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Land-use characteristics of urban sprawl around Hungarian middle-sized towns

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1. Abstract

The urbanisation of Central Eastern European Countries is low compared to the Western European examples: The rate of the surfaces affected by urbanisation is 0.14%, in the Czech Republic and 0.11% in Slovakia and Hungary(Feranec et al. 2010). The growth of new artificial surfaces (defined by Bossard et al. (2000) Nomenclature main category Nr.1) and land consumption increased after 1990, particularly in the urban catchment area (Hardi et al. 2020; Cieslak et al. 2020; etc.). Only a few studies – highlighted the capitals and cities – deal with exact spatial aspects of urban sprawl in post-socialist countries and provide evidence to spatial planning and regulation. In present study we aimed to answer the following questions: What are the most important functions of new artificial areas after the regime change in Hungarian middle-sized town and their neighbourhood? Can the urban sprawl be explained by demographic changes in study area? What kind of natural, semi-natural or agricultural areas are affected by urban sprawl? Which zones have the most intensive growth in new artificial surfaces?

To answer the questions CORINE Land Cover Change (CLC CHA) geodatabase and statistical data between 1990 and 2018 were analysed, illustrated, and interpreted for 12 Hungarian middle-sized town and their catchment areas. The first results suggest that the tendency of urban sprawl is different from the aspects of demography. Also, the authors would like to draw the attention on the importance of motorway construction in consumption of natural land and weak protection of arable land with excellent production conditions and Natura 2000 areas. Recent study provides information to regional planning by repelling the function of areas affected by land consumption.

2. Introduction

Land use and urban sprawl pose a major challenge for landscape and urban policy makers (EEA 2016, EEA 2007). The spatial expansion of cities has characterized recent urban development across Europe and studies confirm that this process will intensify in the near future. This is not only a concern for sustainability, but also its long-term adverse effects from environmental, economic, and social point of view (Hennig et al. 2016). The research presented seeks to answer the following question: What are the most important functions of new artificial areas after the regime change in Hungarian middle-sized town and their neighbourhood? What is the relation between population trends and urban sprawl in the study area?What kind of natural semi-natural or agricultural areas are affected by urban sprawl? Which zones have the most intensive growth in new artificial surfaces?

3. Background and Literature Review

Urban sprawl cannot be explained by population growth (Evers et al. 2020): in several regions, the population of urban areas is declining (Hennig et al. 2015), so the reasons lie in the change in urban lifestyle (Hennig et al. 2016). Eastern European countries, including Hungary, are affected by the increase in artificial surfaces after 1990, especially in the catchment area of towns and cities (Hardi et al. 2020; Cieslak et al. 2019; Lennert 2018; Gutman and Radeloff 2017; Grigorescu et al. 2012). However, compared to European examples, urbanization in this region is very low (ratio of artificial surfaces is 0.14% in the Czech Republic, 0.11% in Slovakia and Hungary compared to Western European examples, like the Netherlands 2.14%, Portugal 0.79% or Germany 0.57%) according to Feranec et al. (2010).

The Central and Eastern European region, including Hungary, provides an exciting area for the change of urban land use, as it can be interpreted as a new stage in the development of towns, and its effects affect the spatial structure of cities in the long run. In order to ensure sustainability, the role of regulation is particularly prominent, which also employs Hungarian professionals (Kovács 2017).

Most studies report results in a limited time and space, or only as a case study, examining either the European or Hungarian literature (Plieninger et al. 2016). Nationwide studies focus on the Budapest agglomeration (e.g. Lennert et al. 2020; Kovács et al. 2019; Cegielska et al. 2018; Egyedné Gergely 2014; Schuchmann 2013; Tosics 1998). However, the situation of smaller towns has only been briefly or ad hocly studied, for example: The environmental effects of the urbanization of Kecskemét and Győr (Hoyk et al. 2020); Zalaegerszeg or Sopron (Bazsóné Bertalan 2018; Kristóf 2018; Vasárus 2016; Lux 2014; Mucsi et al. 2009; Pocsi 2009; Kókai 2006; Hardi 2002); forms of land use in the Great Plain (Kovács 2011). These studies from different disciplines use different methods and focus on different aspects of urban expansion and urbanization. Only a few surveys use the CORINE Land Cover (CLC) database.

4. Method and Data

In the research the definition of functional urban areas (FUA) (OECD 2013) and settlement groups (KSH 2014) were applied, their common intersection –the urban regions that fell into both categories – resulted the 12 regions (Figure 1), with the centers of the following towns: Békéscsaba, Debrecen, Dunaújváros, Kaposvár, Kecskemét, Nyíregyháza, Sopron, Szeged, Székesfehérvár, Szolnok, Tatabánya, Veszprém (Figure 1). Based on the methodological comparison of the two delimitations, it can be said that the settlement group expresses a closer relationship between the central settlement and the settlements classified in its catchment area than the FUA (Iváncsics and Filepné, 2018).

The size of the selected FUA areas varies from 37,320 hectares (Tatabánya FUA) to 165,200 hectares (Székesfehérvár FUA). Their population (2020) is between 86,757 inhabitants (Dunaújváros FUA) and 331,648 inhabitants (Debrecen FUA). In Hungary (9,303.4 thousand hectares, 9.77 million inhabitants, 2020) and compared to the Budapest FUA (253,800 hectares, 2.5 million inhabitants, 2014), they can be considered as medium-sized settlements (see Table 1 for details).

The method of selecting the settlements allowed me to examine three spatial categories within the given FUA regions, thus refining the results. As a result, I defined a central town, which in each case is the central settlement of the catchment area. Each of the examined Hungarian catchment areas can be considered monocentric. The group of settlements more closely connected to the central town is the settlements of the settlement group (by KSH 2014). This can be considered as an inner ring or within the studied regions. In addition, further settlements in the FUA region draw an outer ring.

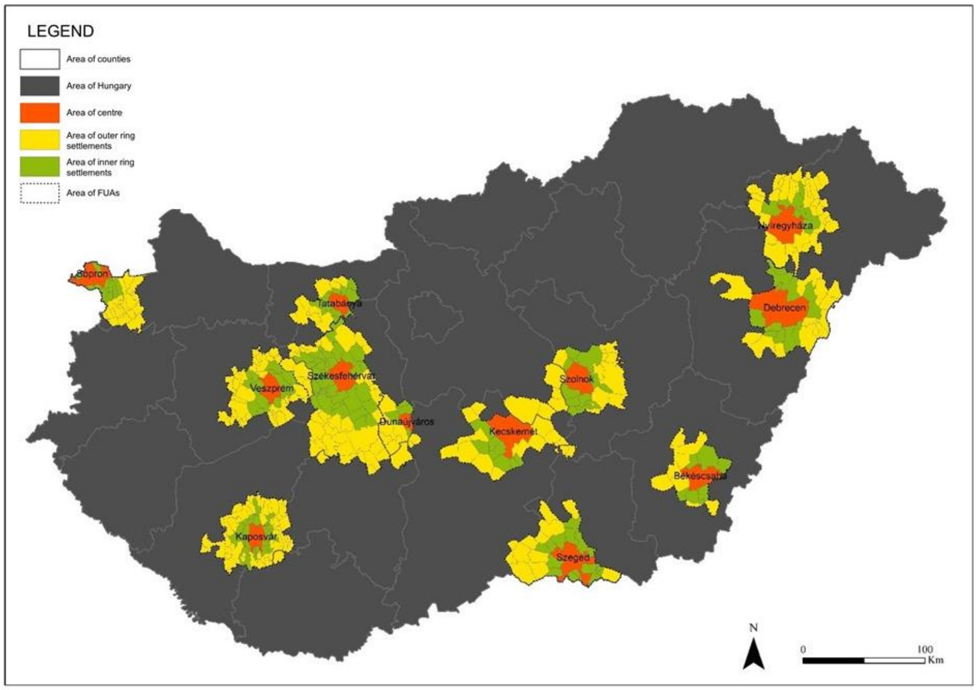

Figure 1. The catchment areas included in the analysis and their triple division (central settlement, inner ring, outer ring)

Table 1. Territorial and population data of the examined catchment areas *(Source: Urban Atlas 2012; KSH Local Register, 2020)*

Name of FUA centre	FUA area (hectares)	FUA population (2020)
Békéscsaba	51 620	155 559
Debrecen	93 540	331 648
Dunaújváros	45 300	86 757
Kaposvár	98 090	111 716
Kecskemét	115 500	189 363
Nyíregyháza	112 800	242 999
Sopron	46 220	96 394
Szeged	80 480	247 158
Székesfehérvár	165 200	274 036
Szolnok	78 000	160 520
Tatabánya	37 320	142 068
Veszprém	77 360	137 584

The research was based on the CORINE Land Cover Change (CLC CHA) database and the Corine Land Cover (CLC) database. The European Commission's free datasets for Hungary are available for 1990, 2000, 2006, 2012 and 2018, and between. The CORINE surface change categories or classes are given in Corine nomenclature (Bossard et al. 2000; Heymann et al. 1994). In order to focus the study, I grouped these classes into a simpler category system, that better fits the purpose of the research (see Table 2 for details). I created 3 main categories (Artificial surfaces, Agricultural surfaces, Natural, Near-Nature surfaces), and then 5 additional categories within the Artificial Surfaces: (i) Residential Areas, (ii) Industrial, Commercial Areas (abbreviated as Economic Areas), (iii) Transport Areas, (iv) Mines, dumps (abbreviation mining areas), (v) Artificial non-agricultural green areas (abbreviation urban green areas). In the Corine nomenclature

1.3.3. Construction site categorized areas were manually categorized into one of the 5 categories presented based on the quality of the final condition based on the Google Earth 2020 survey.

Table 2. The applied land use categories of the analyses, based on Corine nomenclature *((Bossard et al. 2000; Heymann et al. 1994*

Corine nomenclature				**Simplification and terms in the research**	
Code	Class 1	Class 2	Class 3 (relevant within Artificial surfaces)	Main categories	Further categories
1.1.1	Artificial surfaces	Urban fabric	Continuous urban fabric	Artificial surfaces	Urban fabric
1.1.2			Discontinuous urban fabric		
1.2.1		Industrial, commercial and Transport units	Industrial and commercial units		Industrial and commercial units
1.2.2			Road and rail network and associated lands		Transport units
1.2.3			Port areas		
1.2.4			Airports		
1.3.1		Mine, dump and construction sites	Mineral extraction sites		Mine, dump and construction sites (abbr. mine sites)
1.3.2			Dump sites		
1.3.3			Construction sites		
1.4.1		Artificial, non-agricultural vegetated area	Green urban areas		Artificial, non-agricultural vegetated area (abbr. urban green areas)
1.4.2			Sport and leisure facilities		
2.1	Agricultural areas	Arable land	…	Agricultural surfaces	
2.2		Permanent corps	…		
2.3		Pastures	…		
2.4		Heterogenous agricultural areas	…		
3.1	Forest and semi natural areas	Forests	…	Natural, semi natural surfaces (abbr. natural surfaces)	
3.2		Scrubs and/or herbaceous vegetation associations	…		
3.3		Open spaces with little or no vegetation	…		
4.1	Wetlands	Inland wetlands	…		
4.2		Maritime wetlands	…		
5.1	Water bodies	Inland waters	…		
5.2		Maritime waters	…		

The CLC CHA stock uses a minimum of 5 hectares of mapping units, which is suitable for regional-scale analysis. The Urban Atlas database is more accurate to 0.25 hectares in urban areas and 1 hectare in rural areas, but for some of the towns examined, it is only available for 2012 or 2018. To examine the spread of small and medium-sized towns in Hungary, I defined 2 study dimensions:

1. I delimited the circle of large towns affected by the spreading and the settlements belonging to their catchment area (12 cities and catchment areas), and within these I divided the settlements into 3 groups based on their spatial location (central settlement, inner ring, outer ring). (SPACE)
2. I defined 5 land use categories to group the new artificial surfaces. (FUNCTION)

5. Results

Examining the extent of the new artificial surfaces in the whole period of the study, a total of 10,101.4 hectares of new artificial surfaces were created in the 12 FUAs, which is 22.5% of the total Hungarian data (Table 3). Before analyzing the land cover data of the examined city regions, the statistical characteristics and its territorial aspects were reviewed with the help of the data of the Hungary's Central Statistical Office (KSH) administrative toponymy, which was supplemented with an individual data request. There are detailed results on the change of the resident population in Németh (2011), however, the tendencies of recent years do not appear in this.

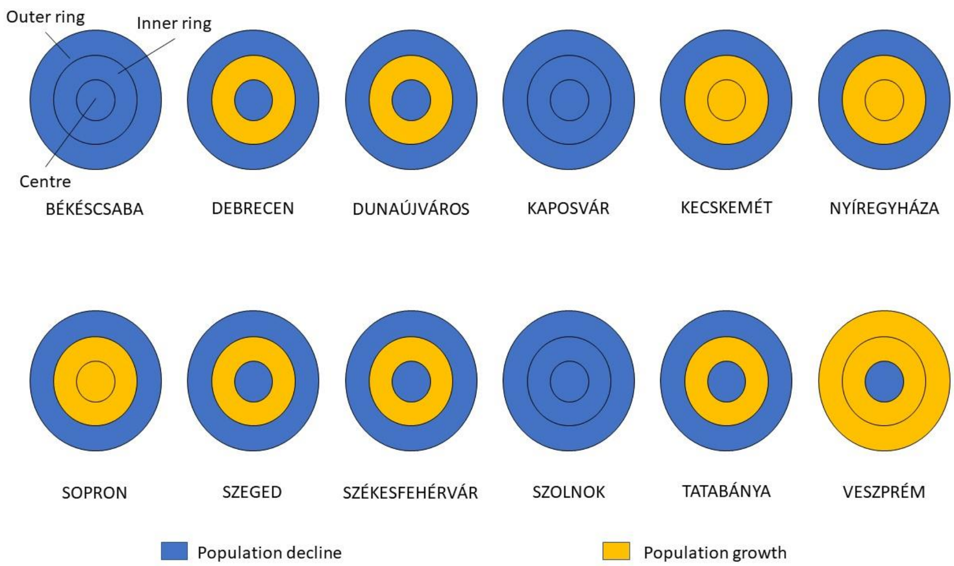

Figure 2. Presentation of the change in the resident population within the studied urban regions, in the central settlement, in the inner ring and the outer ring between 1990 and 2018. (own editing based on KSH Gazetteer)

Based on the logic presented in the previous chapter, the diagrams for the change of the new artificial surfaces were presented (Figure 3, Table 3). It can be stated that the growth of artificial surfaces in the centers is higher than the average of the 12 regions everywhere, in addition, the growth is also above average in the whole region of Dunaújváros and in the inner ring of Tatabánya. The data differ from the previously presented statistics, the difference is due to the functions of the new artificial surfaces. While suburbanisation and the stock of residential buildings are mostly related to residential and economic surfaces, the areas of transport, economy and mining that cause a significant increase are weakly related to the above data series.

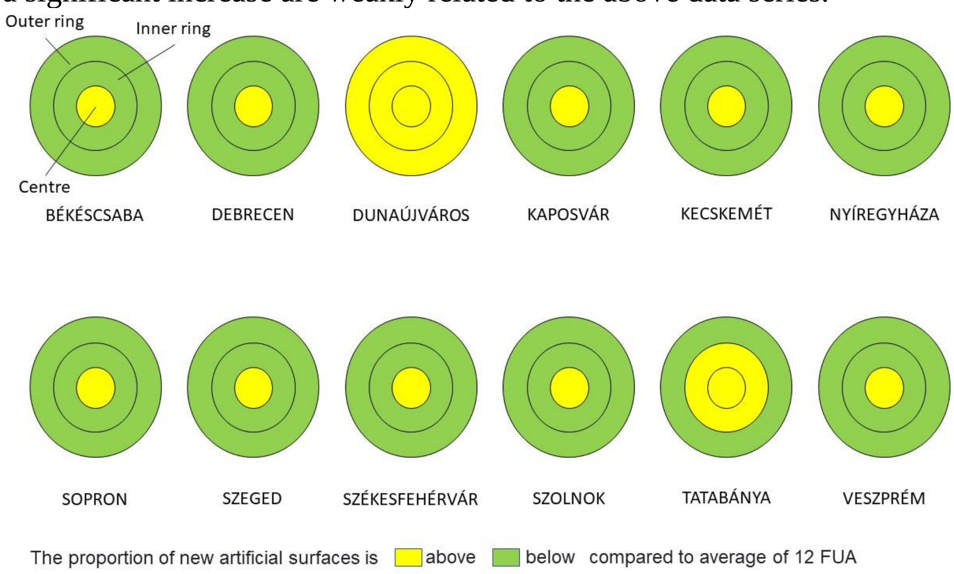

Figure 3. Demonstration of the change of the new artificial surfaces within the studied urban regions, in the central settlement, in the inner ring and the outer ring between 1990 and 2018. (own editing based on KSH individual data request)

Table 3. The extent of the new artificial surfaces between 1990 and 2018 in the studied FUAs, Hungary and Budapest FUA. *(own editing, source: CORINE)*

Name of FUA centre	New artificial surfaces (hectares)	Name of FUA centre	New artificial surfaces (hectares)
Kaposvár	259,1	Dunaújváros	890,6
Békéscsaba	294,9	Kecskemét	978,3
Veszprém	637,5	Székesfehérvár	1191,8
Tatabánya	650,8	Debrecen	1307,3
Sopron	762,7	Nyíregyháza	1458,1
Szolnok	820,1	TOTAL	10101,4
Szeged	850,0	Hungary	44968,5

The appearance of the new artificial surfaces in the period 1990-2018was reviewed according to the 3rd division formed within the regions, in each FUA (Figure 4). The results differed according to whether the new artificial surfaces are more concentrated or balanced in the FUA centre, the inner ring, or the outer ring. Following the grouping, Figure 3 shows that in the majority of the studied FUA regions, a new artificial surface was established in the central town. In addition, Szeged and its catchment area show concentration towards the center. The increase typical of the areas outside the central town can be said in the case of Dunaújváros and Tatabánya FUAs. For Nyíregyháza and Szolnok FUA, the growth was concentrated in the area of the outer ring and the central town.

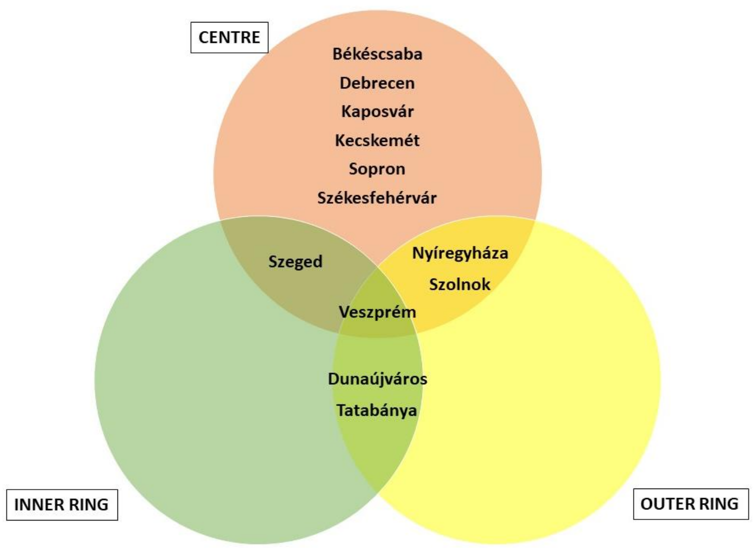

Figure 4.: Spatial distribution of new artificial surfaces in the studied FUA regions. (own editing, source CORINE)

Characterization of new artificial surfaces according to the FUNCTION dimension

The investigated functions provide a meaningful explanation for the quality of the new artificial surfaces. The new artificial surfaces appearing in each FUA over the whole period are shown in Figure 5.

The growth of the **new economic areas** can be explained by the greenfield industrial investments and the appearance of new commercial facilities, their role after 2006 is significant. Looking at the whole period, the new economic areas play a decisive role, with more than 300 hectares of new land in the Tatabánya, Nyíregyháza, Székesfehérvár and Kecskemét FUAs and less prominent where only 50 hectares of new economic areas were observed in the Békéscsaba and Kaposvár

FUAs. In the case of Kecskemét FUA, 47% of all artificial surfaces appear. In the case of Tatabánya FUA, 49% have an economic function. Tatabánya FUA is also outstanding in that the appearance of the economic areas is most responsible for the spread between 2000 and 2018.

New transport areas are significant in the following cities and their catchment areas: Nyíregyháza, Debrecen, Dunaújváros, Szolnok (especially in the period 2012–2018), Székesfehérvár (especially in the period 2012–2018). In the regions of Dunaújváros (76%) and Nyíregyháza (52%), the proportion is particularly outstanding, accounting for the majority of new artificial surfaces in the entire period under review. The new transport area is not significant in some regions, but Békéscsaba FUA 2000–2012, Debrecen FUA 2012–2018, Kaposvár FUA 1990–2000 and 2012–2018 still play a significant role in the sprawl.

Regarding **new mining areas**, two prominent areas are Dunaújváros FUA, where there is no mine at all, and Békéscsaba FUA, where 48% of the new artificial areas were given in the whole period. In the case of Szeged, Szolnok and Székesfehérvár, more than 200 hectares of new mining land appeared, Székesfehérvár is particularly outstanding with a new mining area of 346.1 hectares. Only in a smaller area, so such areas were less important in Sopron, Kaposvár, Kecskemét FUAs.

The growth of **new residential areas** is one of the consequences of suburbanization, its appearance is outstanding in the period of 1990 and 2006 - which coincides with the typical period of suburbanization in Hungary, however, after 2012 there is a strong decline. The functional urban areas of Nyíregyháza, Kecskemét, Szeged, Sopron and Debrecen stand out with more than 200 hectares of new residential area. The case of Sopron FUA is unique, here this function is very significant in the whole examined period, within the new artificial surface cover it reaches 60%, in the case of Kaposvár the same value is 43%, in the case of Debrecen 42%. Less than 50 hectares of new residential space appeared in Békéscsaba and Dunaújváros FUAs.

New urban green areas are not typical. The case of Veszprém FUA is unique with a total of 111.6 hectares, presumably due to the expansion of holiday areas (Németh 2011), on the other hand, the appearance of new urban green spaces in the city is constantly significant. In the case of the functional urban areas of Békéscsaba, Dunaújváros, Szolnok, Nyíregyháza and Kecskemét, no new urban green areas have appeared.

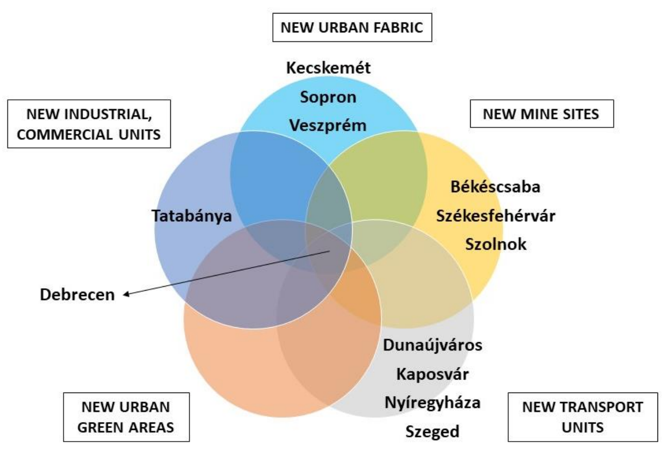

Figure 5. The new artificial surfaces by function in the studied FUA regions. (own editing, source CORINE)

6. Discussion and Conclusion

With the help of the data of the CORINE land cover database, the research focused on the changes of the 12 town of Hungary and its catchment area in the period after the change of regime, by examining the new artificial surfaces. The extent of the new artificial surfaces in the examined 12 FUAs in the period between 1990 and 2018 is a quarter of the Hungarian national data.

Examining the differences between the chosen Hungarian FUAs, it can be said that the largest increase was observed in Debrecen and Nyíregyháza, while the smallest increase was observed in Békéscsaba and Kaposvár. It can be stated that most of the new artificial surfaces have been created in the administrative area of the central town, although here the results need to be refined due to differences due to the size of the administrative area and the area of the city core, but they still show concentration. In my opinion, one of the main drivers of the growth of the outer areas is the construction of motorways, such as the Nyíregyháza and Dunaújváros FUAs.

The growth of the new economic areas is outstanding in the Tatabánya, Nyíregyháza, Székesfehérvár and Kecskemét FUAs, and low in the Békéscsaba and Kaposvár FUAs. New transport areas are following the dynamics of highway construction. New mining areas also show seasonal and spatial differences, and their appearance can be linked to the boom in construction. Due to its location, the city of Sopron and its catchment area stand out, as a large proportion of new residential areas appeared during the entire period under review. The appearance of a new urban green area can be linked to holiday areas and larger outdoor recreation facilities (Németh 2011), which explains the outstanding values of Veszprém and its surroundings (Lake Balaton resort area). With the help of the surface cover data, we also justified the known phenomena of Hungarian urban sprawl, thus the effects of highway construction on the growth of cities. In the future, the morphological aspects of the results, the effects of spatial planning regulations and domestic policies (housing policy, nature conservation or transport policy) on land use should also be examined, with the help of the CORINE database, to give even more attention to this segment of sustainability. Thus, the Hungarian urbanisation remained low compared to Western European examples the urbanisation has increased since the 1990s, despite declining populations. The importance of managing conflicts caused by the sprawl in rural areas, natural, semi-natural and agricultural areas will increase in the future.

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