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Analyses of the growth of urban space

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AIMS AND STRUCTURE OF THE THESIS

Land use and urban sprawl pose a major challenge for landscape and urban policy makers. The spatial expansion of cities has characterized recent urban development across Europe and studies indicate that this process will intensify in the near future. The unpredictable consequences of the disappearance of natural or near-natural and agricultural land as non-renewable resources are rarely mentioned. The fields and forests around the city, but also the areas covered by water, are engulfed in concrete, the landscape is transformed, and the management and preservation of green areas incidentally appear in development plans. Uncontrolled growth and overbuilding are not only concerns with respect to sustainability, landscape and nature protection, but also have long-term adverse environmental, economic and social effects. The Central and Eastern European region has a low rate of urbanization (the rate of change of built-in artificial surfaces), compared to the examples of Western Europe. Researchers call attention to the accelerating growth of artificial surfaces in the region and in Hungary, especially in the urban catchment areas. However, the extent, spatial aspects, characteristics and reasons for this are not known precisely.

It is already known that the growth of cities cannot be explained by the increase in population: in several regions, the population is declining, so the reasons lie in the change in urban lifestyles. Numerous studies have been published on urban sprawl and the various aspects of its urbanization processes. These processes affect the social, infrastructural and regulatory environment of cities and, conversely, the institutional and societal changes have an impact on the change in the urban 'landscape'. This is particularly exciting to study in post-socialist countries, where regime change is still taking place today. The Central and Eastern European region, including Hungary, is unique in terms of changes in urban land use, as the post-regime change trends can be interpreted as a new stage in the Theory of Spatial Cycle, which explains the urban development, and their effects influence the spatial structure of cities in the long run. In order to ensure sustainability, the role of regulation is particularly prominent, which also interests Hungarian professionals.

The topicality is supported by the fact that most studies in this field are limited in time and space, or this topic appears only in the form of case studies in the European or Hungarian literature. Nationwide studies focus on the Budapest agglomeration. However, the situation of smaller cities has been analyzed only in the short term or in the form of case studies, for example: urbanization, suburbanization and its environmental effects in the vicinity of Kecskemét, Szeged and Győr; the economic development of Pécs, Miskolc and Győr; the uncoordinated urban growth in Kecskemét; an analysis of the social effects of suburbanization in the vicinity of Győr; the socio-economic effects of suburbanization in Miskolc; the sustainability of peri-urban areas through the Sopron case study; and changes in land use patterns in the Great Plain and its cities. These studies from different disciplines use various methods and focus on different aspects of urban expansion and urbanization. For

example, few surveys use a land cover database. An interesting aspect of the topic is the experience gained from the joint study of the city and its surroundings, the rural background, the consequences of regulation and the means by which the process can be steered towards sustainability.

My research questions revolve around this topic:

- When, with what features and where do newly built-up areas appear in the city area?
- How can the structure and process of the spatial growth of Hungarian large and medium-sized cities be characterized after 1990? How have the new installations affected the compactness of cities? How can the changes be interpreted in relation to the catchment area and the morphological urban area (MUA) of the central city?
- What types of agricultural or near-natural land have fallen victim to the development?
- What effect could the Hungarian regulation have on the growth of the examined cities?

MATERIALS AND METHODS

To answer the research questions, GIS and statistical analyses of land use data have been applied. The Corine Land Cover Change (CLC CHA) and Land Cover (CLC) databases (1990, 2000, 2006, 2012 and 2018), Google Earth, statistical databases, maps of National Spatial Planning Plan of Hungary, archive maps and photo collections served as the basis of the present research. To determine the extent of sprawl and compactness and to compare the examined settlements, two indicators were developed – the results of which I illustrate in a matrix; and two more indicators were applied to the examined areas based on the literature. 12 functional urban areas (FUAs) were included in the research based on international and national definition of catchment area: Békéscsaba, Debrecen, Dunaújváros, Kaposvár, Kecskemét, Nyíregyháza, Sopron, Szeged, Székesfehérvár, Szolnok, Tatabánya, Veszprém.

Three dimensions of examination were determined for second-tier Hungarian towns:

1. TIME: Based on Corine database the following periods were applied: 1990–2000, 2000–2006, 2006–2012, 2012–2018.
2. FUNCTION: The functions of new land use categories were determined: (i) urban fabric, (ii) industrial and commercial units, (iii) transport units, (iv) mine sites, (v) urban green areas.
3. SPACE: the spatial pattern (morphology) and the compactness of the new artificial surfaces appearing in the regions and their central settlements were examined.

The relationship of Hungarian regulations and land cover changes were examined by comparing the map stock of National Spatial Planning Plan of Hungary and the new

artificial surfaces. The Prime Minister's Office and the Lechner Knowledge Center provided me the files in the fall of 2021, which were analysed using the ArcMap and the Excel software. The comparison of the land cover data and the maps of National Spatial Planning Plan was possible for two periods. A historical analysis and a detailed examination of the tendencies for the period after 1990 in the case of a randomly selected Hungarian town, Veszprém, helped to answer the research questions. The FUA and the town of Veszprém were analysed in detail, involving the local spatial planning plans. My selection criteria included the appearance of features relevant to the sprawl in the settlement and its neighbourhood: diverse topography, economic and cultural significance, the presence of expressways, a growing population, and the available map stock.

Statistical methods were applied to process and interpret the data: different data sets were analyzed with the help of linear interpolation, cluster analysis, and the relationship between the indicators was explored with correlation analysis.

SCIENTIFIC RESULTS

The research highlighted the land use aspects of the sprawl of second-tier towns in Hungary, in detail:

- A methodological framework was formulated for the multidimensional study of new artificial surfaces using the Corine land cover database.
- During the study of urban growth, I integrated the definitions of agglomeration around the town.
- An indicator was developed to measure the sprawl of towns on a regional scale. Two further indicators known in international practice were calculated to characterize compactness and water permeability.
- The time, function and morphological characteristics of the artificial land use changes were presented of the studied urban regions.
- The role of regulation at the national and settlement level were examined to explain the changes.
- In the Veszprém case study, the growth of the town and the relationship between green space and urban growth over a historical period were presented.

New Scientific Results

THESIS 1 An examining method for urban growth based on the Corine land cover database

A comprehensive research method was defined to characterize the growth of cities based on the land cover database, along the dimensions of time, function, space:

1. Based on Corine database the following periods were applied: 1990–2000, 2000–2006, 2006–2012, 2012–2018.
2. The functions of new land use categories were determined: (i) urban fabric, (ii) industrial and commercial units, (iii) transport units, (iv) mine sites, (v) urban green areas.
3. Based on a literature review related to the space dimension, analyses of the functional urban area (FUA, OECD 2013), the administrative area of the central settlement and the morphological urban area were carried out. To define the spatial properties of new artificial surfaces, INOSTROZA et al. (2013) infill, axial, and isolated categories were used, and to define the shape (compactness) of the MUA, the CILP indicator (HUANG et al. 2007) were applied.

The Corine and Corine CHA databases provide a good basis for examining urban growth, but the results can be refined by including additional databases. The Urban Atlas database is limited in time (available for 2012 and 2018 for Hungary), but is more suitable for MUA analysis. In addition, Google Earth imagery helps refine uncertain categories and eliminate Corine errors. The Porosity Index (HUANG et al. 2007) based on Urban Atlas database also provides a suitable basis for delimiting water-permeable surfaces, and is suitable for estimations regarding to green infrastructure. To interpret the sprawl, demographic data was included, and the change in the proportion of new artificial surfaces and population in the settlements between 1990 and 2018 were presented in a matrix. The method is suitable for examining both Hungarian as well as other European cities and urban areas.

THESIS 2 The development of surface cover in the studied FUA

The most important land cover changes in the 12 functional urban areas (FUAs) were reviewed with the help pf Corine and Corine CHA database between 1990 and 2018. It can be stated that agricultural surfaces are the characteristic land uses. Regarding the regions, there are differences compared to the national average in terms of typical land cover:

- high ratio of agricultural surfaces (80% or above), in Békéscsaba, Dunaújváros, Nyíregyháza, Szolnok FUAs,
- high ratio of natural or semi-natural surfaces (30% or above): in Debrecen, Kaposvár, Veszprém FUAs,
- high ratio of artificial surfaces (around 10%): in Dunaújváros, Tatabánya FUAs.

The trends have not changed significantly, the decrease of agricultural surfaces and the increase of artificial and natural or semi-natural surfaces can be identified. The following regional differences and similarities are observed:

- the drastic decrease of agricultural surfaces is typical in Kecskemét, Nyíregyháza FUAs, while the natural and semi-natural surfaces increased here,
- in Sopron FUA the agricultural and natural or semi-natural surfaces decreased as well.
- the increase of artificial surfaces is observed in all the examined FUAs.

The trends of new artificial surfaces were grouped according to periods and FUAs. I found that the artificial surface growth of the western part of the country can be set relatively earlier than that of the eastern part of the country. The period 2006–2012 was not relevant for any of the FUAs from this perspective.

Compared to the national average (6.5% artificial surface, 64.7% agricultural surface and 28.8% natural or semi-natural surface, 2018) there are differences in the typical land cover in the studied regions. The values of Kaposvár reflect the national distributions the most. Extensive growth of new artificial surfaces observed in the FUA of Dunaújváros, Kecskemét, Székesfehérvár, Debrecen and Nyíregyháza. The least intense changes were experienced in Kaposvár and Békéscsaba FUAs. A total of 10,072 hectares became artificial surfaces in the study areas between 1990 and 2018. This is less than 25% of the national transformation (44,968 hectares) in the same period. The tendency of the new artificial surfaces in the examined FUAs and in Hungary is similar between 1990 and 2012, but differs between 2012 and 2018: while in the studied FUAs a slight upward trend is valid in Hungary. For each FUA, the period of the largest growth of new artificial surfaces is highlighted and grouped according to whether they belonged to the eastern or the western part of the country (the reference point was the Danube line). According to this, an east–west divide can be established. An exception is the Székesfehérvár FUA, due to the transportation development, the peak was identified in the period between 2012–2018.

THESIS 3 Describing urban sprawl in 12 FUAs

To review the sprawl in second-tier towns in Hungary, the ratio of new artificial surfaces was calculated to the artificial surfaces in 1990 within the FUAs. The result was compared with population change between 1990 and 2018. The results were identified by the method of cluster analysis, based on which 4 groups were formed:

1. Group 1 – Average trend: Debrecen, Kecskemét, Nyíregyháza, Szeged, Székesfehérvár, Tatabánya, Veszprém FUA. These FUAs stand out in relation to the growing or slightly declining population compared to the national average, but new artificial surfaces have appeared close to or slightly above the national average.
2. Group 2 – Stable size: Békéscsaba, Kaposvár, Szolnok. The sample is characterized by a larger population decline and a small artificial surface

increase. The similar trend of Kaposvár and Békéscsaba FUAs is striking, while within the group it differs due to the higher artificial surface growth.

3. Group 3 – Special geographical situation: Sopron. The prominent proportion of new artificial surfaces explains the separation from the other clusters, with more similarities to the FUAs of the first cluster in terms of slight population growth.
4. Group 4 – Sprawling trend: Dunaújváros FUA: The outstanding proportion of new artificial surfaces explains the separation from the other clusters, but here it is more similar to the 2nd cluster in terms of population decline.

The indicators were determined for the 12 examined FUAs (i) individually, (ii) for the whole group of the 12 FUAs, and (iii) for the whole country for the sake of comparability. It can be seen that most of the studied FUAs are characterized by similar tendencies. In the case of the first two groups, Szeged and Békéscsaba were the cluster centers. Perhaps, Debrecen differs from the first group in terms of the database due to the large population growth, it could have formed a separate cluster if a larger group number had been determined. The trends in the FUAs of the first group are considered to be average, while the FUAs lagging behind were rather included in the second group, regarding population change and new artificial surfaces. The significant increase in Sopron can be explained by its border position and the proximity of two capitals, Vienna and Bratislava. Dunaújváros FUA is considered to be the most sprawling one, where both the increase in artificial surfaces and the decrease in population are above average.

THESIS 4 Characterization of surface cover changes along the TIME dimension

The examination of the new artificial surfaces was examined in the breakdown of 4 time intervals (1990–2000, 2000–2006, 2006–2012, 2012–2018) (time dimension), taking into account the functions. Most of the new artificial surfaces appeared between 2000 and 2006, but differences were found in the distribution by function. The detailed findings are as follows:

- Between 1990 and 2000, the proportion of new artificial surfaces is the lowest, as well as the proportion of new transport units (1.4% of all new artificial surfaces in the whole period).
- Between 2000 and 2006, there was a strong increase in new artificial surfaces (33% over the whole period), especially in urban fabric (11.9% of all new artificial surfaces over the whole period).
- Between 2006 and 2012, the appearance of new urban green areas was particularly low (0.5% of all new artificial surfaces in the whole period), and the growth rate of urban fabric decreased significantly compared to the previous trend (3.4% of all new artificial surfaces). in addition to the

fact that growth in industrial and commercial units has remained stable, and growth in new transport units has intensified.

- In the period between 2012 and 2018, a higher increase in new transport areas (10.4% of total new artificial surfaces in the whole period) and mine sites (5.5% of all new artificial surfaces in the whole period) were identified than before.

77.3% of new urban fabric appear between 1990 and 2006, which can be attributed to suburbanization and national housing policy measures. After 2006, despite the housing policy measures, no significant increase in new urban fabric can be detected. The intensity of the appearance of new transport units differs significantly from region to region and can be compared to the target areas and periods of the national motorway expansion. The emergence of new industrial and commercial units is similar in the examined periods. Building industry may responsible for the appearance of the new mine sites.

Between 1990 and 2018, 1885 hectares, between 2000 and 2006, 3321 hectares, between 2006 and 2012, 2538 hectares, and between 2012 and 2018, 2508 hectares of new artificial surface appeared in the studied FUAs. In internal ratios, there are several explanations for the changes. In terms of urbanization cycles, the phenomenon of suburbanization can be detected regarding of the emergence of new residential areas (urban fabric). In this context, the measures responded to social needs and supporting housing are also dated to this period (Széchenyi Plan). The appearance of new industrial and commercial units is stable for the whole period, differences were identified by regions. The new transport units can be explained by the construction of motorways, expressways and main roads in the study area. I did not find any explanation for urban green areas, while the period between 2006 and 2012 is characterized by the lower proportion of mine sites, while for the latter category, the growth in the period 2012–2018 is outstanding.

THESIS 5 Characterization of surface cover changes along the FUNCTION dimension

The functions of the new artificial surfaces of urban growth were identified based on the Corine nomenclature, manually correcting the gaps in the database by Google Earth. Using cluster analysis, the results were grouped by period, function, and FUA. Based on these, the following conclusions can be formulated:

– The proportion of new urban green and recreational areas created is low in the whole period (1990–2018) within the newly created artificial surfaces (4.1% in the whole period). The new locations are closely related to the existing resort functions (especially in the case of Veszprém FUA). The role of new green areas is marginal in the regions of the Great Plain, with the exception of Szeged and Debrecen FUAs.

- The cluster analysis confirmed that the peak period of the appearance of urban fabric in all the examined regions is between 1990 and 2006, so suburbanization appears in all settlement regions.

- The appearance of mine sites between 1990 and 2018 does not show a pattern.
- Based on the functions of the new artificial areas created in the whole period (1990–2018), the unique characteristics of each region can be identified: Veszprém FUA has extraordinarily high (111.6 hectares) new urban green areas. In Dunaújváros FUA, the extent of the new transport units (676.4 hectares) is high and it can be regarded as a transport corridor based on the patterns drawn by them. The constantly emerging new urban fabric of Sopron FUA (457.4 hectares in total) can be explained by their unique geographical location.

The results partially overlap with the results of the TIME dimension, so the new findings were reported in the thesis. The growth of the new industrial and commercial units can be explained by the greenfield industrial investments and the appearance of commercial facilities, their role after 2006 is significant. Looking at the whole period, the new industrial and commercial units play a decisive role, with more than 300 hectares of new land in the Tatabánya, Nyíregyháza, Székesfehérvár and Kecskemét FUAs. The new transport units follow the dynamics of motorway construction and are also significant factors in the appearance of artificial areas, especially in the following cities and their catchment areas: Nyíregyháza (M3 and 338 roads), Debrecen (M35 and 46, 441 main roads), Dunaújváros (M6), Szolnok (M4, especially in the period 2012–2018), Székesfehérvár (main road 8 especially in the period 2012–2018). In the regions of Dunaújváros (76%) and Nyíregyháza (52%), the proportion is particularly outstanding. The increase in new urban fabric is a consequence of suburbanization, which can be explained by new social trends, both national and local housing policy measures. The FUAs of Nyíregyháza, Kecskemét, Szeged, Sopron and Debrecen are outstanding in terms of new residential areas. No new urban green area is typical; however, the case of Veszprém FVT is unique with a total of 111.6 hectares, presumably due to the expansion of resort areas (NÉMETH 2011). On the other hand, the appearance of new urban green areas in the town due to the enlargement of the local zoo explains the result. In the case of the FUAs of Békéscsaba, Dunaújváros, Szolnok, Nyíregyháza and Kecskemét, no new urban green area appeared.

THESIS 6 Characterization of surface cover changes along the SPACE dimension

The surface changes were presented and analyzed with GIS tools within all of the FUAs. The new artificial surfaces are arranged around the central settlement in Békéscsaba, Debrecen (especially the residential area), Kecskemét (especially the urban fabric and industrial and commercial unit), Kaposvár, Nyíregyháza, Szeged (especially the industrial and commercial unit) FUAs. The development of the road network is outstanding in Dunaújváros, Nyíregyháza, Székesfehérvár, Veszprém and Tatabánya FUAs. The new artificial surfaces are scattered around Szolnok,

and the new urban fabric is also scattered around Szeged FUA. The grouping of new artificial surfaces within FUAs was described by INOSTROZA et al. (2013). Purely isolated installation is not typical of any of the examined FUAs.

1. Infill: Kaposvár and Kecskemét (except the southern industrial area).
2. Axial: Dunaújváros, Tatabánya.
3. Mixed (infill, axial and isolated): Nyíregyháza.
   a. Infill and axial: Debrecen, Veszprém, Szeged.
   b. Infill and isolated: Békéscsaba, Sopron.
   c. Axial and isolated: Székesfehérvár, Szolnok.

In Kaposvár and Kecskemét FUAs, an infill type, connected development to the already built-up areas, is clear. Due to the morphological features of Kaposvár FUA, its expansion fills the green area between the strip plots and vineyards. In Kecskemét FUA, the new residential developments are more connected to the scattered farmland areas and to the western outskirts of the city. The exception is the greenfield factory area in the southern area, which is connected to the city body by its vast extent. The example of Dunaújváros and Tatabánya FUAs is typical of the installation along the axis, in both cases an important transport route, and in the case of Dunaújváros, the Danube is the driving force of the spatiality of growth. In the case of both FVTs, fill-type installations can be observed, typically with residential and economic function, but the characteristic along the axis is the dominant one. Based on the observations in the area of Nyíregyháza FUA, all three types of construction can be observed: the new industrial and commercial units are isolated, the transport units are along the axis, while the new urban fabric is isolated and infill. In Debrecen, Veszprém and Szeged FUAs, new installations appear as infill and axial areas. Typically, urban fabric and industrial and commercial units are connected to the road network. In the case of Békéscsaba and Sopron FUAs, the infill and the isolated type of installation appear simultaneously. In Békéscsaba FUA, we can typically talk about isolated installation due to the peculiarities of different functions: mine sites and transport units are isolated. Sopron was expanded with a large amount of new urban fabric, which appeared in the central settlement in a filling and isolated way in the catchment area. In addition to the installation along the axis, we can also find isolated patches in Székesfehérvár and Szolnok FUAs. In the case of Székesfehérvár, the new urban fabric is isolated, the industrial and commercial units follow the road network in the direction of Budapest and Veszprém.

THESIS 7 Characterization of the spatial relationship system of the central settlement and the morphological urban areas (MUAs) based on artificial surfaces

The differences were analysed between the administrative area of the central town and the spatial categories of the MUA in the sample of 12 towns and found that the ratio of the administrative area of the central town to the extent of the MUA

varies between 8–32%. The proportion of the MUA is typically lower in the towns of the Great Plain. The low proportion of Sopron (8%) can be explained by the proximity of the border and historical reasons (demarcation). The highest proportion is observed in Dunaújváros (32%) and Tatabánya (27%). I found that in the examined sample, the proportion of green infrastructure is the highest in the MUA of the two settlements that fill the administrative area the most and that bear the hallmarks of modern urban architecture the most.

The examination of the territorial distributions became necessary due to the different characteristics of the administrative area of the settlements (MENDÖL 1963). I presented the differences between the town in the geographical sense and the town in the administrative sense in the 12 areas examined: for example, the administrative area of Debrecen is much larger than the MUA, while in the case of Kaposvár, for example, this difference is smaller.

THESIS 8 Compactness: Appearance of new artificial surfaces in relation to FUA, the administrative area of the central town and the morphological urban area (MUA)

The results were revied in relation to the FUA, the administrative area of the central town and the MUA. Between 1990 and 2018, almost half of the new artificial surfaces (46.2%, 4775.8 hectares) were created in the central town for the total number of FUAs. The proportion of industrial and commercial units and urban fabric created between 1990 and 2018 is higher in the administrative area of the central town than in its functional urban area (61% of the new industrial and commercial units and urban fabric, i.e. a total of 3,520 hectares, are located in the 12 central towns).

The appearance of the new artificial surfaces in relation to the 12 central MUAs was also characterised. The surfaces tightly connected to the MUA typically have a residential and economic function. The new artificial surfaces occupy the most agricultural areas (arable land, pasture) on the outskirts of the city. The direction of the growth of the MUA is basically determined by the traffic routes, natural formations and the already existing industrial functions, adjacent urban fabric, building patterns, with the fact that the conditions differ from town to town.

Regarding the change in compactness between 1990 and 2018 using the CILP indicator, the towns (MUAs) were characterized according to the following groups:

1. Increasing compactness: Békéscsaba, Sopron, Szeged.
2. Decreasing compactness: Debrecen, Dunaújváros, Kaposvár, Szolnok, Tatabánya.
3. Highly decreasing compactness: Kecskemét, Nyíregyháza, Székesfehérvár and Veszprém.

The new artificial surfaces of Békéscsaba is typical in the north, continuing to the other side of the railway line, along the north–west axis. The growth of Sopron shows an east–west arrangement, adapting to the main transport axes. In the case of Szeged, in contrast to the line of the Tisza, an increase can be observed in the north-west–south-east direction. The new developments related to the city of Debrecen show an east–west orientation. The north–south growth of Dunaújváros is counteracting compactness, even though only a few spots are closely connected to the MUA. In the case of Kaposvár, a slight decrease is observed, and the result can be considered surprising due to the filling nature of the installations. Presumably the increase in the district is causing the change. The north–south growth of Szolnok affects the axis of the transport routes and the peripheral areas far from the line of the Tisza, it can be characterized by larger spots moving away from the MUA. The growth of Tatabánya (northwest) is in the direction of the nearby larger town, Tata. For Group 3 cities, the increase is protruding. In the case of Kecskemét, the large area of the new Mercedes factory explains the change. In Veszprém the new industrial area connected to the northern part is responsible for the growth. In Székesfehérvár, the industrial and commercial units appeared in the northern and eastern directions, while in the case of mixed developments appeared in the south, the new urban fabric and the already built-up patches connected by them cause significant growth. From the study, the increase in residential area towards Sóstó and Oros results in long extensions, which also means a significant increase in the urban area. Here, the connection of homesteads with a complex cultivation structure is also understandable.

THESIS 9 Comparison of the National Spatial Planning Plan and the new artificial surfaces

The new artificial surfaces appear mainly in agricultural areas. The result is based on a comparison of their territorial classifications of the land cover changes in the Corine period 2006–2012 and the regional and zoning territorial classifications of the National Spatial Plan that came into force in 2008; and the land cover changes appearing in the Corine period 2012–2018, and the regional and zoning plans of the National Spatial Plan that came—nto force in 2013. The extent of transport units as in the agricultural area is significant in both periods. The area of arable land with excellent production conditions is also significantly affected by the developments, despite the restrictions, mainly transport routes, industrial and commercial units appear on the best quality arable land. Meanwhile, residential, industrial and commercial units typically appear in urban areas.

The changes were reviewed for the area of Veszprém FUA. It was found that new artificial surfaces (residential area, transport units, mine sites and industrial and commercial unit) appeared in the Natura 2000 areas and the ecological network that includes them. After 2000, no new artificial surface appeared in forest area with excellent production potential and arable land with excellent production

potential, in addition to the fact that the arable land with excellent production potential has a small impact on the area of Veszprém FUA.
Based on the comparison of the spatial planning plan of the town of Veszprém adopted in 2005 and the new artificial surfaces by Corine in the period between 2006 and 2018, 81% of the new artificial surfaces of a total of 87 hectares corresponded to the spatial planning plan. Exceptions are new mining, urban green areas, and transport units between 2006 and 2012, which appeared in Natura 2000 sites.
Based on the findings, the rules for the construction of Natura 2000 sites, i.e. the ecological network area and arable land with excellent production conditions, do not provide protection against the appearance of artificial surfaces.

The relationship between change and regulation has been reviewed on a national and regional scale. Although it was possible to analyse the changes only over a different periods due to the small size of the differences, meaningful conclusions can be drawn that call attention to the need to protect high-quality arable land and Natura 2000 sites.

THESIS 10 Urban green spaces in Veszprém that have survived in the historical period

With the help of delimitations and categorizations made in map databases, I determined the green spaces in the central area of Veszprém that have survived in this quality since 1856. Based on the results, it can be stated that the following areas have been preserved as green spaces throughout history:

- surfaces with special topography,
- historical gardens,
- cemeteries,
- planned public spaces in the area of greenfield investments,
- areas at town edge.

By matching the map files, the green spots emerged that retained their role in and around the town despite their decline. The importance of these green spaces is increasing with the density of the MUA, and their protection is extremely important for the liveability of the town.

THESIS 11 The quality change of urban green spaces in the historical period in Veszprém

With the help of delimitations and categorizations made in map databases, archival photo documentation and statistical data, the quality change of the green spaces of Veszprém was reviewed between 1856 and 2018. The results were compared with the Hungarian and general European changes. Based on the results, it can be stated that the development of green spaces in Veszprém differs from European and

Budapest trends: it follows a different development path (reconstruction of the town centre, lack of large-scale park developments, marginal role of green spaces in the centre). Regarding the development of the green spaces of Veszprém, the following periods were identified:

- 1856–1920: Organic growth.
- 1920–1949: Stagnation.
- 1949–1960: Path finding.
- 1960–1990: Selective development.
- 1990– Postmodern.

Based on the results, the historical monitoring of the green spaces of Veszprém can be divided into periods. At the end of the 19th century, before World War I, the parks had a primarily recreational role, and concerning their quality, the aimed was to create representative parks and gardens. The paved, intensively used streets were part of the green infrastructure, the immediate surroundings of Veszprém were coloured by popular walking paths and excursion places. During the world wars, the everyday use and function of green spaces remained. Functional spaces, such as the market or representative surfaces, have been simplified due to declining maintenance costs. Substantial change was experienced after the world wars, when a new era of socialism brought fundamental changes. Representative surfaces became advertisers of the new ideology, lost their privileged position, and were used by a wide range of people. In some parts of the Érsekkert (Bishops' Garden), for example, playgrounds have been created and huge statues have been erected in popular places. Developments in heavy industry have also started, where the role of green spaces is marginal. The capacity of educational institutions has been increased, and the importance of outdoor spaces suitable for everyday sports activities has also grown. To address the issue of housing, they began designing housing estates, which also feature extensive green space. After the change of regime, due to the budgetary situation, large-scale, new-minded developments in public areas started only in the 2000s, the most beautiful example of which is the rehabilitated green corridor along the Kolostorok és Kertek (Monasteries and Gardens) along the Séd Stream in 2008 or the downtown public area development started in 2010. The objective of the Veszprém Green Surface Development Strategy (2019) for the period 2020–2024 is renewal, which it intends to achieve with the means of sustainability and climate protection.

CONCLUSION AND RECOMMENDATIONS

Answers to research questions

When, with what features and where do new built-up areas appear in the city area?

The question is answered by examining the new artificial surfaces. The most intense period of their appearance is between 1990 and 2006. I was able to identify discrepancies by examining the functions, which shows that the appearance of new urban fabric happened between 1990 and 2006, while new transport areas appear in line with the construction waves of highways and expressways. The extent of new industrial and commercial units is continuous during the periods under review. The appearance of the new artificial surfaces is typical of the central town, its situation is related to the main transport routes, and it can be related to the topographic features. In addition, it can be stated that new residential and economic areas typically dominate on the outskirts of the MUA.

Regarding the period before 1990, economic and residential areas appeared after World War II, in the period of socialist urban development to a greater extent than ever before, on the edge of the city at that time. The peak period was in the 1960s and 1970s. I found that the economic areas designated by the socialist industrialization and the transport axes attract new economic incorporations, after 1990 a new economic area is characteristic of the settlements with an earlier economic role. Domestic suburbanisation can be detected by examining new residential developments, their appearance slowed down after 2006 based on land cover. New urban green areas are to a small extent typical of the studied scale, they are concentrated in the surroundings of the resort areas. In the examined sample, I identified areas with unique characteristics: due to the geographical position and historical heritage of Sopron and Dunaújváros, they show a different development trajectory. Due to the low rate of appearance of new artificial surfaces, Békéscsaba, Kaposvár and Szolnok can be classified into separate groups, while the other settlements show a similar development trend.

How can the structure and process of the spatial growth of Hungarian large and medium-sized cities be characterized after 1990? How has the new installations affected the compactness of cities? How can the changes be interpreted in relation to the catchment area and the morphological urban area (MUA) of central city?

I interpreted the pattern of new installations according to three categories: infill, isolated, and axial. Buildings vary according to function, new farm and urban fabric are typically infill or axial, while mine sites and transport units appear in a more isolated way. In some cases, a road or a geographical formation determines the direction of the developments, as in the case of Dunaújváros, Tatabánya, Veszprém;

while in other cases, the characteristic morphological conditions and the existing structure affect the location of the new artificial surfaces, as in Kaposvár, Nyíregyháza or Sopron. The towns divided by the Tisza (Szeged, Szolnok) also form a separate group. Typically, new installations do not increase the compactness of the city, except for Békéscsaba, Szolnok and Szeged. I have shown that there are serious differences between the settlements and the size of the administrative area in terms of the settlements of the sample (8–32%), which can also be interpreted as a difference between the periphery and the inner area. Presumably, there may be historical and geographical reasons for this: the towns of the Great Plain typically have an extensive outskirt area, which was formerly sparsely inhabited due to homesteads, swampy landscapes, Turkish occupation, etc.; while the popular towns of socialist industrialization, Tatabánya and Dunaújváros, fill the administrative area the most. There are also differences between the individual settlements, both in terms of structural features and the new installations, which I have discussed in detail.

What types of agricultural or near-natural land have fallen victim to the development?

The victims of the appearance of artificial surfaces are arable land, farms, or large pastures. Forests or shrub forests are less commonly affected. In addition, the installations affect excellent and high-quality arable land to a similar extent as less good ones. While within the national areas designated in the National Spatial Planning Plan, the forest management area was mostly affected by the new transport areas, the settlement area is characterized by industrial and commercial units and urban fabric. The example of Veszprém shows that in the historical perspective, the new developments reduce the horticultural areas of the city edge, and the relocations typically affect them. With the emergence of new artificial surfaces, the green spots within the MUA are also steadily declining. Areas that stand out due to their function or the possibility of their incorporation due to their capabilities can survive.

What effect could the Hungarian regulation have on the growth of the examined cities?

The areas of national regulation only pose a weak constraint. The new artificial surfaces appear mainly in agricultural areas, a significant part of which is in arable lands with excellent production conditions, which are to be protected according to the National Spatial Planning Plan, and their incorporation is limited. Based on the case study of Veszprém, the restriction related to forest areas seems to be useful based on the data, but it would be worthwhile to examine the effects in a wider sample. The Natura 2000 site classification does not mean protection either, I have also detected constructions in this area. The fate of many areas is decided at the local level, and the designations of the local spatial planning plan and their amendments appear as important tools in the hands of local governments.

Recommendations

Research and scientific work have also confirmed that arable land and Natura 2000 sites are the losers in urban sprawl. The protection of these areas is the task of the Hungarian territorial regulation, which, although it applies strong restrictions, does not provide exclusive protection for these areas, and its (lack of) observance can also be considered a concern based on the results. Occupancy of economic areas can even be linked to compensation in more valuable natural and agricultural areas.

The green infrastructure of the towns decreased in the studied period (2012–2018), while their built-up areas increased. The use of green infrastructure to curb urban growth or promote more liveable urban life at home is still in its infancy. Budapest is a pioneer, but the same cannot be said of the small and medium-sized towns studied. Although we can find examples where the use of green infrastructure has yielded contradictory results (to some extent, a rise in property prices has been demonstrated as a result (NETUSIL et al. 2014) and the growth of the city has not been halted (Portland, PARK 2018, JUN 2004)). Taking into account these risks and drawing conclusions, it is recommended to encourage municipalities to use "green tools" in their territorial policies.

Incentives for joint planning of local governments are lacking in domestic regulations. Joint planning would facilitate the sharing of functions, which could be a solution not only for economic reasons, but also for the need to protect a particular natural or cultural value. French spatial planning practices are familiar with such tools as the voluntary maps (Charte Paysagére, Chartedu Parc Naturel Régional), the landscape plan (Plande Paysage) or the PAEN (La protection des espaces agricoles et naturels périurbains, peripheral areas) (SALA et al. 2014).

The design of a compact city can only be effective if it is accompanied by measures aimed at liveability. International examples (the city of Stara Zagora in Bulgaria or the Royal Harbor Eco-District project in Sweden) confirm that, in parallel with filling (even brownfield) developments and higher level area indicators, rethinking and restructuring the use of open space is essential to increase liveability. These include the creation of appropriate environmental quality, the even distribution of services through the establishment of secondary centres, or the alignment of community and market interests (EVERS et al. 2020).

The area required to build a road network is significant and often affects valuable production areas. In addition, the morphology of urban development and the location of future economic areas are also influenced by the route network. In addition to the suggestions of MÉSZÁROS (2021), I consider it important that several route variants be developed during the selection of the trail lane, which also considers the optimal land use and avoids valuable nature conservation or agricultural areas.

There is a lack of coherence between territorial policy and housing policy. While the aim of spatial development and spatial planning is to set the framework for a more compact urban growth than at present, housing subsidies encourage the construction of newly built properties, which typically result in greenfield construction. It would be important to steer home-seekers towards the renewal of existing real estate and encourage investment in brownfields.

There is a lack of coherence between territorial policy and economic policy. To the best of my knowledge, in the case of disadvantaged settlements, the institution of free

enterprise zones is the one that can affect the territorial aspects of investments, but the principles of sustainable land use are also lacking here (protection of arable land or avoiding greenfield investments where possible). The relationship between territorial policy and economic policy may appear in the responsible use of land by local governments, but this is rare. The example of Veszprém shows that there are new economic areas in the former socialist industrial areas and their catchment area and next to the ring road, which can be explained by transport and logistics opportunities and the decisions of the current city management, rather than by regional policy incentives. This phenomenon also appears in Győr and Miskolc (LUX 2014). I suggest that territorial policy goals be more strongly reflected in national economic policy.

There is a lack of coherence between territorial policy and the law on local government. The current structure of municipal resources encourages municipalities to generate revenue through local taxes and land sales. In the 1990s and 2000s, personal income tax revenues dominated. This fact should shift municipal policies and new land uses towards the creation of new residential areas, while the current situation promotes the sale of land – thus economic use and the role of businesses is preferred, which also entails the emergence of new artificial areas. It would be worthwhile to review the effects of the Local Government Act on land use; and based on these to include incentives in it that would direct local governments towards the renewal of the existing real estate portfolio and promote brownfield investments instead of growth.

The PhD thesis presents new results in terms of the new artificial surfaces that appear during the growth of cities, the characterization of dispersal, the morphology of urban growth and the urban development of Veszprém. The results are not only theoretical, they also contribute to the tools of Hungarian regional development and spatial planning, they draw attention to the importance of the growth of Hungarian second-tier towns, the protection of agricultural and natural or semi-natural surfaces and the prominent role of local governments in sustainable land use.

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