation of only one part of the walls).

9 From those 30 housing estates, 7 are now changing their categories, thus, we have decided to restrict our analysis to the remaining 23.

In the 1990s several research projects (Iván, L. 1996; Csizmady, A. 1998; Egedy, T. 2000) focusing on housing estates identified some common factors which are related to the status of housing estates. Those are the size, the age, the morphology of housing estates and the developer who financed the construction. Taking into consideration the aforementioned factors the large housing estates with panel buildings built in the 1970s by the local councils have the lowest status while the smaller, old, non-panel estates and the panel estates built in the 1980s mostly by private investors (condominiums, ministries, institutions) are considered to be in better position. Since it is most likely that the very same features of the housing estates also have an influence on the rehabilitation activities, it is worth taking a closer look at our data in this context.

Size of housing estates (number of dwellings)	Proportion of dwellings in somehow renovated buildings	Of which			
		Renovated	Painted	Under renovation	Other improvements
below 500	25.6	13.2	8.5	0.9	3.0
500–1499	21.7	11.4	5.9	0.1	4.3
1500–4999	20.7	12.0	3.4	0.6	4.7
5000–9999	24.1	14.5	3.8	0.5	5.3
above 10000	24.5	15.4	0.0	3.0	6.1

Table 14: Intensity of renovation by the size of housing estates, %
Source: compilation of the authors

The impact of the size of housing estates is neither unequivocal nor significant *(Table 14)*. The share of complete renovation at large estates is a bit higher than in the smaller ones, but the difference is rather narrow. By contrast, there are substantial differences within the different size-groups.[10] From among the thirteen large

10 The finding is somewhat surprising in the light of the former research results. As Csizmady, A. (2003) pointed out, the size of housing estates correlated to their status: most of the large housing estates have lower status of population, a few ones have middle-status profile. Lower status people are obviously less able to

housing estates (above 5000 dwellings), five have a high share of renovation (above 25 percent) whereas four are hardly renovated (below 5 percent).

The age of housing estates is also an important factor for several reasons. First, housing factories started to produce pre-fabricated panels in 1967, so estates built prior that were made of traditional building materials. It is especially important because the governmental fund for rehabilitation is available only for the pre-fabricated buildings. Secondly, the difference between the time of construction of the oldest and the youngest panel houses is also more than 20 years. Although the technology was largely the same during the whole period, its application somewhat developed over time. The technical problems were typical for estates built in the 1970s, then in the 1980s the quality of buildings improved. This can be an explanation why the elite housing estates, which were typically built in the late 1980s with modified construction, are hardly renovated. In fact, the renovation rate is lower on housing estates built during the 1980s than on those that were constructed between 1965 and 1979 *(Table 15)*. It seems that the first generation of panel buildings needed renovation the most. There is also a significant difference between the first and the second half of the 1980s. In the first part of the decade mainly large, 'traditional' housing estates were built, while during the last phase smaller-scale elite housing estates became dominant. In the latter group there is less need for complete renovation and the weight of 'other improvements' is greater (it usually means the change of windows). It is not surprising that re-painting is outstandingly very frequent way of renovation in the old 'pre-panel' (mainly brick) housing estates.

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cover the costs of renovations, thus one can expect a relatively low renovation rate in larger housing estates. The unexpectedly high rate of renovation on such estates is probably a consequence of the ongoing state (and EU) supported rehabilitation programmes.

Building period of housing estate	Proportion of dwellings in somehow renovated buildings	Of which			
		Renovated	Painted	Under renovation	Other improvements
–1954	14.7	1.6	9.6	0.8	2.7
1955–1959	22.7	6.5	14.3	0.0	1.9
1960–1964	19.7	3.7	9.0	0.5	6.5
1965–1969	34.9	10.1	16.7	1.3	6.8
1970–1974	26.0	18.0	0.4	2.3	5.3
1975–1979	23.2	16.4	0.6	1.3	4.9
1980–1984	20.1	14.8	0.3	0.2	4.8
1985–	15.1	6.8	1.7	0.3	6.3

Table 15: Share of renovation by the building period[11] of housing estates, %
Source: compilation of the authors

As emphasized in the literature the location of the estates is one of their most important characteristics. It is not only connected with their status (Csizmady, A. 2008), but also with the actual level of their renovation. The housing estates which are embedded in villa quarters are tend to be more renovated *(Table 16)*. They are not elite housing estates, but typically small ones (below 500 dwellings) and most of them do not differ from their surroundings. Many of them were built before 1970, but even those constructed during the panel period were of better quality than the large housing estates (with bigger flats, better conditions, etc).

The prestige of housing estates in the inner quarters or adjacent to them are varies, there are both high-status and low-status housing estates among them. Interestingly enough, the renovation of centrally located housing estates proceeds in opposite way compared to the renovation of old tenement houses. In the case of latter ones, the higher status quarters were renovated first (Kovács, Z. et al. 2013), whereas in the case of housing estates of inner quarters the status does not correlate with the level of renovation.

11 The period in which the majority of buildings of housing estates were constructed if there is an overlap.

Location of housing estate	Proportion of dwellings in somehow renovated buildings	Of which			
		Renovated	Painted	Under renovation	Other improvements
Villa quarters	17.1	14.0	2.9	0.2	0.0
Inner quarters	9.1	2.3	1.5	0.5	4.8
Transition zone	31.4	17.7	5.7	0.6	7.4
Outer districts	17.5	11.0	1.2	1.8	3.5

Table 16: Intensity of renovation by the location of housing estates, %
Source: compilation of the authors

The differences within a housing estate are not as sharp as in the inner city quarters where the heterogeneity of buildings is much stronger. In spite of the homogeneous dwelling stock of housing estates, the differences created by the status of the first dwellers which resulted from the tenure and housing distribution system. These differences remained unchanged in the 1990s in spite of the change of population (Csizmady, A. 1998).

Due to the lack of data about processes of 2000s, we have only some impressions about the modification of social composition of inhabitants at the level of buildings. On the basis of our knowledge related to the housing market boom in the late 1990s (Farkas, J. et al. 2004), we assume that population change accelerated on the housing estates. According to real estate analysts two characteristics of the housing estate buildings may have an influence on their position at the housing market. First, the demand towards panel dwellings depends on the size of the buildings. Low-rise buildings (below five storeys) and houses with a relatively low number of dwellings are more appreciated than the high-rise ones, where generally lower-status people reside, often late with the payment of service charges.

The other factor influencing the market position is whether the building is renovated or not. The dwellings in renovated houses can be sold at higher prices and within shorter time, however, the increase of prices does not (or rarely) cover the costs of the renovation (Németh, K. 2011; IngatlanHírek 2012). Our data indicate that the rate of renovation is higher in bigger buildings[12] than in the smaller ones *(Table 17)*. It also suggests that renovation can be a strategy of flat owners in larger houses to improve (or at least to stabilise) their positions on the housing market. In fact, it is generally the only possible strategy since panel buildings are mono-functional (i.e. residential) unlike the old inner city tenement blocks which can be converted into offices. Within the group of housing estates, renovation can lessen the differences between the smaller (non-renovated) and the renovated larger houses. If rehabilitation programmes were cancelled for a longer period, a new cleavage would emerge between the renovated and non-renovated larger buildings.

Size of buildings (number of dwellings)	Proportion of dwellings in somehow renovated buildings	Of which			
		Renovated	Painted	Under renovation	Other improvements
below 20	17.1	2.8	11.0	0.3	3.0
20–49	19.1	9.6	5.9	0.5	3.1
50–99	19.0	10.1	3.4	0.6	4.9
100–199	22.0	12.8	1.6	1.2	6.4
200–299	25.1	20.7	0.0	0.7	3.7
above 300	36.0	21.5	4.0	4.0	6.5

Table 17: Share of renovation by the size of the buildings, %
Source: compilation of the authors

Within large housing estates (with more than 10 percent renovation rate) the spatial distribution of renovated houses does not indicate specific concentration, in most cases the renovated buildings are completely dispersed. Concentration can be found only in some cases, namely in the centre of the housing estate or along its main road.

12 The categories ‘buildings above 200 dwellings’ consist of almost exclusively high-rise (10–15 storey) buildings.

There are also large, hardly renovated housing estates (with 1–3 percent renovation rate). In this group there is a special case; Pesterzsébet (housing estate built in the 1970s, contains 7200 dwellings) where there are a lot of new houses (7 separate buildings, altogether almost 1000 dwellings) mixed with the old, not renovated panel buildings. This new addition to an already existing housing estate, which increases the population density, traffic etc., is very rare in Budapest, while quite common in other post-socialist cities like Sofia or Warsaw. It is much more typical that some new houses emerge near housing estates, separated from the block of flats, still enjoying the advantages of the good infrastructure (Csizmady, A. 2008).

V.6. Conclusions

The future of large housing estates remains a challenge both in Western and Eastern Europe in spite of the changing socio–spatial context and problems. Due to the fact that one of the most obvious shared legacies of the former state-socialist countries are the large housing estates that shape the urban landscapes from Berlin to the Caucasus (and beyond), it is a common interest to closely follow the situation of those estates.

The rehabilitation of housing estates in Budapest started about 10 years after the construction of the last panel buildings. Since then only a small part of the blocks has been renovated, nevertheless, some differences among the housing estates and their perception have already emerged. The rate of renovation is relatively high in some low status large housing estates built in the 1970s. The renovation is likely to be an instrument that could be used to prevent the declining status and position of such housing estates on the housing market. Achieving that aim could be further enhanced by the renovation efforts of residents. Completely renovated housing estates are hardly found in Budapest, while there is a great number of them without any renovation. If the government financed rehabilitation support was cancelled for a longer period, the large non-renovated housing estates would be in a desperate situation, because they are not be able to compete with either the smaller estates with good location or the renovated larger ones on the housing market.

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Part B

Urban climate, environment and ecology

VI. The urban climate of Budapest: trends and perspectives

Ferenc Probáld

Abstract

Homogenized meteorological data derived from continuous instrumental observations are available in Budapest for a period of more than 230 years. The peculiar characteristics of the urban climate and the considerable local climatological differences within the administrative area of the Hungarian capital city were first thoroughly investigated in the 1960s. At the same time a network monitoring the major components of air pollution was established. Soon after that, however, the meteorological observations in the city core were phased out, and since the 1970s little has been done to reveal how the summer heat island of the city has changed. Meanwhile, the impact of the anthropogenic heat release due to the spectacular expansion of automobile traffic and the widespread use of air conditioners may have added an estimated 1–1.5 °C to the temperature surplus of the city. As evidence of the large-scale climate change, the homogenized temperature record of Budapest shows a strongly growing frequency and persistence of severe heat waves plaguing city dwellers. Regional models predict rising temperatures with more pronounced summer warming until 2100 in the Carpathian Basin. Therefore, the cooler local climates of the Danube islands and the Buda Hills should be appreciated as valuable environmental assets to be saved by more reasonable land use policies and stricter property development regulations.

Keywords: Budapest, urban climate, heat island, climate change, urban land use

VI.1. Milestones of climate research in Budapest

Systematic observations and instrumental meteorological measurements started in 1779 in Buda which was the southeastern outpost of the observatory network organized by the Palatine Meteorological Society of Mannheim. Thus, by now we have got an air temperature measurement record embracing more than 230 years with reliable data which have been homogenized by scientists of the National Meteorological Service in order to eliminate errors and minor alterations that could be ascribed to repeated relocations and some changes of the instruments of the station as well as to the growth of the surrounding city that had taken place in the meantime. The records of the central observatory of the National Institute of Meteorology were first thoroughly evaluated by Réthly, A. (1947) in a groundbreaking work which has provided a fine assessment of all major macroclimatic features of the Hungarian capital city. He also published some data on the temperature difference between a downtown and a suburban station. The first maps of the distribution of monthly mean temperatures in Budapest were published by Bacsó, N. (1958); he failed, however, to disclose the source and length of the underlying temperature records.

The first network consisting of 56 permanent stations for the purpose of measuring air pollution (sulphur content and dust deposition) in Budapest was established by the National Institute for Public Health in 1958. Though the number of stations had to be sharply reduced after 1960, the scope of their programme has been steadily broadened and the instrumentation accordingly improved several times. Nevertheless, the actual state and problems of air quality as sensitive environmental issues received little or no publicity in the media that had been strictly controlled by the party-state until the political turn in 1989. Even the city council could not decide to adopt a decree on smog alert and alarm before 2003. At present the National Air Pollution Monitoring Network operates stations equipped with automatic instruments at 12 points of Budapest and this is completed by manual sampling at regular intervals at further 15 sites. The task of the network comprises monitoring the concentration of SO_2, NO_2, NO_x, CO, ozone and particulate matter (PM10, PM2.5), thus providing an overall perspective on the actual and the average state of ambient air quality in different parts of the city.

During the 20th century regular meteorological observations and instrumental measurements were taken up and continued over a shorter or longer period of time at 24 different sites within the present borders of Budapest. The data provided by these stations could be used to throw light on the local differences in the climate of the city area. However, among these stations there was only one that had been located in the proper core of the city, in a large, grass-covered courtyard of the City Council Building (Madách tér). Measurements at that site were performed between 1965 and 1969, thus providing a record appropriate to reveal the properties of the typical urban climate and to compare them with the natural background climate represented by the Pestlőrinc Observatory that has been located at the remote southeastern rim of the old suburban belt. By taking advantage of all the available, mostly unpublished records of the National Meteorological Service, the local differences and the particular urban features of the climate including some parameters of ambient air quality were first described, analysed and mapped in Budapest by Probáld, F. (1974). This pioneering endeavour also comprised a quantitative assessment of the role of the various components of surface energy balance in the thermal climate of the city and their deviation from the figures characteristic to the surrounding rural areas.

Owing to financial difficulties the scope of meteorological measurements in Budapest has witnessed sharp reduction since 1970 with only four stations being left from the former network, none of them operating in the city centre. Thus, urban climate research has practically been abandoned in Budapest except for some attempts to utilise satellite imagery for the study of the heat island (Bartholy, J. et al. 2005; Dobi, I. et al. 2009). Satellite measurements, however, cannot produce continuous data records and they provide information merely about the temperature of the surface instead of the ambient air at a height of 2 m. These figures can be quite different from each other and the degree of their correlation varies considerably over time and space; consequently remote sensing is not a feasible substitute for field observations. Therefore in describing the intensity and the temporal changes of the urban heat island in the next section, we still have to rely on the hourly breakdown of thermograph records taken in the 1960s from the station located at the city centre and from the outlying Pestlőrinc Observatory. Nevertheless, recent changes of the macro-scale climate of Budapest allow us to draw some conclusions concerning the actual state and the future of the urban environment, too.

VI.2. The urban heat island

Ever since its first scientific demonstration by L. Howard in London in the early 19th century, the urban heat island has received keen attention from the climatologists realizing the significance of this phenomenon from both theoretical and practical point of view. The spatial pattern and the temporal changes of the heat island are determined by a great variety of factors, such as the location, the background climate and weather conditions, the size of the city, the fabric of roads, buildings, parks and their geographical distribution in the urbanized area. Consequently the thermal regime of each city is more or less unique, thus it deserves careful study. In Budapest the key features of the heat island represented by the temperature surplus of the city core compared to the natural surroundings can be summarized as follows.

The annual mean temperature in Budapest's downtown is by 1.2 °C higher than outside of the city. The annual cycle of the urban–rural temperature difference reaches a peak in January (1.5 °C) and a secondary high in July (1.3 °C). The usually quite windy and cloudy March is characterized by the minimum temperature surplus of the city (1.0 °C). In Budapest early inquiries made into the surface energy balance by establishing the monthly means of its components have revealed the physical background of the urban heat island, too (Probáld, F. 1971). The summer warming of the city can mainly explained by a higher direct turbulent heat transfer to the air which is due to the decrease in the evaporation and consequently in the latent heat transfer as well. In winter the heat released by human activities can be regarded as the key factor shaping the temperature difference between the city and its surroundings. While the city dwellers are certainly not displeased with a warmer environment in winter, they may feel quite different in the hot season of the year when the human comfort is adversely influenced also by the diurnal variation of the heat island intensity.

The rugged urban surface made up of massive concrete and stone structures is able to absorb large amounts solar radiation during the day, store this energy and release it to the atmosphere at night.

This process leads to a substantial delay of the diurnal temperature cycle and results in a characteristic variation in the intensity of the urban heat island with the minimum urban–rural temperature difference observed for a short while late in the morning and with a peak of about 2 °C in the evening followed by almost no change for most of the night *(Figure 28)*. For the same reasons, similar daily temperature regimes have been detected by measurements performed in numerous other cities, too.

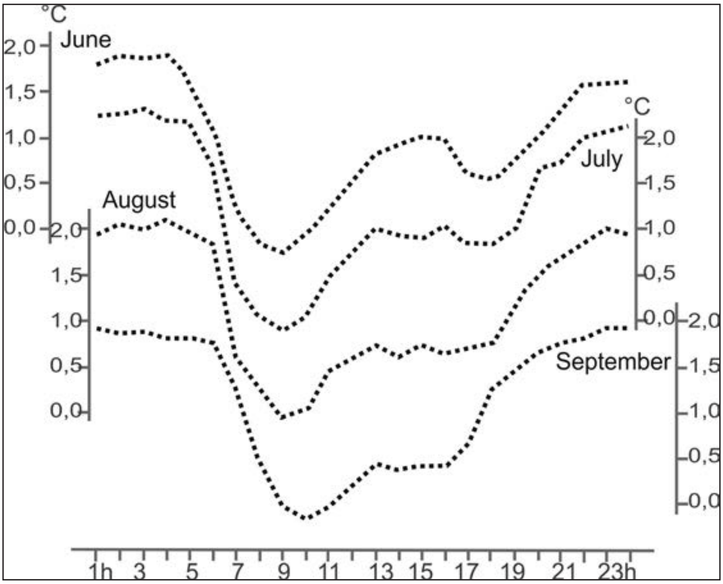

Figure 28: Diurnal cycle of the temperature difference between the downtown (City Council) and the suburban outskirts (Pestlőrinc) in summer
Source: Probáld, F. 1974

The urban heat island is a bit weakened by cloudy and windy weather conditions, whereas on clear, sunny days it gets stronger and the urban–rural temperature difference may exceed the average figures by several tenth of a degree with a tendency of further growth during the period of lasting heat waves. There are also remarkable microclimatic differences within the densely built up area of the city. This has been demonstrated e.g. by measurements which were performed on three consecutive clear and hot days in July 1966 at

2 meter height above a safety island in the middle of the Madách Square, located in the downtown of Budapest. The air of the large square lacking any greens and permanently exposed to the sunshine turned out throughout the afternoon and the evening to be warmer by roughly 1 °C than the nearby grassy courtyard of the City Council and the difference amounted to 3 °C in comparison with the rural areas. The human comfort in such urban spaces is adversely affected and the stress increased also by the thermal radiation emitted by the pavement and the walls of the buildings which are even more heated than the air.

The calm and clear anticyclonic weather characteristic to the lasting heat periods is often coupled with accumulation of various pollutants in the ambient air of the city. The bulk of these pollutants, such as NO_2, the well-known precursor of ozone as well as CO and particulate matter of various sizes come from the heavy car traffic. The concentration of fine particular matter often exceeds the limit set by the air quality standards. This occurs usually in winter. Budapest witnessed also some ozone alerts in the summer, but heat alerts became even more frequent during the last couple of years.

VI.3. Rising heat stress in the city

After a steady decline of more than two decades, the population of Budapest today is not larger than it was fifty years ago. During its last period of growth in the 1970s and early 1980s, however, large housing estates were built in the former industrial and suburban belt of the city. These constructions certainly have some impact on the microclimate of their surroundings, but they could hardly bring about significant changes in the intensity and the meso-scale pattern of the heat island. Meanwhile, the city witnessed the emergence of at least three new factors which are likely to affect the present and future properties of the urban climate:

1.) Tremendous changes have taken place in the quality of the fuel used in the city. Until the early 1960s the heating of the dwellings had largely been based on coal that caused frequent winter smog due to the accumulation of sulphur dioxide and soot particles in the air. In the subsequent decade, however, coal burning was quickly and almost totally replaced by natural gas. This was done for pure economic reasons, but as a favourable side-effect air quality has been greatly improved. Nevertheless, this success has been largely offset by the spectacular expansion of automobile traffic over the last decades with the peak probably left behind lately at least in the inner city where more and more measures have been implemented to keep congested traffic away. Thus, transportation as a whole has become the major source of air pollution and it is also contributing to the anthropogenic heat release concentrated along the main traffic routes.

2.) The last one or two decades also witnessed the more and more widespread use of air conditioners in Budapest, responsible for a new summer peak of electricity consumption. This process is mainly due to the technical development and the higher living standards, but the need to mitigate the indoor impact of the more frequently occurring heat waves cannot be disregarded either. At the same time, air conditioners produce a positive feedback that may strengthen the heat stress of the outdoor urban climate particularly on the hottest summer days and in the most densely built up areas.

During the last couple of decades numerous attempts were made to quantify the anthropogenic heat emission of the transportation and the buildings in several cities (e.g. in Tokyo and Philadelphia). The methods and conclusions of these surveys were thoroughly reviewed by Sailor, D. J. (2011). According to recent building model calculations of Seprődi-Egeresi, M. – Zöld, A. (2011), the summer heat output of the houses required to maintain the optimal indoor temperature of 24 °C in the densely built up inner city of Budapest would amount to 7300 kWh/m^2 day which roughly equals to 45 W/m^2.

In this paper a different approach is adopted based on the regularly published daily electricity consumption data of the Hungarian Independent Transmission Operator Company (MAVIR). The electricity consumed in Hungary during the heat waves in June of 2013 exceeded the figures for an average May weekday by 20 thousand MWh. This difference can largely attributed to the use of air conditioners. As about 10 per cent of the total increase may appear in the inner city of Budapest (30 km^2), our estimate suggests here a heat output from this source amounting to 25–30 W/m^2 that is about 8 per cent of the daily average power of global irradiance in June. Since the majority of the dwellings, contrary to the assumption inherent in the study of Seprődi-Egeresi, M. – Zöld, A. (2011), has still not been equipped with air conditioners, our figure comes probably closer to the reality. Both of the above estimates ignore, however, the heat emission of the traffic which falls in most cities considerably behind the energy consumption of the buildings. Based on the inquiries in cities with a climate more or less similar to Budapest (Sailor, D. J. 2011), we can assume that the combined meso-scale impact of the vehicle traffic and the air conditioning systems have resulted in an additional urban summer air temperature rise of 1.0–1.5 °C since the 1960s.

3.) Though the effect of the above mentioned two factors on the average urban warming is certainly not negligible, the threat coming from recent changes of the macro-scale climate and weather conditions put the issue of urban heat stress in an even more sinister perspective (Stone, B. 2012). These changes have manifested themselves in the growing frequency and longer persistence *(Figure 29)* of heat waves (Vincze, E. et al. 2013). The figures reveal rather worrying trends as they have appeared in the homogenized temperature record of Budapest. The station of the National Meteorological Service is located on the Buda side in a densely built up neighbourhood showing however a temperature which is usually lower by about 0.5 °C in comparison to the city centre. The daily mean exceeding here 27 °C on three consecutive days indicates the threshold of the most serious 3rd grade heat alert in the city. Concerning the concomitant health effects we refer to the survey of Páldi, A. – Bobvros, J. (2008) based on the Budapest record from the period 1970–2000 which has demonstrated that a 5 °C increase of daily mean temperature during heat waves is usually accompanied with a mortality growth of 10 per cent. This death toll is mostly due to the collapse of the cardiovascular system of the elderly and patients suffering from chronic heart disease.

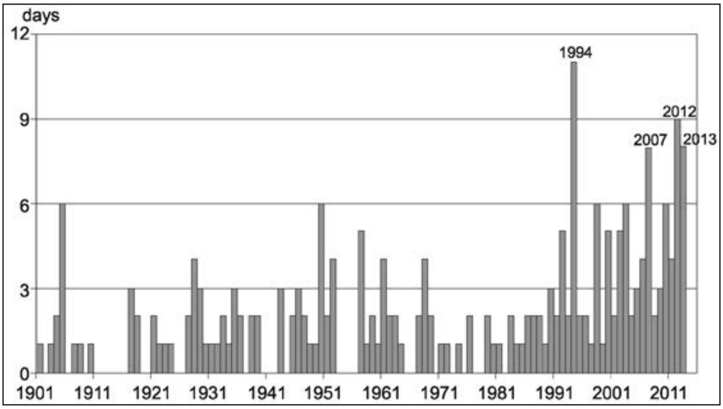

Figure 29: Persistence (number of days) of the most lasting heat waves of the given years (daily mean above 27 °C)
Source of data: VINCZE, E. et al.2013

According to the most likely scenarios of regional model estimates, temperatures in the Carpathian Basin are bound to rise in accordance with the medium projection of the IPCC. However, warming will be more distinct in the summer with an expected temperature increase of at least 4 °C until 2071–2100 against the reference period at the end of the 20^{th} century (BARTHOLY, J. et al. 2007; BARTHOLY, J. et al. eds. 2011). This change will be coupled with a dramatic increase in the frequency of heat waves. The annual number of hot days ($t_{max} \geq 30$ °C) will triple during the 21^{st} century, thus getting 34–38 days higher than the average of 18 days registered in the last 30 years of the millennium (BARTHOLY, J. et al. eds. 2011; VINCZE, E. – SZÉPSZÓ, G. 2012). And these are merely average figures, which do not take into account the additional warming effect of the city.

VI.4. Use and misuse of climatic assets

It is hard to admit, but except for some measures with micro-scale impact only, in a city with an inherited rigid structure like Budapest awful little can be done in order to change the general characteristics of the urban climate, to cope with the trend of global warming and to relieve the growing thermal stress the people have to suffer from in summer. Therefore one has to pay special attention to those areas where the natural conditions are more or less able to counterbalance the discomfort caused by the typical urban climate. Within the confines of Budapest we find two areas with particularly favourable atmospheric environment, namely the banks and the small islands of the Danube River and the Buda Hills with their great variety of microclimates. The remarkable differences compared to the downtown appear even in the monthly mean temperatures of the mid 20th century and they must have substantially grown since that time *(Table 18)*.

Site	April	May	June	July	August	Sept.	Year
Margitsziget	–1.0	–1.3	–1.6	–1.7	–1.6	–1.7	–1.2
Szabadság-hegy	–2.9	–3.2	–3.2	–3.1	–2.8	–2.7	–2.9

Table 18: Deviations of the monthly mean temperatures (°C, 1954–1968) of Szabadság-hegy (Szabadság Hill, height: 470 m a. s. l.) and the Margitsziget (Margit Island, 103 m a. s. l.) from those of the city centre (City Council, 105 m a. s. l)
Source: Probáld, F. 1974

In calm, sunny anticyclonic weather afternoon and evening temperature differences could be measured between the Margitsziget and the large downtown squares that were 2–3 times higher than the monthly means *(Figure 30)*. Under similar conditions surface temperature differences of 8–10 °C between the downtown and the Margitsziget as well as between the downtown and the Buda Hills are quite usual as it has been demonstrated by satellite measurements (Bartholy, J. et al. 2005). This is of cause also linked with less frequency and shorter persistence of heat periods when daily peaks exceed 30 °C and night lows are higher than 20 °C.

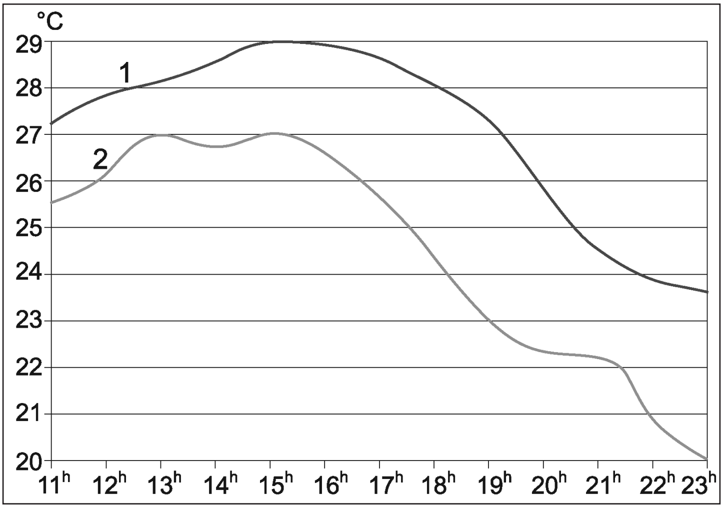

Figure 30: Diunal change of the air temperature on a safety island of Madách tér (Madách Square, 1) and in a park of the Margitsziget (Margit Island, 2). Average of field measurements on three consecutive summer days in 1966.
Source: Probáld, F. 1974

Thus, the population with dwellings in the hilly districts of Buda suffers much less from the summer heat while it can enjoy more sunshine and snow in the winter. The Buda Hills rise to an altitude of more than 500 m (that is about 400 m above the Danube valley). The hilltops and the upper parts of the slopes are still covered by recreational forests forming a nature protection area, while most of the slopes were built up during the last century with good quality 4–5-storey houses surrounded by more or less greens. Despite the heavy loss of vegetation due to the extensive housing construction, the slopes of the Buda Hills are still sources of a frequently occurring night-time mountain breeze which can mitigate the summer heat of the city by conveying cleaner and cooler air toward the densely built up areas. The tectonically preformed, northwest–southeast directed valleys are in good accordance with the prevailing wind direction and they serve together with the Danube valley as natural ventilation channels. Due to the prevailing westerly winds, the air is much cleaner on the Buda side, and severe air pollution is restricted to the key traffic routes. There is abundant evidence provided by recent polls and by the actual real estate prices that the Buda districts have the highest prestige and stand out among the favourite target locations of those intending to move while there are only few people willing to leave Buda for the sake of a new dwelling in Pest. The equally easy access to the nature and the city centre, the various amenities provided by the Buda Hills are remarkable assets for the Hungarian capital even in the international competition of cities, since supply of quality dwellings and environmental issues rank high among the priorities of postmodern societies.

Regrettably enough, the development of the land use during the second half of the 20th century largely disregarded the limited extent and the particular value of the natural endowment of this area. The orchards, vineyards and nice gardens of the 19th century have withdrawn and the rest of the forests have been more and more encroached upon by constructions with functions that simply do not fit to this environment and can hardly be removed any more. In the 1970s and 1980s even huge panel housing estates appeared and high rise buildings were erected on the slopes *(Figure 31)*. As most obvious examples of the misuse of environmental assets, military barracks, higher educational and training institutions of the police and the army as well as nuclear research facilities still occupy considerable areas of the Buda Hills which should have been saved for more reasonable purposes.

Figure 31: Gazdagrét: large-scale housing estate of the late socialist era on the slope of the Buda Hills
Source: photo of László Jeney

From the islands of the Danube River, Margitsziget with an area of 96.5 hectares lies closest to the city centre. The whole island is a beautiful park suitable for walking, jogging and other leisure time activities. Beside several sport facilities we also find there a wellness hotel taking advantage of the thermal water taken from local wells for medical purposes. Thus, the island has become a favourite public place and its amenities are properly utilized, sometimes even crowded by the great number of visitors. While Margitsziget is threatened by eventual overuse, the advantages offered by two similar islands situated a bit further northwards (Óbudai-sziget, Népsziget) seem to lay almost idle in lack of reasonable management and development strategies which would serve the public interest. This can be most clearly exemplified by the southern half of the Óbudai-sziget which has been sold to a foreign-owned development company wanting to build on the site of the abandoned shipyard a high-rise hotel, casinos and a large-scale entertainment centre. This highly controversial project, however, had been pending for about ten years. Finally, the government bought the land back in 2013, hopefully with the intent of establishing there public recreational and sport facilities.

The banks of the main branch of the Danube River have a total length of 58 km within the confines of Budapest. In a survey conducted in 2007 by using both field trips and aerial photos we have found that the total length of the densely built up areas amounted to 18.6 km (Izsák, É. et al. 2008). The embankments serve here as the main north–south directed arterial traffic roads and they are bordered by a dense row of tall buildings that blocks any air exchange between the water surface and the nearby streets of the city core. Opening direct access to the cool and nice riverside for the walking pedestrians has been envisaged several times, but the problem is still to be resolved.

Derelict, partly entirely abandoned industrial establishments of the brownfield belt occupy 16 km (27.6 percent) of the banks while sections of 12.4 km (21.4 percent) length seem to be void of any reasonable human use, though even here the willow and poplar groves of the floodplain fulfil a valuable ecological function as wildlife corridors. At some places on Csepel-sziget the potential use of the riverside is restricted because of the vicinity of wells providing piped water for the city. In most cases, however, the key obstacle of utilization is the lack of flood control levees or the heavily polluted soil. To overcome these difficulties considerable investments would be required from the property developers.

Figure 32: Marina Part (Marina Coast): gated community, recent development in the brownfield belt at the Danube River
Source: Photo of Tamás Egedy

Nevertheless, the brownfield belt and other idle sections of the riverside still offer great perspectives for future development. At the turn of the century the opportunities of profitable investments also arouse the interest of some foreign-owned big real estate companies which started to construct gated communities with luxury apartment houses at the river, taking advantage of the favourable environment and the magnificent vista to be enjoyed at the sites selected for development *(Figure 32)*. The drive to make as much profit as possible has become, however, manifest in the extreme building density, the shortage of greens and sometimes quite dull architecture of these projects (Kauko, T. 2012). The realization of further grandiose development plans were brought to a temporary halt in 2008 by the economic crisis and its disastrous impact on the real estate market.

VI.5. Conclusion

The metropolitan growth and the climate change have brought about new global ecologic conditions (Sassen, S. 2009) and this would require also much more responsibility in preparing decisions as regards the values of the environment. In Budapest the ultra-liberal mayor and council that led the city between 1990 and 2010 adopted a laissez-fair attitude, thus allowing the private development companies to get through their interests at the cost of the whole urban community. In order to save the environmental assets of Budapest and to achieve a turn toward a sustainable property development, better governance, comprehensive planning, appropriate regulation measures as well as they rigorous implementation are needed.

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VII. The estimation of the impact of urbanization on climate and extreme weather phenomena

Vladimir Loginov

Abstract

This chapter investigates with the impact of anthropogenic heat sources on Belarusian cities and the countries of the world. The calculation shows that in the majority of the countries the anthropogenic heat fluxes (AHF) exceed the geothermal flow by times and in the Netherlands and South Korea more than 40 times. Maximum AHF values in these countries exceed 10 percent of the inflow of solar radiation to the climatic system (about 240 Wt/m^2). It is estimated that urbanization plays an increasing role in the rise of thermal resources in South Belarus. The abnormally high temperature values in South Belarus are partly caused by the additional local impact of urbanization. The night temperatures' rise compared with daily temperatures stopped in the last 15 years. The average annual temperature difference between large cities and the countryside was about 0.25–0.30 °C in the last 30–40 years. It shows differences of air humidity, frequency of fog, heavy rainfall and hailstones for cities and the countryside.

Keywords: climatic changes, urbanization, weather phenomena, heat fluxes, Gomel, Minsk

VII.1. Task description

The work by F. Johns, P. Groisman's etc. (Jones, P. D. et al. 1990) was well-founded to assess the contribution of urbanization to the modern climate warming. They used the observation data of rural meteorological stations from 1901 to 1987 for a number of areas of the Earth. They came to the main conclusion that urbanization was responsible for a maximum of 0.05 °C temperature rise in the European part of the former Soviet Union, the eastern part of Australia, China and the USA, which is 10 times less than the general temperature rise in the specified period.

In one of the last works dealing with this issue, a more significant impact of urbanization and the scales of its influence on the heat waves

(Hairullin, K. Sh. et al. 2009) was mentioned. It was based on the broad-scale research on the climate description in the large cities of the former Soviet Union, which was done in the 1960s–1980s ('Klimati gorodov'). They show that the large cities – Moscow, Leningrad, Novosibirsk – in comparison with countryside 'heat' the urban atmosphere by 0.6–1 °C. On some winter days with anticyclonic weather conditions the difference between cities and countryside can be 8–10 °C in 'favour' of cities. Urbanization greatly contributes to the frequency of extreme phenomena, such as thunderstorms, hails, fog, etc. In comparison with countryside, the number of foggy days in cities decreases by 20–30 percent due to the temperature rise, the number of days with hail and thunderstorms increases by 15 percent and 10 percent respectively (Hairullin, K. Sh. 1977; Hairullin, K. Sh. – Yakovlev, B. Ya. 1990; Matveev, L. T. et al. 2006). The controversial issue of the urban influence on humidity, fog, heavy rains and hails will be analyzed more thoroughly later.

The conclusion of the work (Hairullin, K. Sh. et al. 2009) is that in the territory of Russia the contribution of urbanization to climate warming is at least 0.3 °C. Important results in this direction refer to the estimation of the influence of chronic pollution zones in urban settlements and roads in Russia. The comparison of the area with 10-fold pollution and the areas of meso-scale urban influence obtained by means of meso-scale surveys shows their spatial coincidence *(Table 19)*. It can be seen that the areas affected by the mesoclimatic influence of large cities are considerably large. This circumstance should be considered particularly significant when estimating the influence of strongly urbanized countries and territories (Europe, the USA and Japan) on climate change. The presented results outline a potential substantial temperature increase in the territory of Europe where the urban saturation (together with roads) reaches 70 percent and the majority of meteorological stations are within the city boundaries. Due to this, there is a necessity to reconsider the contribution of urbanization to modern climate warming, which in most cases is attributed to the rise of the amount of greenhouse gases in the atmosphere.

In the former Soviet Union the urbanized territories occupied 1 percent of the total area, however, in the European part of the former Soviet Union this is considerably larger, which can also play an essential part in the scale of the climate change, related to urbanization. This is also proved by the anthropogenic heat sources in large cities of the world.

Region	Pollution area		Mesoclimatic urban influence area
	10-fold	2-fold (roads accounting)	
Moscow	1.05	7.0	1.6
Saint Petersburg	0.90	5.0	1.2
Russia (area %)	1.2 %	4.3 %	2.1 %

Table 19: The area (thousand km^2) characteristics of urbanization impact on the pollution (by pH) and temperature air rise. (The area of the Russian Federation is 17075.4 thousand km^2)
Source: calculation of the author

Employees of the Institute of Physics of Atmosphere named after A. M. Obukhov of the Russian Academy of Sciences offered an evaluation method of values of anthropogenic heat fluxes in the urbanized territories, based on the use of statistical data on the population and area of cities, and also data on power consumption per capita (Ginzburg, A. S. et al. 2011). Values *AHF* (Wt/m^2) are calculated from the formula:

$$AHF = k \times PD \times EC$$

where *PD* refers to population density within the city boundaries (inhabitants/km^2), *EC* is power consumption in the country per capita in tons of oil equivalent (1 t of oil eq. is equal to 41,868 GJ) and *k* is dimension factor.

A weak point of the given technique is how the city boundaries (borders) are determined, which essentially influences the values of urban population density and the specific values of anthropogenic heat fluxes. The other drawback of the given technique, obviously, is the use of the power consumption data of a whole country for estimation of anthropogenic heat flux in a specific agglomeration. It is also necessary to consider the incompleteness of any statistical data regarding the commercial deliveries of energy sources and the completely insufficient consideration of local kinds of fuel. A major advantage of this empirical estimation is the use of readily available data and the simplicity of calculations.

VII.2. Analysis of the results

Anthropogenic heat sources in the Belarusian cities are assessed with the use of the presented method. *Table 20* provides absolute values of anthropogenic thermal fluxes power (MW year^{-1}) in the Belarusian cities. As expected, the highest values of anthropogenic thermal fluxes power are typical of Minsk, the country's capital and the regional centres.

№	City	Population, thousand people	Area, km^2	Population density, people/km^2	*AHF*, MWt year^{-1}
1	Minsk	1834.2	307.0	6.0	715
2	Gomel	484.3	127.6	3.8	189
3	Mogilyov	354.0	109.5	3.2	138
4	Vitebsk	348.8	91.8	3.8	136
5	Grodno	328.0	142.1	2.3	128
6	Brest	310.8	145.3	2.1	121
7	Bobruisk	215.1	90.0	2.4	84
8	Baranovichi	168.2	50.2	3.3	66
9	Borisov	147.1	53.0	2.8	57
10	Pinsk	130.6	47.7	2.7	51
11	Orsha	117.2	38.8	3.0	46
12	Mozyr	108.8	37.9	2.9	42
13	Soligorsk	102.3	10.8	9.5	40
14	Novopolotsk	98.2	48.5	2.0	38
15	Polotsk	82.2	40.8	2.0	32

Table 20: Absolute values of anthropogenic thermal fluxes power (MWt year^{-1}) in Belarusian large cities
Source: calculation of the author based on national statistical data for 2009 and 2010

If the maximum specific anthropogenic heat fluxes are to be considered, they are the highest in cities where the population lives in multi-storey buildings. As a rule, the territory of such cities is small: Soligorsk, Baran and some others.

On the whole, 75 percent of the population lives in 212 settlements and these occupy about 1.5 percent of the territory of the country. Anthropogenic streams of heat in a number of countries of the world are presented in *Table 21*.

Country	Pop, million people	Area, 1000 km^2	Pop. density, people/km^2	Energy con-sump-tion	*AHF*		
					Wt/m^2	Regarding the fluxes	
						Geo-thermal energy, %	Solar energy, %
Netherlands	16.656	33.8	493	4.901	3.206	45.8	1.34
Korea	48.580	99.5	488	4.483	2.905	41.5	1.21
Belgium	10.840	30.5	355	5.782	2.724	38.9	1.13
Luxemburg	0.512	2.6	198	9.972	2.618	37.4	1.09
Japan	128.057	372.9	343	4.129	1.881	26.9	0.78
Germany	81.752	357.1	229	4.231	1.285	18.4	0.54
Czechia	10.251	78.9	130	4.485	0.773	11.0	0.32
Poland	38.187	312.7	122	2.562	0.415	5.9	0.17
Hungary	9.986	93.0	107	2.740	0.390	5.6	0.16
USA	308.746	9161.1	34	7.768	0.347	5.0	0.14
Ukraine	45.779	603.6	76	2.937	0.296	4.2	0.12
Belarus	9.481	207.6	46	2.939	0.178	2.5	0.07
Russia	142.905	17075.4	8	4.745	0.053	0.8	0.02
Canada	31.613	9970.6	3	8.262	0.035	0.5	0.01
Brazil	190.756	8502.7	22	1.184	0.035	0.5	0.01

Table 21: Anthropogenic heat fluxes of some countries
Source: calculation of the author based on national statistical data for 2009 and 2010

The data in *Table 21* show the rank of Belarus in Europe and in the world according the anthropogenic heat flux. Regarding specific *AHF* values in Europe it surpasses post-Soviet countries (except Ukraine), northern countries (Finland, Norway and Sweden) and also southern Turkey. The values in other European countries are higher either due to greater population density or higher energy consumption per capita. The Benelux countries have the highest values of anthropogenic thermal loadings in Europe, as well as South Korea and Japan.

According to available estimations, the mid-annual anthropogenic heat flux for the surface of the Earth now is about 0.03 W/m^2, which is comparable to an average global geothermal stream (0.07 W/m^2). With reference to the ground surface, the *AHF* value rises up to 0.1 W/m^2, for the continental part of the USA it is 0.4 W/m^2, for Western Europe it is 0.7 W/m^2, and even for such a small town as Basel it changes from 5 in the suburbs to 20 W/m^2 in the centre (Mohov, I. I. 2009; Belova, I. N. – Ginzburg, A. S. 2010).

The calculations show *(Table 21)* that in the majority of the world countries *AHF* exceeds a geothermal stream by times, and in the Netherlands and Korea this difference is more than 40-fold. Exceptions are the largest countries with relatively low populations (Australia, Brazil, Canada and Russia).

Anthropogenic heat fluxes are four times lower than the average inflow of solar radiation to the climatic system (about 240 W/m^2) (Mohov, I. I. 2009). Only in the countries with maximum *AHF* values (Belgium, Luxembourg, the Netherlands and South Korea) do they exceed 1 percent of the average inflow of solar radiation to the climatic system *(Table 21)*.

At the same time, in large megacities the *AHF* value reaches hundreds of W/m^2, which is quite comparable to the sunlight stream and, in some cases, to the value of a solar constant – about 1366 W/m^2. Some decades ago there were regions, for example the Ruhr in Germany, the east of the USA and some areas of Japan, where *AHF* were 5–6 W/m^2. These areas are comparable to the scales of synoptic atmospheric disturbance. Meanwhile, currently the flux of anthropogenic heat in the Ruhr has reached about 15 W/m^2 (Mohov, I. I. 2009).

Average *AHF* values of 1–2 W/m^2, measured in some countries, exceed the variability of solar radiation; they are comparable to the radiating anthropogenic impact of GHG and the maximum values of radiating influence of volcanic eruptions (Mohov, I. I. 2009). We should notice that this rather courageous conclusion does not coincide with that in the work by Jones (Jones, P. D. et al. 1990), which points out that urbanization plays a small role in the climate warming (no more than 0.05 °C from warming value). Differences in the evaluation of the urbanization role in climate change require additional research of the issue and probably the revision of the concept of urbanization having a small part in modern climate change, at least in the urbanized regions of the Earth (Europe, North America, Japan, etc.).

VII.3. The role of urbanization in the increase of South Belarusian thermal resources

Belarus is characterized by a developed agricultural industry which is substantially based on the use of climate resources. The most significant consequence of global warming for Belarus is the change of agro–climatic boundaries. This conclusion has been reached by comparing the boundaries of agro–climatic areas and isolines of the sums of active temperatures, calculated for 1989–1999 (Melnik, V. I. – Komarovskaya, E. V. 2008). As it is known, according to the scheme of district division by A.H. Shklyar, there are three agro–climatic areas in the territory of Belarus : Northern – moderately warm, humid; Central – warm, moderately humid and Southern – warm, unstably humid. They are characterized by the sums of daily averages in the growing season, varying through the latitudes from 2000 in the North to 2600 C in the South (Sklyar, A. H. 1973). It is affirmed that warming has led to the shift of agro–climatic area boundaries by 60–150 km to the north, having caused the disintegration of the Northern area and the formation of a fourth, fragmented new area in the southwest and the southeast of Belarusian Polesye with the sums of active temperatures above 2600 °C (Melnik, V. I. – Komarovskaya, E. V. 2008; 2010). The fourth agro–climatic area (Melnik, V. I. – Komarovskaya, E. V. 2008; 2010) is based exclusively on the data of weather stations related to large cities, while other stations near to them in the countryside and more southern rural meteorological ones are located in the third area *(Table 22)*.

Weather station	Season				Year
	Spring	Summer	Fall	Winter	
All stations	6.19	17.01	6.32	–4.86	6.17
Large city (above 100 000 p.)	6.42	17.23	6.50	–4.67	6.38
Countryside (town/village)	6.13	16.95	6.26	–4.92	6.11
Difference: 'large city–countryside'	0.29	0.28	0.24	0.25	0.265

Table 22: Average values of air temperatures according to seasons on the categories of the Belarusian weather stations, 1946–2007
Source: calculation of the author

The data in *Table 22* show that the air temperature in Belarusian large cities (with a population of over 100 thousand people) is notably higher than in small towns and villages during all the seasons. To evaluate the impact of urbanization in the dynamics of thermal resources for South Belarusian weather stations, the data of agro–climatic directories are compared on the sums of active temperatures above 10 °C for the various periods *(Table 23)*.

	1881–1980 (I)	1881–1990 (II)	1986–2005 (III)	Difference, periods	
				(III–II)	(III–I)
Brest	2466	2494	2683	189	217
Pinsk	2408	2464	2628	164	220
Gomel	2441	2440	2641	201	200
City stations on an average	2438	2466	2651	185	212
The High village	–	2428	2515	87	–
Vasilevichi	2402	2419	2516	97	114
Zhitkovichi	2420	2412	2531	119	111
Lelchitsy	2455	2447	2579	132	124
Bragin	2415	2422	2505	83	90

Table 23: Dynamics of active temperatures sums above 10 °C of South Belarusian weather stations (directories data)
Source: calculation of the author

For a final conclusion regarding the question of the origin of abnormally high values of thermal resources in a number of weather stations in South Belarus, information from adjacent country was required. Such data on the monthly average air temperatures for the post-war period have been gained from four Ukrainian weather stations which are the nearest to the southern borders of Belarus (Kovel, Sarny, Ovruch, Chernigov). Using these data at various periods the sums of temperatures have been calculated. Then they have been compared to similar data from South Belarusian stations. The assessment results are in *Table 24*.

Region	1966–1985		1986–2005		Difference by periods	
	May–Sept.	April–Oct.	May–Sept.	April–Oct.	May–Sept.	April–Oct.
South Belarus	2386	2828	2468	2937	82	109
City stations incl.	2410	2855	2512	2994	102	139
Countryside stations	2370	2810	2438	2898	68	88
North Ukraine	2401	2849	2478	2950	77	101
Difference: North Ukraine – South Belarus	15	21	10	13	–5	–8
Difference: North Ukraine – City stations incl.	–9	–6	–34	–44	–25	–38
Difference: North Ukraine – Countryside stations	31	39	40	52	9	13

Table 24: Dynamics of active temperature sums of South Belarusian and North Ukrainian weather stations (for the period of 20 years)
Source: calculation of the author

The data of both periods show higher sums of temperatures for North Ukraine in comparison with South Belarus, which can be naturally explained by the more southern geographical position of Ukraine. The data reveal higher temperature sums at city stations of Belarus than in the Ukraine. That, undoubtedly, results from the existence of large city heat islands in South Belarus. The matter is that all four South Belarusian city weather stations are located in cities with a population of over 100 thousand, and the stations in Brest and Gomel are situated in cities with a population of more than 300 thousand people. As for the four Ukrainian weather stations, however, only the one in Chernigov belongs to the latter category, and other stations of North Ukraine are in cities with a population of 20 to 70 thousand people.

The calculation of differences of active temperature sums in South Belarus and in the neighbouring territory of North Ukraine has shown the following. Differences of active temperature sums above 10 °C by periods in all relevant weather stations show positive dynamics, justifying thereby the warming for the last 20 years (1986–2005). However, at city stations these differences are expressed more explicitly: 185 and 212 °C respectively, regarding various basic periods (1881–1980 and 1881–1990), while at the countryside stations they are only 104 and 110 °C. It points to the fact that the warming process in cities is considerably amplified by the urbanization of the territory and it is demonstrated by the positive dynamics of differences of temperature sums between city and countryside stations (15, 40 and 121 °C).

The comparative results show that if the effect of urbanization is excluded in temperature sums for city weather stations in South Belarus, there is no reason to single out the fourth agro–climatic area. Thus, the above-stated results prove that abnormally high values of temperature sums in South Belarusian weather stations are caused by the additional local impact of urbanization, which essentially affects the value of regional estimations of thermal resources of the southern areas of the country. In the light of the obtained results it is possible to state that there is not yet enough reason to single out a new (fourth) agro–climatic area and, in general, it is necessary to consider attempts of revising thermal resources of the regions without considering the contribution of urbanization to the modern climate warming. Further study of this issue with daily temperatures from 2006 to 2013, when there was an intense temperature increase in the warm season, and other methods of over 10 °C daily mean air temperature dates estimation confirmed the presence of the fourth agro–climatic region in much of the south of Belarus. The study has shown that the position of agro–climatic region boundaries depends on the period (Loginov V. F. – Tabalchuk T. G. 2014).

VII.4. Estimation of the contribution of urbanization to regional climate change

In the course of our analysis we shall start from the temperature values received from the Minsk station and the values which could be in the same location without the influence of a large city. The latter data were provided by the use of the GIS ArcView3.2 according to spline interpolation data. Therefore, the stations located in large cities have been excluded from the data file – six regional centres, and Novogrudok station as well, which, due to the rather high location of the weather station (278) distort the even latitude–longitudinal distribution of temperatures. Hence, the estimation of background temperature values was done on the basis of data from 19 weather-stations.

The choice of the spline interpolation technique is an important factor regarding the obtained results. The ArcView system represents two methods of spline smoothing – regularization and tension (Belova, I. N. – Ginzburg, A. S. 2010), differing in the smoothness degree of interpolation of a surface. The first method creates a smoother surface of the temperature field, whose points, however, can fall outside the limits of the initial data range; the second one changes the rigidity of the model depending on the character of the modelled phenomenon: points on a surface are closer to the initial value range. Both methods have the means of certain transformation of the constructed surface of a temperature field by the use of weight and other additional parameters.

Let us consider the basic results of the research. In the conditions of a rather smooth temperature field the difference between the modelling estimations of these two methods is insignificant. However, from the methodical point of view, considering the smoothness of the temperature field, the regularization method creating a smoother surface is more preferable. To ensure a greater smoothness of the latter and to get maximum correctness of the results, a spline-regularization has been applied with the use of weight parameter equal to 0 (ArcGIS).

Unfortunately, irrespective of the choice of interpolation method, the lack of data near the borders and outside of the Belarus territory results in certain distortions in the interpolation surface near the borders. These distortions, however, are hardly valid in the middle of the area where Minsk is located, so this allows the full use of the given method. In our case the mentioned distortions are most appreciable in the north and the southeast areas of the country.

The cards of the calculated background distributions of average summer temperatures *de-facto* show the distribution of temperatures in the absence of large cities in the territory of Belarus. For Minsk in the chosen periods for 1961–1990 and 1991–2009, the difference between the real and calculated temperatures was 0.09 and 0.15 °C respectively. These figures reflect the urban contribution to the temperature change by periods.

An important feature of a heat island is that its intensity shows seasonal changes and it has an accurately exposed daily course, especially in cloudless weather conditions. The latter is explained by seasonal and night ground inversions of temperature 'closing' thermal emissions of the city heat island in a thin ground layer of the atmosphere.

With the application of the presented algorithm, the distribution cards of extreme daily background temperatures of Belarus have been compiled and the minimum and maximum temperatures for the hypothetical (not urbanized) territory of Belarus (Loginov, V. F. – Mikutskii, V. S. 2011) have been defined.

It has been revealed that there is a difference between the speed of temperature fall regarding relief latitude in the west (Grodno) and the east (Gomel, Mogilev). In the east the rate of temperature fall with relief latitude increase is more than twice as high as in the west.

In the Mogilev area the maximum and minimum temperatures in the south are 1 °C higher on average than in the north, whereas in the Grodno area the difference between the southern and northern areas is about 0.4 °C, i.e. the temperature gradient in the latter case is more than twice as low. It means that the temperature conditions in the Grodno area as a whole are more homogeneous in comparison with the Mogilev area. It also proves that in continental areas the change of temperature with latitude in the conditions of modern climate warming is more essential: the average climate warming is more intensive in continental areas. The physics of these processes is as follows:

1.) On continents the conditions are more favourable for the absorption of long-wave than short-wave radiation (there is a strong absorption band of long-wave radiation in the range of 13–17 microns);
2.) In oceans the absorption of direct solar radiation occurs in the afternoons in the water layer, and long-wave ones are in the surface film, which stimulate the growth of evaporation and the decrease in the temperature of the ocean surface. Therefore, there are conditions for more intensive warming in the centre of continents, and also in winter and at night owing to the weak vertical convection in the atmosphere at this time. In the tropics the warming 'is spread' by vertical convection to big heights, which makes the warming in these latitudes insignificant.
3.) The temperature rise is the biggest in high latitudes, which is caused by the contribution of albedo feedback and the influence of the strong gravitational stability created by cooling close to the terrestrial surface, which suppresses convection and long-wave radiation transfer, resulting in the concentration of heating caused by CO2 rise in a thin surface layer.

The research allowed us to define the factors influencing the asymmetry of the daily course of temperature, but it has not been possible so far to determine the impact of the various such factors on the asymmetry of a daily course (Jones, P. D. et al. 1990; Stenchikov, G. L. – Robock, A. 1995; Loginov, V. F. et al. 2003).

Our previous research (Loginov, V. F. – Mikutskii, V. S. 1997; 2000) also revealed an intensive night temperature rise during the period prior to the beginning of the 1990s. At this time the accelerated winter temperature rise in comparison with summer was also observed. However, from the second half of the 1990s the warming has increased in summer. In winter the speed of warming slowed down a little for the last decade. It is appreciable when the analysis of daily temperature values was done.

The calculations show that in the first period (1961–1990) the contribution of aerosols to the change of temperature in a city is estimated to be –0.28 °C and during the second period (1991–2009) the same is –0.29 °C. A corresponding estimation of the contribution of heat islands in temperature change is 0.49 °C for the first period and 0.67 °C for the second (increase in the contribution by 0.18 °C).

Thus, the method of definition of background temperature values in the urbanized territories has been approved in the work. The application of the spline interpolation method of 3-dimensional data and the possibilities of the GIS ArcView 3.2 make it possible to estimate the contribution of aerosols to modern climate change. It has been found that aerosol pollution led to a temperature decrease of about –0.28–0.29 °C during the periods of 1961–1990 and 1991–2009. The contribution of heat islands is +0.49 °C for the first period and 0.67 °C for the second one. The estimation of the contribution of heat islands in the temperature change from the first period to the second is determined as about +0.18 °C, and the corresponding estimation of aerosol contribution changes has slightly increased. This shows that the degree of aerosol pollution during the last period practically has not changed in comparison with the period 1961–1990.

During the transition from the period 1961–1990 to 1991–2009 the background daily temperature increase appeared to be about 0.30 °C higher than the night temperature increase, thus indicating the change of the character of warming in a daily course. While earlier the warming was more intensive at night, during the last decade the temperature rise was bigger in the afternoon. It coincides with the earlier stated phenomenon of the intensification of summer warming from the second half of the 1990s. The rate of climate warming in winter slowed down a little in comparison with the last decade. It is hard to say whether it is a stable change of the tendency or another short-term fluctuation in the character of climate changes.

The used approach to estimate the contribution of various anthropogenic factors in the change of summer temperatures seems effective to us for the analysis of the reasons for temperature variation. Besides, the method of definition of background characteristics can be useful to estimate agro–climatic resources of a territory when 'background' temperature fields are important, but not 'disturbed' by large city temperature fields.

VII.5. Evaluation of the urban impact on air humidity, fog, heavy rains and hails

The comparison of the urban impact on air humidity and fog has shown a discrepancy between the results received by Russian and Belarusian researchers. Therefore it is worth examining this question more thoroughly.

So, for forty post-war years the average monthly values of the difference of partial pressure (hPa) in Minsk and Maryina Gorka were negative, i.e. the partial pressure in Minsk was lower than in Maryina Gorka. Relative humidity was also less in Minsk. The reduction of relative humidity in the direction of the city centre was also revealed. With a city growth the number of days with relative humidity decreases by more than 80 percent. In the cities of Minsk and Gomel there was a growth in the number of foggy days. On the other hand, in Moscow there is some increase in the frequency of high relative humidity (> 70 percent), the general and lower cloudiness and the general growth of moisture content, which relates to the urban warming influence.

L. T. Matveev's works with his co-authors (Matveev, L. T. et al. 2006) carried out particularly detailed research on the mode of air humidity *(e)* in St. Petersburg and its surroundings. Pressure differences *(Δe)* of water steam in St. Petersburg and settlements of Belogorka and Sosnovo appeared positive in winter, i.e. the water steam pressure appeared higher in St. Petersburg than in its surroundings. The difference depends on the season and the time of day and it varies from 0 to 1.5 gPa. The latter value is typical of summer nights. It was shown that in winter, when evaporation conditions in a city essentially do not differ from those in the vicinity (a terrestrial surface is covered with snow and the grassy cover is absent), the basic role in e change is played by the anthropogenic factor. When all kinds of fuel are burnt in the city, a great amount of water steam is formed. Another important factor is the spreading urban land cover in a city, influencing the speed of water evaporation. As a result, in winter the water steam content in a city is higher than in the surrounding areas. At night in the conditions of inverse temperature distributions, with the weakened speed of wind and turbulent air exchange, the evaporation role is small both in summer and winter, therefore at night in winter it is $\Delta e > 0$.

In the observed afternoon and evening periods, in the conditions of the developed turbulent exchange, especially in summer, a more significant role in e formation is played by the speed of evaporation. This speed is less in the city than in the surrounding areas: a bigger part of precipitation is discharged into the sewage system and so does not participate in the evaporation and the vegetative cover in the city is poor. Due to this the difference Δe 'city–countryside' during the summer period in the afternoon and in the evening is essentially less than at night.

The research of rapid daily changes of air humidity was carried out both in Minsk and nearby cities and other settlements (Volozhin, Berezino, Maryina Gorka) from 2000 to 2006. It revealed that our results do not contradict the data obtained by the Russian meteorological stations from 1975 to 1980 *(Table 25)*.

		Δe_1		Δe_2		Δe_3	
Season		Winter	Summer	Winter	Summer	Winter	Summer
Time, h	0	19	38	42	–128	57	120
	3	18	68	41	–73	55	134
	6	17	77	40	–58	54	133
	9	21	–6	42	–142	52	78
	12	17	10	40	–145	51	50
	15	16	21	32	–148	50	46
	18	18	11	34	–167	52	47
	21	19	–29	39	–225	55	59
Night		18	39	40	–61	40	61
Afternoon		19	9	37	–61	40	60
Day		19	24	39	–61	40	60

$\Delta e_1 = I\ eat - e_{МГ}$; $\Delta e_2 = I\ eat - e_{Б}$; $\Delta e_3 = I\ eat - e_{В}$

Table 25: Average values of the air humidity difference 100 Δe (hPa) (adjusted for a geographical position of stations)
Source: calculation of the author

From *Table 25* it follows that winter air humidity in Minsk is higher than in the settlements located in the southeast, east and northwest of Minsk at a distance of 50–100 km. Meanwhile, in the afternoon the summer air humidity in Minsk appeared to be lower than in Berezino and in Maryina Gorka observed separately (9 and 21). This conclusion partially coincides with that of Belarusian researchers obtained during the analysis of average monthly values of the difference of partial water steam pressure in Minsk and Maryina Gorka. However, on average the air humidity (partial water steam pressure) in Minsk appears to be higher than in the surrounding areas by the value of several tenth gPa. The only exception is for the summer data from the Berezino station.

The analysis of humidity differences ‘large city – countryside’ in more detail, i.e. for every winter and summer month, has shown a greater spread of their values in summer. However, the general features of changes of pressure differences are the following:

1.) Practically in all observations in winter months the air humidity in a large city is higher than in the countryside.

The basic role in the formation of positive differences ‘large city – countryside’ is played by the anthropogenic factor: the incineration of all kinds of organic fuel leads to the formation of additional quantity of water steam in a large city.

2.) In June and July air humidity in a large city, especially in the afternoon, has appeared to be lower than in its vicinity. This can be explained by the lower level of total moisture transpiration by plants in a large city in comparison with the countryside, where vegetation covers a big area, and, as it has been shown above, by the reduction of air temperature in a large city in the afternoon in comparison with the vicinity. Hence, our data for the summer period basically confirm the conclusion of the Belarusian researchers obtained through the analysis of differences of partial water steam pressure ‘large city – countryside’ in the 70s–80s of the 20th century. As for the differences of partial water steam pressure ‘large city – countryside’ in winter months, the increased anthropogenic impacts of the last years have led to the fact that the production of water steam due to fuel burning has become higher than in the 1970s–1980s and the minus sign of humidity difference has become positive.

The conditions of fog formation are closely connected with humidity. As it was mentioned, the urban influence concerning fog formation conditions is inconsistent: while humidity reduction reduces the threat of fog formation, the increase in the number of condensation nuclei enhances it. The exact results vary according to the actual conditions in each large city. The ratio of the mid-annual number of foggy days in Minsk and Maryina Gorka, Gomel and Vasilevichi is provided below.

These data show that the growth of Minsk and Gomel is accompanied by the growth of the number of foggy days. Since the last decade the ratio to ‘background’ has increased by 15–20 percent *(Table 26)*.

Site	1961–1965	1966–1970	1971–1975	1976–1980	1981–1985
Minsk – Maryina Gorka	0.92	0.89	0.93	1.04	1.15
Gomel – Vasilevichi		0.94	0.91	1.11	1.09

Table 26: The ratio of mid-annual (five years average) numbers of foggy days in Minsk and Maryina Gorka, Gomel and Vasilevichi
Source: calculation of the author

The analysis of the frequency of brume and fog in a large city (St. Petersburg) and nearby settlements has shown that in natural conditions brume is formed 4–5 times more frequently than fog. In a large city the number of foggy days decreases in comparison with nearby settlements (Matveev, L. T. et al. 2006). The authors recognize that, on average, temperature is higher in a large city, and to reach the state of moisture saturation and fog formation more steam is required. The number of kerns in the atmosphere is always sufficient. Hence, according to the authors, a principal cause of dispersion or the reduction of the fog intensity (brume) and, as a consequence, the reduction of their occurrence in a city in comparison with the surrounding areas, is a reduction of the relative humidity in a city under the influence of temperature rise. Rise in temperature in a large city by 0.3–0.5 °C actually exists, and consequently, it can lead to the dispersion of fog. However, as shown in our works (Vorontsov, P. A. – Hairullin, K. Sh. 1977; Borisenkov, E. P. – Loginov, V. F. 1998; Voronin, V. I. 2005), in summer afternoons the temperature in a large city is lower than in the vicinity. That casts doubt on the conclusion about the reduction of fog frequency in a city at least in the afternoons and therefore it calls for further research.

Brume formation is also affected by air pollution promoting the increase of its occurrence in comparison with what would be observed in the absence of pollution. Water steam starts to be condensed on hygroscopic particles (kerns) long before reaching a saturation condition. Then, if relative humidity reaches the values close to 100 percent, fog is likely to form. The frequency of brume is always higher than that of fog.

The analysis of the number of foggy days has shown that during the observed 30-year period the yearly number of foggy days was decreasing up to the middle of the 1990s, while subsequently the fog frequency stabilized in the last decade *(Figure 33)* (Loginov, V. F. et al. 2010).

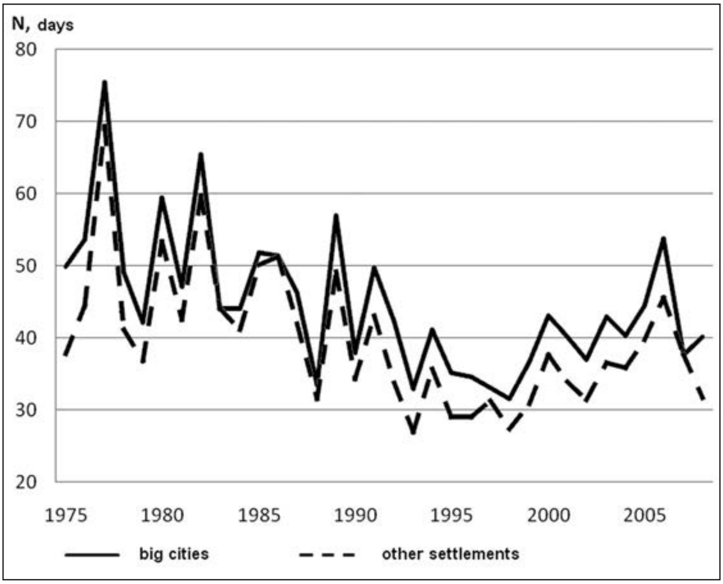

Figure 33: Change of mid-annual yearly number of foggy days, falling to one meteorological station in large cities (continuous line) and other settlements of the countryside (dashed line) in Belarus
Source: calculation of the author

In *Figure 33* the change of the mid-annual number of foggy days can be seen in large cities (continuous line) and other settlements of the countryside (dashed line). The fog frequency in large cities was higher than in the countryside in all years of the considered period.

VII.5.1. Showers

Urbanization was not proved to have an impact on the frequency of showers in the Belarusian cities. For the last two decades the increase in the shower frequency has occurred practically at all meteorological stations. The number of showers in the territory of Polesye is a little higher, which is possibly related to a greater cloud water capacity in South Belarus. Showers are a little more frequent on heights and on more wooded territories. If a city is considered as a big heterogeneity, sharply distinct from the surrounding districts and a powerful aerosol source (a source of kerns), then showers in cities should theoretically occur with greater frequency. A convective cloudiness is formed more often above the city, which should also favour the formation of showers.

VII.5.2. Hails

The number of days with hails in large cities is higher than in other settlements of the countryside *(Figure 34)*. This is explained by the fact that the atmosphere in cities is polluted by aerosols. Buildings, roads, highways and other urban elements are getting dirtier than soil and grass within a day. The convection increases above large cities and bigger cloudiness is formed than in the surrounding areas.

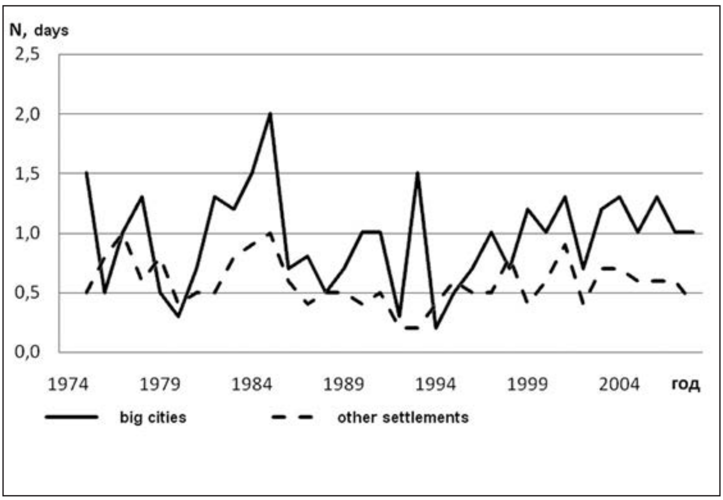

Figure 34: Long-term changes of annual number of days with hails per year for large cities and other settlements of Belarus
Source: calculation of the author

Besides, the city is 'heterogeneity' height. It can be considered as the roughness of surface. The latter transforms vertical and horizontal movements of air. It means that conditions in large cities are more favourable for the formation of hails. In *Figure 34* the long-term course of change of mid-annual number of days with hailstones can be seen for large cities and also for the countryside. From *Figure 34* it follows that the number of days with hails per one meteorological station is 40 percent higher.

VII.6. Conclusions

The estimations of the amounts of anthropogenic heat fluxes in urbanized areas of Belarus and some other countries were made using methods developed by the A.M. Obukhov Atmospheric Physics Institute. The highest anthropogenic heat fluxes were revealed in The Netherlands, Korea, Belgium and Luxembourg. For instance in Hungary, due to the greater population density, anthropogenic heat fluxes are more than twice as high as in Belarus.

The contribution of the 'heat islands' to the temperature change of Minsk from 1961 to 1990 was about 0.5 ˚C, and during 1991–2009 it reached almost 0.7 ˚C. In the period from 1961 to 1990 warming was greater at night, but in recent years this feature is not visible in the temperature pattern. Observed summer temperature rise tends to be more intensive than the winter one.

A significant feature of 'heat islands' of large cities is their seasonal variations of intensity and clear dependence on the diurnal temperature, especially in cloudless weather. Probably, it is defined more frequent inverse temperature stratification during the cold season and at night. Associated with thermal emission temperature increase is 'locked' in a thin layer in winter, and convection 'smearing' it in a thicker layer of the atmosphere in summertime.

Excluding the effect of urbanization growth in the amount of temperatures at meteorological stations in Belarusian large cities, using meteorological data before 2005 cannot allocate a fourth agro–climatic area in Belarus. However, meteorological data during the last years (2005–2013) confirm the existence of a fourth area.

Analysis of differences in humidity ‘large city–countyside’ shows that during the winter months the humidity in a city is higher than in surrounding areas. The burning of organic fuels leads to the formation of additional water vapour in the urban territory. Total transpiration by plants in a city is lower than in the surroundings, with larger vegetated areas. Therefore, humidity in a city is lower than in neighbourhood, especially during daylight hours.

Growth of cities like Minsk and Gomel is accompanied by an increased number of foggy days. However, in very large cities like St. Petersburg, the number of foggy and misty days still decreases, due to the higher temperature in large cities in comparison with the countryside. Therefore, to obtain conditions necessary for the formation of fog and mist, more water vapour is required.

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VIII. Integrated assessment of the state of urban environment (example of Minsk)

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Tamara Kukharchyk – Ludmila Krauchuk

Abstract

This chapter presents the approaches and results of integrated assessment of the state of urban environment on an example of Minsk which is the largest city and an industrial centre in the country. Indexes used for the assessment of air quality, underground water and soil pollution as well as for vegetation state on the territory of Minsk are given. Integrated assessment was based on the analysis of monitoring and statistical data, results of geochemical investigation, modelling. Functional–planning zones were used for spatial analysis and mapping.

The results have shown that as a whole for Minsk in its perspective borders on 43 percent of the area the state of the environment is estimated as favourable, on 31.6 percent – rather favourable, on 12.6 percent – rather adverse, on 7.6 percent – adverse and on 5.2 percent of the area – the most adverse. The most adverse ecological situation has developed in a south-east part of the city where about 80 thousand people live.

Keywords: urban environment, integrated assessment, indexes, functional zones, spatial structure, Minsk

VIII.1. Introduction

The environmental quality is one of the main factors of sustainable city development as well as of human well-being and the overall quality of life in cities. Currently, about 70 percent of the total population in Belarus lives in urban areas and the tendency of urbanization growth is just as typical of Minsk as of many other countries (Rahman, A. et al. 2009; EEA 2010; Loginov, V. F. ed. 2011). Citizens are affected by the complex influence of different kinds of environmental pollution, high noise level, food contamination, lack of comfortable recreation zones, etc.

Therefore the revealing of ecological problems in cities and the outlining of the spatial structure of environmental pollution are very important tasks for urban planning and decision making. With the integrated assessment of the urban environment different data types could be synthesized including statistical, monitoring, results of investigations, maps, etc.

Nevertheless, there is no universal methodology for the integrated assessment of the urban environment because the initial data concerning the environmental state as well as the geographical condition of cities and urban design show various differences. Monitoring data and results of environmental research differ in details (number and location of monitoring stations, number of samples and time of sampling), which makes it very difficult to describe the ecological situation with a complex index. There is not usually sufficient information for the spatial assessment of the quality of the urban environment. In general, the integrated assessment of the urban environment is time-consuming and expensive, and the approaches depend on purposes, initial data and many others factors. The level of environmental media pollution is largely taken into account, sometimes the intensity of technogenic loads, the sustainability and/or vulnerability of landscapes or even social aspects are also considered (Ecological Union Monitoring 1992; Ratanova, M. P. – Bitukova, V. P. 1999; Pudovkina, T. A. – Purdik, L. N. 2001; Khomich, V. S. et al. 2002; 2004; Eremeyeva, S. S. 2005; Popov, A. A. 2008; Rahman, A. et al. 2009). Functional zones, grid, landscape–ecological regions are used for mapping and the spatial description of the ecological situation.

Minsk is the capital of Belarus and the largest city and industrial centre of the country. Over 1.8 million people live here, which accounts for 18.4 percent of the total population of the country. There are large enterprises of machine-building and metal-working, factories of electronic and household appliances, building materials, food-processing plants as well as enterprises of public services, building, transport and communication. The city occupies an area of 30.8 thousand hectares.

Minsk is located in the central part of Belarus. Its highest point is 280 m, the lowest one is 182 m. The amount of precipitation is 600–700 mm per year. The River Svisloch divides the urban area into two parts. The hydrographic network has been substantially transformed in the process of city development: some small rivers have been diverted into collectors, and their valleys have been completely built up, while some artificial reservoirs have been created.

Sod-podzolic sandy and loamy sandy soils dominate within Minsk, which are transformed into urban soil with very a different soil profile and a large amount of anthropogenic materials. Soil reaction varies from 3.6 to 7.4 and on average it is 6.4. In comparison with natural soils, the soils of the city are more alkaline – the pH value exceeds neutral indices in 30 percent of cases (Germenchuk, M. G. et al. eds. 2007).

Minsk is developing in accordance with the national legislation and special strategic documents, such as the Strategy Plan of Sustainable Minsk Development up to 2030 (2004), the Master Plan of Minsk Development up to 2030, the Complex Urban Program 'Minsk Is a Healthy and Clean City' (2001). In 2008, the Territorial Scheme for Environmental Protection within the framework of an updated Master Plan was carried out. For this purpose the integrated assessment of the state of urban environment in Minsk was completed.

VIII.2. Methods and materials

The method of the integrated assessment of the urban environment is based on the integration of data on the pollution of atmospheric air, soils, ground waters and the state of vegetation. The method has been developed and approved to estimate the condition of the environment of Svetlogorsk (Khomich, V. S. et al. 2002; 2004). On the whole, it is close to the methods of environment assessment in Moscow and St. Petersburg (Ecological Union Monitoring 1992; Ratanova, M. P. – Bitukova, V. P. 1999).

The procedure of the integrated assessment of urban environment includes:

⊕ data collection (statistics, monitoring, results of previous investigation) and analysis;

- ⊕ field investigation of soil pollution and the state of vegetation with special attention to impact zones;
- ⊕ choice of territorial area (unit) for spatial analysis and mapping;
- ⊕ assessment and mapping of the level of atmospheric air, groundwater and soil pollution as well as the state of vegetation (trees);
- ⊕ integrated index calculation for functional zones;
- ⊕ zoning of the urban area with the designation of the regions with the most unfavourable environment.

The complex indexes were calculated for functional areas within perspective borders of Minsk in accordance with the Master Plan (2004). In total, there are 237 areas, 106 of which are residential districts, 55 are landscape–recreational, 45 are industrial, 25 are public and 6 are special territories *(Figure 35)*.

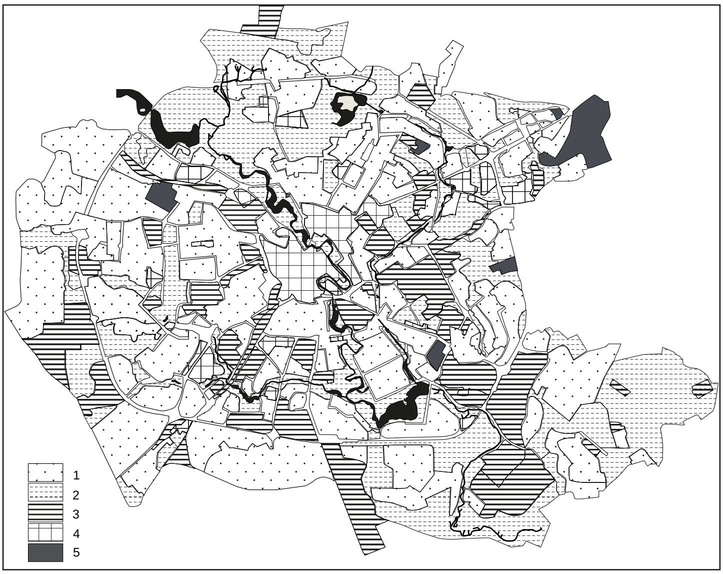

Figure 35: Functional zones within the perspective borders of Minsk:
1. residential, 2. landscape–recreational, 3. public, 4. industrial, 5. special
Source: edition of the authors

VIII.3. Results and discussion

VIII.3.1. Atmospheric air

The stationary sources located in the city emit more than 30 thousand tons of pollutants into the atmosphere, while mobile ones emit about 150 thousand tons (Loginov, V. F. ed. 2011). The monitoring of air pollution in the city is carried out at 15 stationary stations. The state of atmospheric air in Minsk is described in some scientific and information publications (Germenchuk, M. G. et al. eds. 2007; Loginov, V. F. 2010; NSMOS 2010; Borovikov, A. N. ed. 2011; Loginov, V. F. ed. 2011), containing information on the monitoring system, network, pollutants and trends of air pollution. According to the results of monitoring, the concentration of nitrogen oxide varies from 16 mkg/m^3 to 67 mkg/m^3, carbon oxide from 470 mkg/m^3 to 1154 mkg/m^3, PM from 3.6 mkg/m^3 to 19.6 mkg/m^3. Sulfur dioxide does not impact the air quality because of its very low concentration. Among specific pollutants formaldehyde and ammonia should be mentioned.

For the assessment of air quality and the designation of the spatial structure of air pollution the following data were used: observation results of the Department of Hydrometeorology and the Minsk City hygiene centre; the results of emission dispersion modelling from stationary and mobile sources; gradients of pollutant concentrations from the city centre to its outskirts; the dependence of pollutant concentrations in the air on the types of territory usage and the location of emission sources. The following scale of air pollution was used *(Table 27)*.

Index	Level of pollution	Comments
1	low	Concentration of pollutants is close to that in rural areas
2	moderate	The measured average concentrations of main and specific pollutants are lower than the averages in the city. Probability of excess of the maximum permissible concentration (hereinafter MPC) of pollutants is low
3	middle	The measured concentrations of main and specific pollutants are close to the average in the city. Probability of excess of MPC for some substances is average

Index	Level of pollution	Comments
4	enhanced	The measured concentrations of main and specific pollutants are above the average in the city. Probability of excess of MPC for some substances is high
5	high	The average daily content of main and specific pollutants exceeds maximum concentration limit or the number of days with excesses of MPC is considerable. Very high excesses of MPC are likely.

Table 27: Scale for air pollution assessment
Source: calculation of the authors

The map of air quality is presented below *(Figure 36)*.

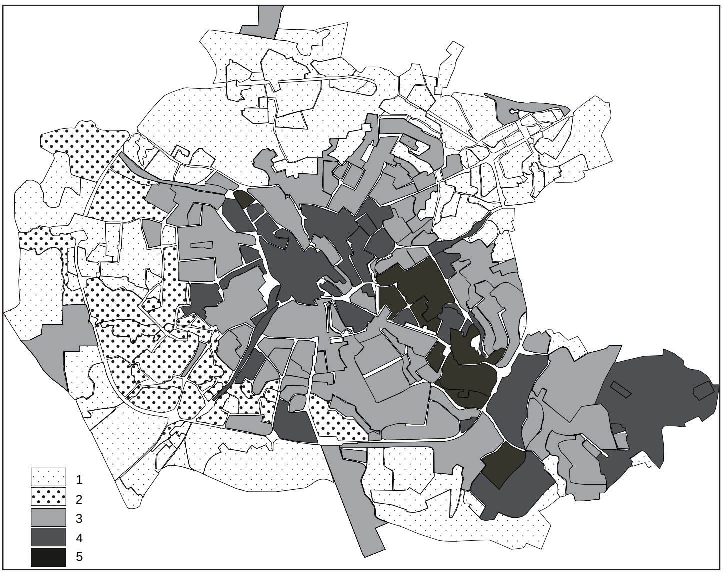

Figure 36: Air quality on the territory of Minsk. Level of pollution: 1. low, 2. moderate, 3. middle, 4. enhanced, 5. high
Source: edition of the authors

It was established that a high level of air pollution prevails in the southeast part of the city where the largest machine-building enterprises and waste water treatment facilities (hereinafter WWTF) are located. The high level of air pollution is typical not only of industrial zones but also of residential and recreation areas.

An increased level of air pollution is typical of the central part of Minsk with public zones (administrative and cultural). The air pollution is stipulated by the heavy traffic of public and private vehicles. This is also the area where railway and bus stations are located.

VIII.3.2. Groundwater

The assessment of groundwater quality is a very complicated issue because there is no regular observation similar to that of air quality. Therefore the results of examinations carried out by some authors themselves, published data and data collected by the Institute of Complex Use of Water Resources were used as well (Kadatskaya, O. V. et al. 2005; Germenchuk, M. G. et al. eds. 2007; Borovikov, A. N. ed. 2011). First, only the proximity of the groundwater level to the surface was taken into account. Besides, the landscapes were revealed, where water level was close to the surface.

To estimate the state of groundwater, excess of maximum concentration limits and frequency of excesses, the sum of ions and the quantity of pollutants which exceed the maximum permissible level (hereinafter MPL) were examined. The following scale and indicators were used for the assessment of groundwater pollution *(Table 28)*.

Index	Level of pollution	Comments
1	Relatively clean	Concentration of ions is at background level; the mineralization is no more than 250 mg/dm^3; no exceeds of MPL
2	Weakly polluted	Concentration of ions is above background level, but below MPL; mineralization is within 250–500 mg/dm^3
3	Polluted	Concentration of ions is above background level; mineralization is 500–1000 mg/dm^3; content of some pollutants exceeds MPL by two times
4	Dirty	Concentration of ions is above background level; mineralization is 1000–2000 mg/dm^3; the content of some pollutants exceeds MPL by 2 to 10 times

Table 28: Scale for the assessment of ground water pollution
Source: calculation of the authors

The assessment of groundwater pollution was made with the use of an integral index for 21 functional zones with a high share of low land and flood plain. Taking into account the existing data three levels of groundwater pollution were differentiated *(Figure 37)*.

Figure 37: Ground water pollution in Minsk. Water quality:
1. weakly polluted, 2. polluted, 3. dirty
Source: calculation of the authors

It was established that water is described as dirty in two functional zones located in the southeast part of Minsk. The main factors of water pollution are leakage of waste water from WWTF and pipes, infiltration of pollutants from solid industrial waste and sewage sludge.

VIII.3.3. Soil

According to examination results from previous years (Lukashev, V. K. – Okun, L. V. 1996; Khomich, V. S. et al. 2004; 2008; Loginov, V. F. ed. 2011), soil in Minsk is polluted with heavy metals, oil, PAH, water soluble compound, etc. The average heavy metal content exceeds the background level by 1.8–2.6 times. There are differences in heavy metal accumulation in the soil according to many factors including the type of territory use. For example, the average copper content in soils of industrial zones is about 2.8 times higher than in those of green and residential ones. The same values are 1.7–1.8 for lead and 1.5–1.8 for zinc.

In general, the content of heavy metals and other pollutants is rather low in comparison with large industrial cities in Russia and other countries. This is explained firstly by the lack of large sources of pollutant emission (ferrous and non-ferrous metallurgy) and secondly by the fact that Minsk was destroyed during the World War II and developed most intensively in 1960–1990, when there was a manifold increase in its area.

For the integrated assessment of soil pollution the following indicators have been used: the summary pollution index (Zc) calculated for five heavy metals (cadmium, lead, copper, nickel and zinc); frequency of MPL exceeds and quantity of chemicals whose MPL were exceeded; actual and potential pollution of soils with persistent organic pollutants (POPs) (polycyclic aromatic hydrocarbons [hereinafter PAH] and polychlorinated biphenyls [hereinafter PCB]), and also oil products.

We used the following scale of soil pollution *(Table 29)*.

Index	Level of soil pollution	Comments
1	Low	Zc values < 4, MPL excess not fixed
2	Moderate	Zc values 4–8; single MPC excess
3	Middle	Zc values 8–16, MCL excess for several elements; potential pollution of soils with PAH, PCB or oil products
4	Enhanced	Zc values > 16, excess of MPC for several elements; occurrence of values exceeding MPC – from 25 to 50 % of cases; the potential or actual pollution of soils with PAH, PCB or oil products
5	High	Zc values > 16, excess of MPC for several elements; occurrence of values exceeding MPC – more than 50 % of cases; the potential or actual pollution of soils with PAH, PCB or oil products

Table 29: Scale for the assessment of soil pollution
Source: calculation of the authors

For the functional zones where examinations were not carried out or the data for the estimation of soil condition were insufficient (1–2 soil samples), the method of analogies including analysis of the situation in adjacent territories was used. Besides, possible sources of pollutants were considered, and in industrial zones the risk category of enterprises was taken into account.

The spatial structure of soil pollution is illustrated in *Figure 38*. It should be noted that this zoning is conventional and does not reflect quantity dependence of soil pollution and its consequences.

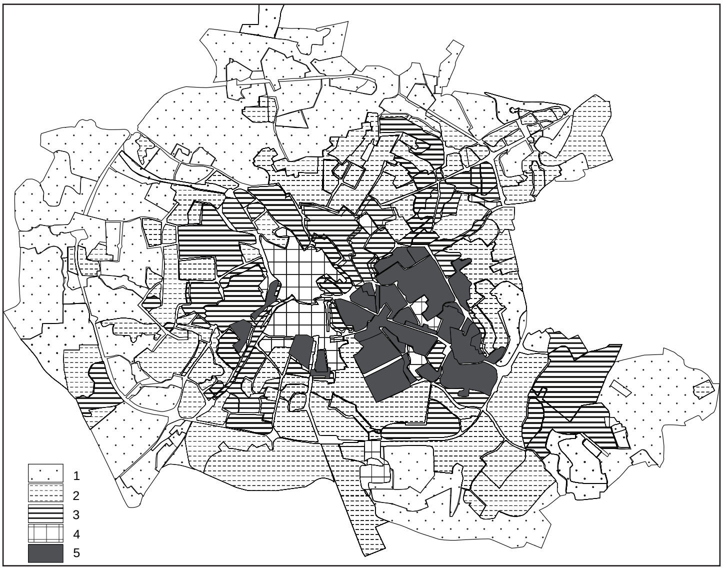

Figure 38: Soil pollution in Minsk. Level of pollution:
1. low, 2. moderate, 3. middle, 4. enhanced, 5. high
Source: calculation of the authors

A high level of soil pollution was observed in several functional zones occupying about 5 percent of the total urban area. Industrial zones prevail among the mostly polluted areas, but there are also two residential and recreational zones with high soil pollution. Different pollutants discharged into the soil have led to pollutant accumulation and geochemical anomaly formation. In some cases local anomalies of heavy metals, PAH and even PCBs were observed. The most important sources are industrial wastes including hazardous ones which are stored in the premises of enterprises. Some kinds of waste (residual ash, slag, sludge, and building materials) are used to backfill low land, ditches, for the construction of roads and parking lots or for other construction purposes.

Soils in residential zones near enterprises are considerably transformed: in most cases the top horizons (usually to 20 cm) are presented by technogenic sediments. In some cases they are well identified as impure residual ash. Technogenic grounds may be the basic source of PAH and heavy metals in soils in certain areas.

VIII.3.4. Vegetation

The examination of green zones, the structure of vegetation, the sustainability of trees in some cities and their impact zones in the territory of Belarus enables us to develop methodological approaches for the assessment of the state of vegetation and for mapping using a complex index (Khomich, V. S. et al. 2002; 2004; Krauchuk, L. A. 2011).

A five-level scale was used for the assessment of the condition of trees. Parameters, such as damage rate of assimilation device, defoliation percentage, amount of dry branches, etc., were used, which can be diagnosed visually (Alexeyev, V. A. 1990; Pugachevskij, A. V. – Krauchuk, L. A. 2007).

The average index of the state of trees was used as the indicator of the integrated state of each urban green zone. The calculation of the index of urban green zones was done with the following formula:

$$L_n = \frac{100n_1 + 70n_2 + 40n_3 + 5n_4}{N}$$

where L_n is the a relative vital condition of an urban green belt, %; n_1 is the quantity of healthy trees (without signs of weakening), n_2 is the quantity of weakened trees, n_3 stands for the quantity of significantly weakened trees, n_4 refers to the quantity of trees drying out and N is the total number of trees (including dead ones).

Urban green zones with an index between 90–100 percent were referred to the category ‘healthy’, those with 80–89 percent were defined as ‘healthy with signs of weakening’, those with 70–79 percent were labelled ‘weakened’, 50–69 percent: ‘damaged’, 20–49 percent: ‘severely damaged’ and those with an index below 20 percent were defined as ‘destroyed’.

For the functional zones not included in the research the condition of trees is assumed to be equal to the average in Minsk. The spatial structure of urban green areas in Minsk is demonstrated in *Figure 39*.

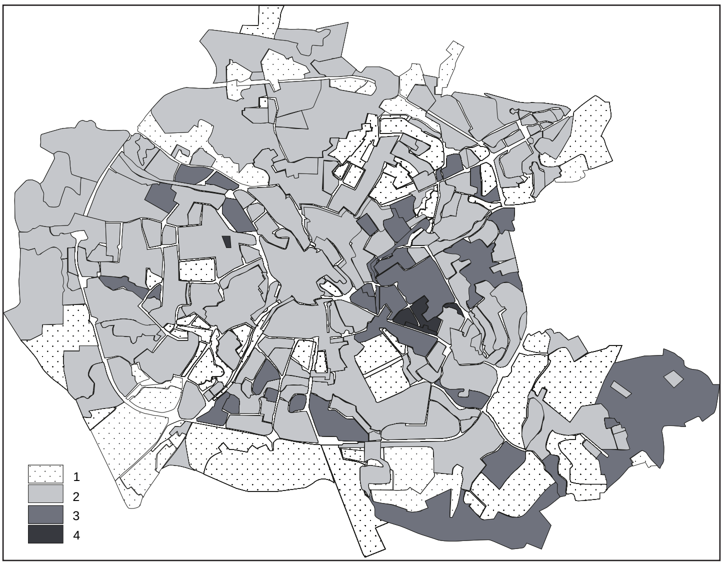

Figure 39: Urban green state in Minsk:
1. healthy, 2. healthy with weakening signs, 3. weakened, 4. damaged
Source: calculation of the authors

VIII.3.5. Integrated assessment

The integrated index of urban environment was assessed for every functional zone of Minsk *(Figure 40)*. On the basis of the obtained integrated indexes varying from 1.0 to 4.3, the zoning of the territory of the city by the ecological condition of the environment (ecological situation) was done. To characterize the ecological situation the following scale was used: < 2.0 – favourable (I); 2.0–2.5 – quite favourable (II); 2.5–3 – rather adverse (III); 3.0–3.5 – adverse (IV); > 3.5 – the most adverse (V).

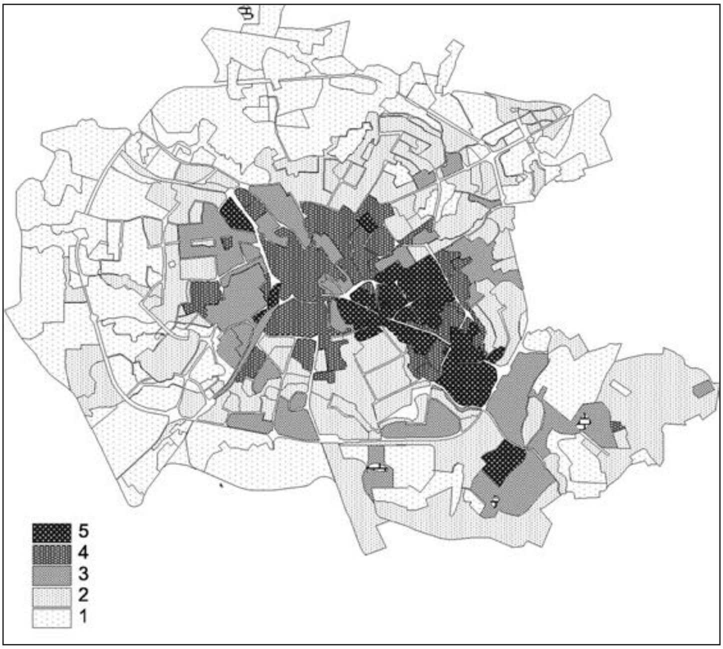

Figure 40: Ecological situation of the territory of Minsk: 1. favourable, 2. rather favourable, 3. rather adverse, 4. adverse, 5. the most adverse
Source: calculation of the authors

The results have shown that the most adverse ecological situation characterizes 13 functional zones located in the southeast part of the city. In total, the share of zones with the most adverse situation is 5.2 percent of the total urban area. Predominantly these are industrial zones, though there are also residential as well as landscape–recreational zones among them.

An adverse ecological situation has evolved in the central part of Minsk. This territory consists of 25 functional zones, including 9 industrial, 6 residential, 4 landscape–recreational and 5 public zones, plus 1 special purpose zone. The total urban area with an adverse ecological situation occupies 7.6 percent of the city territory.

Among the residential zones where the ecological situation is considered to be adverse, it is necessary to mention one zone which is practically surrounded from all sides by considerable emission sources (bus and railway stations in the north, the airport and aircraft repair factory in the south, and a freight yard and car-repair factory in the west).

Relatively adverse ecological situation has been observed in 27 urban planning districts, including 10 residential, 6 landscape–recreational, 2 public and 9 industrial zones. The majority of them are next to zones belonging to the adverse or the most adverse category. Within the city of Minsk, 12.6 percent of the total city area belongs to the rather adverse ecological category.

85 functional zones belong to the quite favourable ecological category, including 36 inhabited, 23 landscape–recreational, 10 public, 12 industrial and 4 special territories. They occupy about 32 percent of the total urban area.

An optimum ecological situation characterizes the city outskirts in its western, northwestern and southwestern parts. There are 87 functional zones occupying 43 percent of the total area of the city within its perspective borders.

For Minsk as a whole, within its perspective borders in 58 percent of the area of residential zones the ecological situation is estimated as favourable, in 25 percent it is quite favourable, in 9 percent rather adverse, in 5 percent adverse and in 3 percent of the area it is the most adverse. Among the landscape–recreational zones the most adverse and adverse situation characterizes 2 percent of the area of the city, while quite adverse situation prevails in 12 percent of the total city area. The zones with favourable and quite favourable situation are predominant, constituting 37 percent and 49 percent of the city area respectively.

The analysis has shown that about 80 thousand people live in zones belonging to the most adverse category, which accounts for 4.5 percent of the total population of Minsk within the borders of perspective building. Besides, a considerable part of the population lives in zones with an adverse situation (about 290 thousand people or 18 percent) and relatively adverse one (245 thousand people or 15 percent).

VIII.4. Conclusion

For the first time for a large city of Belarus (by the example of Minsk) a series of large-scale maps which describe the state of an ambient air, soils, waters and vegetation using integrated indices by functional areas was prepared. It showed that the application of functional areas for the state of urban environment mapping is a perspective methodological approach, as it allows to describe the ecological situation in a city by comparatively homogenous areas and the share of population which suffer several unfavourable impacts.

The obtained spatially differentiated integrated assessment of the urban environment, taking into account natural and technogenic factors of its formation, has served as a basis for urban planning, technical, technological and organizational actions aimed at the realization of planning decisions and ecological regulations according to the General Plan of Minsk City and the development of priority actions for the optimization of the environment in zones belonging to the most adverse ecological category.

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IX. Ecological frame of environmental planning in urban agglomerations (case of Minsk)

Mikhail Struk

Abstract

This chapter deals with the explanation of optimal environmental planning in the major metropolitan area. The assessment of the current environmental planning regulations regarding the city itself and the suburban area is completed. It has been established that in the first case it focuses on the formation of a spatially coherent system of natural complexes, in the second case it refers only to forest protection.

Due to the growing urban population and anthropogenic pressure recommendations were made to introduce environmental planning for the suburban area to carry out the functions of environmental sanitation, water supply and recreation. It is based on a recommended spatial model of the ecological system providing specialized methods of nature management in different parts of the urban areas. Ecological and geographical criteria were determined for setting suburban area boundaries of the natural frame. They are based on the analysis of external matter and energy relations of the city mainly by air and water flows. On the basis of the obtained criteria the external environmental boundaries of Minsk agglomeration were identified. It has been established that they cover a more extended territory than the boundaries of suburban and green zones.

Keywords: ecological frame, suburban territory, natural systems, environmental boundaries, Minsk

IX.1. Introduction

One of the priorities of the sustainable development of large metropolitan areas is to ensure favourable environmental conditions within their borders. Their state depends mostly on the presence and location of natural systems which have not been significantly changed by the economic activity in the cities and the surrounding areas. Therefore, conservation and optimal planning of the latter have become very important.

Some specific management arrangements for the organization of the natural components of urban agglomerations are being made currently. They affect both the urban and suburban areas.

The basis of these mechanisms regarding a city consists, firstly, of the assessment of green areas, which concerns both the urban area as a whole and its individual functional zones (Ministry of Architecture and Construction of Belarus 2003). Secondly, the spatial relationship is planned between these green areas not only within the city, but also in the natural systems of suburban areas.

Regarding suburban areas the building standards require the formation of a green zone including the existing forests into the first group of wood management (State Forestry Committee of the Council of Ministers of the USSR 1978). Industrial logging of these forests is prohibited, only their sanitary felling and thinning are allowed. This ensures the priority of sanitary and recreational values of the suburban forests over their economic value.

The role of the ecological factor in the urban development is increasing at last. The state of the environment in residential areas, and the work and relaxation of people becomes its most important indicator (European Comission 1996). In this respect it is important to determine to what extent the applicable environmental planning systems of cities and their surrounding areas corresponds to the increasing environmental requirements and, if necessary, to identify the ways of its optimization.

The aim of the research was to assess the natural frame as a form of the environmental planning system of the urban agglomeration. To achieve this, the problems of the ecological assessment of the existing approaches to the regulation of such organization, the rationale of its principal model, the definition of criteria to set up territory borders, and their selection for a future urban area were solved.

Minsk city agglomeration has been chosen as a research area. It is largest in Belarus and is one of the relatively large agglomerations in Europe. The population in Minsk is constantly growing, its population as of January 1, 2011 was 1864.1 thousand people.

The processes of suburbanization are going on in the development of the city, which are accompanied by the population growth in the suburban areas. In the next few years satellite towns are being planned on the basis of existing small urban settlements (located within 30 km from Minsk).

IX.2. The current regulation of the environmental planning system of the urban area itself

The internal zoning of the cities according to their predominant function is provided by the building standards. Residential, public, industrial, landscape and recreational areas are specified as well as the territories of transport infrastructure, engineer infrastructure, agricultural use and special purposes.

The natural systems located within the city along with urban and suburban green areas are part of the landscape and recreational areas, which are designed for recreational activities. The standards of green spaces for the cities of Belarus were set according to their share in the urban area, which should be at least 30 percent, and for residential areas not less than 25 percent (Ministry of Architecture and Construction of Belarus 2008). There are also the standards of per capita green areas for common use. They depend on the population of the city and range from 8 to 21 m^2 per person.

To ensure pedestrian and transport links between green spaces and residential areas special standards of accessibility are used. Thus, for everyday recreation the pedestrian accessibility of green places in any residential area should be no more than 5 minutes. The same accessibility of green areas near the places of residence for everyday recreation, health and fitness sessions, walks, games for preschool-age children should be within 15 minutes, while the accessibility of the parks by transport should not be more than 20 minutes.

Green areas in Minsk occupy 45 percent of the territory, including forests (9 percent) and tree and shrub vegetation (4 percent). The density of general use planting is 18 m^2 per one city resident. These figures prove rather a sufficient supply of green areas for the city on the whole. However, they are rather unevenly distributed over the urban area, and this stipulates their deficiency in most parts of the city (Krauchuk, L. A. 2011).

The urban natural systems should form a coherent system of open and green spaces (natural frame). In each particular city this requirement should be obviously realized with regard to local conditions.

The Minsk Master Plan till 2030 suggests the formation of 'ecological corridors' which should ensure recovery of its air basin (Kolontai, A. 2003). For this aim some restrictions are introduced on residential building; as well as the increased greening is required in those parts of urban areas, which have a particularly important recreation value. Building in green wedges linking urban and suburban landscapes and in recreational areas is also prohibited.

The city drainage network lies in the basis of the environmental planning system of Minsk. In accordance with the direction of the rivers in the city, its formation is provided in the form of water and green area corridor combined with the water-park circle. Water and green area corridor crosses the city from the northwest to the southeast. It is formed by the River Svisloch with its floodplain and surrounding natural systems. Water and green circle is created by small rivers – tributaries of the River Svisloch, as well as by a series of artificial ponds in the surrounding green areas.

The provided scheme of environmental planning system of the city, adopted in the Master Plan can be considered optimal for Minsk. It provides the spatial relationship between urban natural systems, as well as the prerequisites for the formation of accessible (by distance) parklands for the population living in different parts of the city.

However, the existing normative base for the development of green spaces and the whole natural frame doesn't eliminate the likelihood of conflicts related to their conservation. In some cases such situations seem to be inevitable; as the city develops, new transport routes emerge and existing roads expand, which may lead to the destruction of certain trees. For such cases, obviously, compensatory actions should be provided.

IX.3. The current regulation of the environmental planning systems of suburban areas

In many countries including Belarus, the separation of green zones around the cities is provided. A green zone is the area outside the city boundaries with forests and forest parks, performing defensive and sanitary functions and being a place of relaxation for the population (State Forestry Committee of the Council of Ministers of the USSR 1978).

In order to establish the areas with green spaces, special standards have been set to ensure that non-urban forests and forest parks are available for the urban population. It takes into account the population of the city and the forestation of each suburban area. The higher the population and forestation are, the higher standards are in use.

The environmental benefits of protecting forests are obvious, because natural forests produce oxygen most efficiently, regulate the water regime and water quality, and generally ensure the preservation of ecological balance.

At the same time, this measure is clearly insufficient for the effective protection of natural systems in the suburban areas, which is caused by several reasons.

1.) The separation of green zones only creates protection for those natural systems that are covered by forests. However, although forests are the most important, they are not the only natural components to form the environment. They also include bogs, meadows, bushes, which act as regulators of water regimes, as wildlife habitat, they prevent soil erosion, etc., therefore they might also require protection.
2.) The absolute conservation of the forest green zone is hardly possible, because, as the city develops, its area increases and the suburban transport network with the appropriate roadside infrastructure expands, it sometimes leads to the reduction of forest lands, too. Furthermore, forests are also cut down when suburban recreational natural systems are planned.

3.) In some cases it is insufficient only to regulate the conservation of the existing natural systems, there is also a need to enhance their recovery or formation. For example, in order to prevent an inflow of soil erosion products into the recreational water body it may be necessary to afforest the slopes occupied by arable land; in order to reduce the pollution effect of the emission source of pollutants – holding plantations in its buffer zone; in order to maintain the ecological balance of the areas of intensive agricultural development – the creation of shelter belts, etc.

Regarding the spatial organization of forests, according to the purpose of the area there are two types within the green zone status: forest park and forestry. Forest parks stand out from the forests by aesthetically valuable landscapes and they usually form the inner belt of a green zone. Aesthetically less attractive forests belong to the external forestry part of a forest green zone.

The above division of green zones has a positive ecological impact. It helps to preserve aesthetically significant forests experiencing intensive pressure due to recreation activities, as it supports their transformation into forest parks. Forest parks due to the relevant arrangement (the creation of roads, installation of appropriate equipment, etc.) are more resistant to the negative impacts of human recreation.

Thus, the separation of a green zone around the city creates certain conditions for the protection of natural systems in the surrounding area. In some cases, mainly in relation to small towns, this measure may be sufficient because their functioning dependence on the suburban area is relatively low and their preservation within forests will provide the environmental needs of these towns.

The situation is different with regard to the major urban agglomerations. They are more dependent on the ecological state of suburban areas. Besides, the anthropogenic pressure on the natural systems within their boundaries is significantly higher and it will only increase later with the growth of the city. In such conditions it becomes necessary to improve the current management mechanism of their protection and spatial organization, which is based on a model of green zone.

IX.4. The substantiation of the model of optimal planning organization of natural systems in suburban areas

This model should be based on the principle of the integration of the environmental heterogeneity of the territory. This principle is partly realized by the allocation of a green zone, when the forested areas are regarded as significant for the formation of the environment, so they get the status of being protected. However, the application of this principle should be expanded, because the forests themselves as well as other natural lands are environmentally unequal according to their location and inherent properties.

The separation of ecologically unequal natural systems will create preconditions ensuring absolute security and establishing the most benign regimes of nature management in the areas that play a particularly important ecological role, by giving them the appropriate status. In turn, the less valuable natural systems can get more freedom as for their use, including the possibility of their conversion, for recreational purposes or technological transformation, for example. The division of the territory into several parts by their environmental significance will allow improving the system of environmental management. Without this division almost all natural objects within its borders may undergo transformations because they are all accepted as equal. But if they are ranked according to their environmental significance, the more valuable objects will be given additional protection from being engaged in economic use.

Ecological studies, dealing with the creation of effective basic models of natural systems of environmental planning proposed various models. The most important one is the model of natural frame, ecological frame and ecological networks.

A natural frame is a system ranked by the degree of its ecological value. It is the connected natural sites, whose inseparable interrelation creates the preconditions for the formation of ecological balance, able to resist anthropogenic influences. It is created in the form of a cellular network, spreading throughout the territory

(Reimers, N. F. 1990). Within its borders the areas with different regimes of use and degree of natural preservation are separated.

An ecological frame is interpreted as a specific set and spatial combination of natural and cultural landscapes, providing ecological stability to the territory (Kolbovsky, E. U. – Morozova, V. V. 2001). Thus, its content is similar to the concept of the natural frame. In fact, the concepts of natural and ecological frame may be considered synonymous.

An ecological network is defined as a system of functionally interconnected protected areas and natural territories, liable to special protection, aimed to preserve the natural ecological systems, biological and landscape diversity, as well as to ensure the continuity of the habitat of animals (NCLI 2011). In this case, there are noticeable differences between the concepts of natural and ecological frame.

The first one of these differences refers to the set of objects that are attributable to the network or frames. In the first case there are only areas with conservation status, in the second – such status does not matter; both protected and unprotected natural areas and sites may be included into the frame. Secondly, in the concept of the ecological network the conservation of biological and landscape diversity is emphasized in contrast to the focus on the preservation of ecological balance prevalent in the concept of ecological frame.

Hence the concept of an ecological network is narrower in comparison with an ecological frame, both regarding the problems being solved and the objectives being set. Therefore, in the organization of suburban area natural systems it is not enough to rely only on this model. Solved with the help of this model, the problem of biological and landscape diversity should be complemented by the objectives of ensuring favourable environmental conditions and natural resource potential. Such addition is provided by the model of natural frame. Therefore, it should be used for the environmental planning system of suburban areas.

IX.5. Rationale of the boundaries of the natural frame of suburban areas

For the formation of the natural frame of a suburban area it is important to set up its boundaries. The greatest effect will obviously be obtained if they coincide with external environmental boundaries of the city. The latter refers to the boundaries of the territory, which has an impact on the environment of the city and the territory within the environment faces urban influence.

The environmental boundaries of the city are formed by its material and energy links with external areas. As the city is located in a particular place of the biosphere, it is included in a system of its inherent linkages carried out by various natural channels – air, water, biological and anthropogenic channels.

In view of the open nature of the biosphere these relationships can spread to very long distances. Therefore, the ecological situation in the city will depend on very remote areas to a certain extent, and also the influence of the city may extend to such territories. However, the biggest priority should obviously be given to the areas that have the closest environmental communication with the city. When determining their boundaries it is necessary to orientate primarily on the connection of air and water flows, as they play an important role in the formation of the environmental conditions of the human habitation.

In order to determine such boundaries for the air channel, well-established approaches to the establishment of urban green zones can be used. They are distinguished on the lands of the state forest fund, taking into account the areas of sanitary protection zones of water sources, areas of sanitary protection of resorts, protective strips along railways and highways, as well as the forest strips around lakes that protect the spawning of valuable commercial fish species, the most valuable forests, anti-erosion forests (State Forestry Committee of the Council of Ministers of the USSR 1978).

For the major cities with a population of over 1 million it is recommended to install green zones on individual projects. The general criteria for all the cities are taken into account when determining their size. The balance of oxygen is also taken into consideration. In the territory of the city this balance is negative. Consequently, oxygen enters into its boundaries from the outside with air flows. The territories surrounding the city, which compensate for the used oxygen, are included in its green zone.

Obviously, not only adjacent, but more remote areas are involved in the production of oxygen, being consumed by the city. At the same time, it can be assumed that the role of the first is more significant, due to their spatial proximity to the city. Similarly, the significance of the location of the sources of air pollution also changes. The closer they are to the city, the greater the risk of pollution to the air basin they represent. As in both noted factors of forming the air quality (the supply of oxygen and pollutants) the area adjacent to the city forming its green zone is more important, it can be regarded as an external environmental boundary for air channel.

For the major cities green zones are set within a few tens of kilometres away. On average, oxygen consumption by a city with a population of one million can be made up due to its regeneration by open spaces in an area of 15 to 20 thousand square kilometres (Vladimirov, V. V. et al. 1986). This means that the radius required for the territory surrounding the city should reach 70–80 km.

The most significant external environmental boundaries of the city on the water channel should be separated taking into account the size of the main river it stands on. The presence, location and use of other water bodies found in suburban and green areas should also be taken into consideration. For the cities situated on the major rivers, the upstream drainage basin can expand to a very large area and include territories in other countries.

At the same time one can hardly consider the entire area of these watersheds to be particularly significant for the city. The rivers have dilution ability, and the larger they are, the higher this ability is. Furthermore, self-purification processes can be observed in them: as a result of these pollutants that enter the river at a great distance from the city can be neutralized downstream. Therefore, within the watershed it is advisable to mark the border that would cover the most essential part for the city.

In order to establish the size of this part of the main drainage basin of the river upstream (from the city), limits of its green zone can serve as a guide. In this case, the area located at a relatively short distance from the city will be classified as particularly significant for the ecological status of urban water. Admission of pollutants into the river directly near the city boundaries provides the greatest threat of pollution of the river area within the city.

Downstream the ecological boundaries of the city on the water channel will be extended to the part of the river where polluting influence will be detected, and the most important boundaries to the part where this effect is particularly noticeable. The excess of maximum allowable concentrations of pollutants or qualitative changes in the river ecosystem can be taken as the criterion for such an effect.

For the remaining (apart from the main river) reservoirs of a green zone, which are used for the city supply and recreation of the urban population, the boundaries of their watersheds should be taken as ecological boundaries. These boundaries together with the local ones on the main river will make the most significant common external environmental boundaries of the city.

For the cities lying on relatively small rivers not only parts of but their entire watersheds should be included into the boundaries of this kind. These rivers have low resistance to external influences, and the quality of water within the city will depend on the ecological state of the entire area.

IX.6. Allocation of the boundaries of the natural frame of Minsk agglomeration

In cities of the size of Minsk suburban areas should be designed and green zones should be established. The current borders of the suburban area in Minsk are defined in the planning scheme made in 2006 (Butrimovich, T. 2008). They are located at a distance of 40–60 km from the city *(Figure 41)*. The radius of the green zone is about 60 km from the city borders. The forest park part is separated within it at a distance of 10–20 km from the city. These are the places of suburban recreation, as well as water intakes of Minsk with zones of sanitary protection.

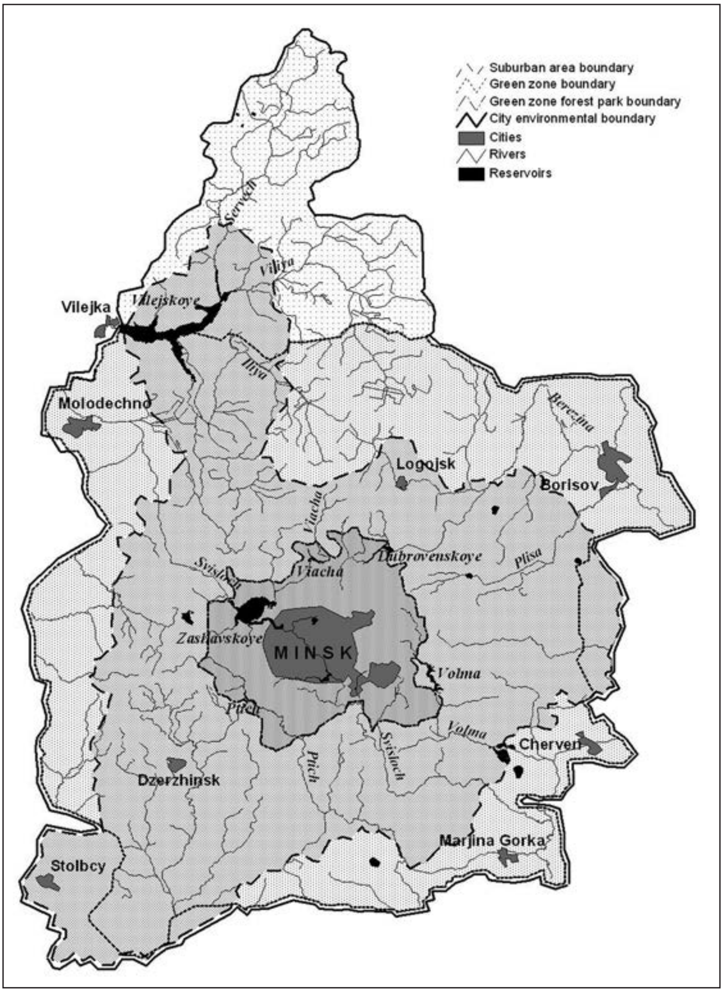

Figure 41: Boundaries of suburban and green zones and environmental boundaries of Minsk
Source: edition of the author

To ensure the environmental interests of the city it is important to determine how the boundaries of the established suburban and green zones correlate with its environmental boundaries. According to the given approaches to the separation of the latter, they may coincide with the air channel links.

In this present case such a coincidence, apparently, may be considered as acceptable. The green zone of Minsk is set as the area that extends to about equal distances from the city in all directions. Consequently, located within its boundaries forests will have a particularly significant impact on the air basin of the city.

On the water channel of links an external ecological city border is determined by the size of the main river and the location of drainage basins that are important to the viability of reservoirs. Their placement has its own specifics for Minsk, caused by the geomorphologic conditions of the city and the surrounding area. These lie in the fact that they are mostly located on the Minsk Upland along which the watershed line of the Baltic and the Black Seas stretches (Struk, M. I. 2007). That is why the rivers are classified as small.

For the recreational needs of the city reservoirs are built on these rivers, and because all of these rivers are small, the watersheds of the created reservoirs cover relatively small areas and do not extend beyond the green zone. The exceptions are the reservoirs of the Viliya–Minsk water system, for which the Vileiskoye reservoir (situated 60 km from the city) appears a donor water body.

The reservoirs of the mentioned water system – Zaslavskoe, Krynitsa, Drozdy – play a main role in the organization of the public recreation in Minsk. About two thirds of the total number of holidaymakers rest in a forest park zone. The Vileiskoye reservoir itself and its coastal territory act as a place of recreation for the people in Minsk. Moreover, the water resources of the Viliya–Minsk water system are used for the water supply of the city and form a major part of the River Svisloch runoff, as well as the water mass of the reservoirs created in the water–green ring. Therefore, ensuring their proper quality appears to be a necessary condition for its sustainable development.

The rivers Viliya and Servech, which form the Vileiskoye reservoir, do not belong to the major ones. Their length as far as their confluence is not more than 100 km, the catchment area of the reservoir is also relatively small; it is 4120 km^2 (Paškoŭ, H. P.

ed. 2007). The drainage basin of such size should be fully included in the most environmentally significant category for the city area, and its watershed line should act as an external environmental city border on water links.

The specified line shows the size of the territory which can affect water resources relevant for the city water reservoirs. A similar borderline should be determined by the polluting influence of the city on the surface water. The receiver of the incoming pollutants is the River Svisloch and its floodplain where they may spread during the floods. The polluting effects of the city on the River Svisloch are observed to the maximum extent in the area stretching from below the municipal wastewater treatment facilities to the village Puhovichi (60 km) (Loginov, V. F. ed. 2009). Further downstream, at a distance of about 90 km from the city the Osipovichi Reservoir is built on it. It, though to a lesser extent, also continues to experience a distinguished polluting effect; for a long time the water quality in it has been unfavourable. (Loginov, V. F. ed. 2010)

Reservoirs usually act as barriers to contaminants, the Osipovichi Reservoir, however, does not stop them completely. High concentrations of some substances are observed in the River Svisloch even below it (NSMOS 2009). A noticeable reduction of pollution in river waters can be observed only after the confluence of this river into the River Berezina. That is why the River Svisloch with the adjacent flood plain along its entire length should be considered the area experiencing the closest ecological links with the city.

Hence, the natural frame of Minsk agglomeration should cover a larger area than the area set for a suburban and a green zone. The environmental measures taken only within these zones are not enough to ensure the environmental interests of the city; they should apply to the entire territory of the ecological frame.

The assignment of the territory to the ecological frame presupposes ranking of natural systems located within its limits by their ecological significance. The basis of this ranking is an assessment of their improving impact on the environment of the city and ensuring a good ecological status of natural resources used for its needs.

Suburban forests have a major significance in the rehabilitation of the urban environment. The highest effect is provided by the forests that have a continuous spatial connection with the landscaped areas within the city, forming a system of green wedges (Rodoman, B. B. 1988). Obviously, they should be classified as the most environmentally valuable.

The significance of the remaining forests and other natural systems can be assessed by the intensity of their direct use for the needs of the city, and the role in the creation of favourable environmental conditions for such use. Thus, a higher rating should be given to the forests and ponds, on the basis of which the main recreation areas of urban residents are created.

In turn, in the catchment areas of noted water bodies particularly valuable natural complexes that play a key role in the formation of their regime and water quality will be allocated. These may include forests and bogs in the headwaters of rivers, grasslands in their flood plains, wooded runoff hollows, etc.

The natural systems that, in their natural state, contribute to the preservation of ecological balance, but their involvement in the economic use would have a risk of negative impact (the formation of gullies, karst, changes in water regime, etc.), should be classified as the most ecologically valuable natural systems. The same applies to natural systems executing a protective function to prevent the spread of contaminants.

IX.7. Conclusions

The present regulation of the natural systems planning organization of the metropolitan area does not fully correspond to the environmental requirements of sustainable development. There are differences in approaches to such an organization in relation to the proper urban area on the one hand, and suburban one on the other. In the first case the formation of an adequate spatially coherent in-city natural frame is provided, in the second case it focuses on the protection of forests only, excluding ecological functions of other natural systems (grassland, aquatic, and wetland).

To ensure the optimal spatial organization of natural systems of the suburban area for the selection of a green zone within it, it is necessary to create environmental planning of this area. It should be based on the model of a natural frame, which will provide spatially differentiated regimes of nature management in its different parts, depending on the environmental values of the natural systems.

The size of a suburban area, applied to the natural frame, should be set taking into account ecological city boundaries. Their separation should be based on the analysis of its most important external real energy links in air, water, biological and technogenic streams.

The separation of external environmental boundaries for Minsk has shown that they cover a larger area than the projected boundaries of its suburban and green zones. Consequently, this territory should act as the object of forming a suburban natural frame, which together with the analogous city frame will provide more favourable conditions for the compliance of environmental interests in the development of the metropolitan area of Minsk City.

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The official cooperation between the Hungarian and the Belarusian geography began to be outlined in a sunny afternoon of June 2010 in the Minsk building of the Geographic Faculty of the Belarusian State University, four years ago. Then we reviewed the potential frames of cooperation with Professor Ekaterina Antipova. It was supported by the academican Károly Kocsis, member of the Hungarian Academy of Sciences, director of the Geographical Research Institute, and we could also win the support of the dean Ivan Pirozhnik and the academician Vladimir Loginov from the Belarusian State University and the National Academy of Sciences of Belarus, respectively. This informal cooperation became official in the autumn of 2010 in the frame of the Academic Mobility Agreement Project between the Hungarian and the Belarusian academies of sciences.

Since then several publications have appeared about Hungary and Belarus in the geographic journals of both countries, however, this is the first, long awaited, significant common publication. Besides the project-based co-operations like e. g. the EastMig (www.eastmig.mtafki.hu) and the ReSEP-CEE (www.mtafki.hu/ReSEP_CEE_Be.html) supported by the Visegrad Fund, a vivid student exchange program was also launched from the autumn of 2010 between the Geographic Research Institute of the Hungarian Academy of Sciences, and the Geographic Faculty of the Belarusian State University with the scholarship program of the Visegrad Fund. Later the Department of Economic Geography of the Corvinus University of Budapest, headed by István Tózsa became also an active partner of the cooperation. The publishing expenses of this book are also fully financed by the Department of Economic Geography.

The editors set up the content frames of this publication together with Vladimir Loginov academician, Ivan Pirozhnik dean, Ekaterina Antipova professor and Liudmilla Fakeyeva senior lecturer. Various authors submitted manuscripts from the Institute for Nature Management of the National Academy of Sciences of Belarus, the Geographic Faculty of the Belarusian State University, the Geographic Institute of the Hungarian Academy of Sciences, the Department of Economic Geography of the Corvinus University of Budapest and the Centre of Geography of the Eötvös Loránd University of Budapest.

English was chosen for the common working language of this study volume to overcome language barriers. We hope we succeeded in setting the language of this publication enjoyable. Due to the limited financial means this volume was made ‘in house’ in many ways. The cover was designed by us, the fragmentation and the typographical preparation of the text was shouldered by László Jeney, my co-editor, senior lecturer of the Department of Economic Geography of the Corvinus University of Budapest, a colleague and a friend of mine.

I would like to express my thanks also to Professor Nikolai Strekha from the Maxim Tanka Pedagogic University of Minsk, who helped me to know my way about the Belarusian geography from the beginning of the summer of 2006.

We hope the Reader; being a researcher, a university lecturer, or even a student, a citizen of Belarus, Hungary or any other country of the world, will gladly utilize this publication.

Dávid Karácsonyi