TENDENCIES AND SPATIAL PATTERN OF URBAN GROWTH IN THE CATCHMENT AREA OF HUNGARIAN MIDDLE CITIES BETWEEN 1990-2018

A VÁROSI NÖVEKEDÉS TRENDJEI ÉS MORFOLÓGIÁJA MAGYARORSZÁGI KÖZÉPVÁROSOK VONZÁSKÖRZETÉBEN 1990 ÉS 2018 KÖZÖTT

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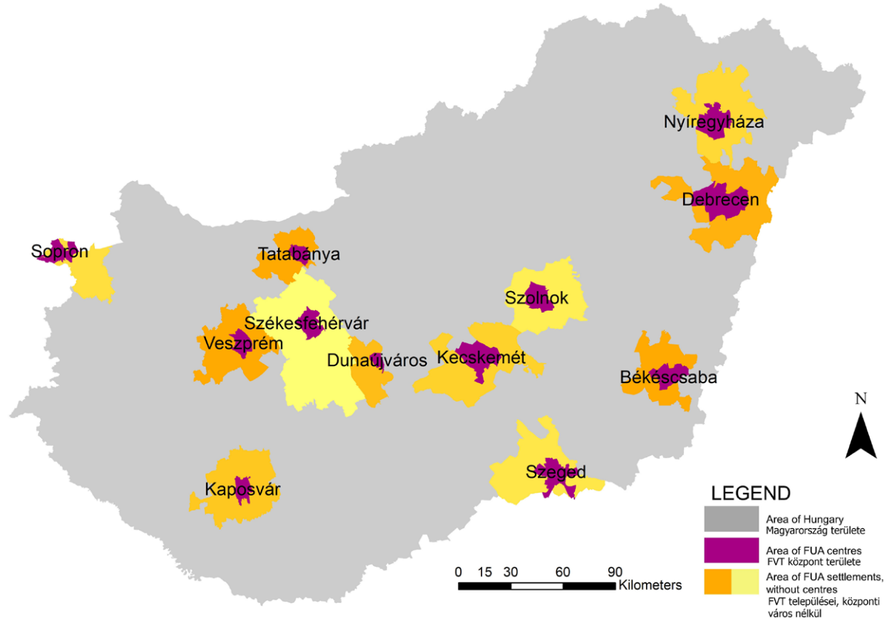
1. ábra/Fig. 1:
A vizsgált FVT-k területe / *The area of the analysed FUAs*



INTRODUCTION

Highlighted challenges of landscape management and urban policy are land use and urban sprawl management (EEA 2016, EEA 2007). Important concerns occurred from the aspect of landscape architecture, like sustainability, disproportional land take, loss of natural habitats, as well as traditional land use (Artmann et al. 2019; Antrop 2004). Nevertheless, the concept of *urban sprawl* is commonly used, several qualitative and quantitative definitions exist (some examples: Steurer and Bayr 2020; Luc-Normand 2020; Szirmai 2011; Ewing 2008; Galster et al. 2001) it is hard to define precisely (Tsai 2005). Egidi et al. (2020: 4) highlights "sprawl still remains a mixed morphological and functional issue, e.g., in terms of housing, land-use, fragmentation, and confusion of landscape characters" referring to Colantoni et al. (2015) and Di Feliciantonio and Salvati (2014).

The analyses of different spatial patterns or morphological distribution of urban sprawl is a core topic of urban planning (Angel et al. 2010; Schneider and Woodcock 2008; Schwarz, 2010; Galster et al. 2001). Compact city, as an objective for urban planning is on the political agenda, to foster organic growth of urban areas and fill the gaps within the urban tissue (CEC 1990, 1996; Kasanko et al. 2005; Batty et al. 2003). In the literature, the most influenced territories are in focus: the central city and its settlement network (Szirmai 2011) and also the periphery, edge, peri urban territories (Lennert 2018; Csemez 2008; Antrop 2004). The definitions of *functional urban area* (FUA) (OECD 2013; 2012) or *urban settlement groups* (KSH 2014) are integrated into the international and national discussions and the statistical systems as well. FUA regions are determined on the basis of population density and continuity of integration. The definition of *urban settlement group,* just like *agglomeration* and *agglomerating area* are used in Hungarian context, determined by multiple indicators by KSH Inostroza et al. (2013) distinguish three main spatial pattern infill, axial and isolated development. By all new development, that is taking place in adjacency with the pre-existing urban tissue, infilling increase compactness, axial growth follows the main development axis, and is strongly determined by infrastructure. No doubt, spatial analyses of urban sprawl needs to be the basis of urban planning an overall review from this respect has not appeared yet from Hungary.

The motivation for compact urban planning was missing from the regulatory environment until 2019 (Act CXXXIX of on Land Use Framework Plan of Hungary and Priority Areas, OTrT). The country-level studies focus on the Budapest agglomeration (for example Lennert et al. 2020; Kovács et al. 2019; Cegielska et al. 2018; Egyedné Gergely 2014; Schuchmann 2013; Tosics 1998). However, on the situation of smaller towns, only short term or case-focused studies were born (Hoyk et al. 2020).

	Corine nomenclature			Simplification and terms in this study	
Code	Class 1	Class 2	Class 3	Main categories	Further categories
1.1.1			Continuous urban fabric		
1.1.2		Urban fabric	Discontinuous urban fabric		Urban fabric
1.2.1			Industrial and commercial units		Industrial and commercial units (abbr. industrial units)
1.2.2			Road and rail network and associated lands		
1.2.3		Industrial, commercial and Transport units	Port areas		
1.2.4			Airports		Transport units
1.3.1			Mineral extraction sites		
1.3.2			Dump sites		Mine, dump sites (abbr. mine sites)
1.3.3		Mine, dump and construction sites	Construction sites		Manually categorised according to the satellite photo from Google Earth 2020.
1.4.1		Artificial, non-agricultural vegetated area	Green urban areas		Artificial, non-agricultural vegetated area (abbr. urban green areas)
1.4.2	Artificial surfaces		Sport and leisure facilities	Artificial surfaces	
2.	Agricultural areas	…	…	Agricultural areas	
3	Forest and semi natural areas	…	…	Natural, semi natural areas (abbr. natural areas)	
4	Wetlands	…	…		
5	Water bodies	…	…		

The present paper explores the trends of spatial growth of functional urban area (FUA) of 12 second-tier Hungarian towns since 1990.

METHODS

The Corine Land Use Change (CLC CHA) database – initiated by European Commission from 1990, 2000, 2006, 2012 and 2018 – serves as the basis of the research. The CLC CHA data was recalculated per analysed areas and visualized to 12 second-tier Hungarian towns and its functional urban areas (FUA): Békéscsaba, Debrecen, Dunaújváros, Kaposvár, Kecskemét, Nyíregyháza, Sopron, Szeged, Székesfehérvár, Szolnok, Tatabánya, Veszprém (Fig. 1,2). The area of selected regions falls between 37,320 ha (Tatabánya FUA) and 165,200 ha (Székesfehérvár FUA). The population ranges between 86,757 inhabitants (Dunaújváros FUA) and 331,648 inhabitants (Debrecen FUA) (Fig. 2), as comparison Budapest agglomeration covers 253,800 ha and has 2.5 million inhabitants (2014).

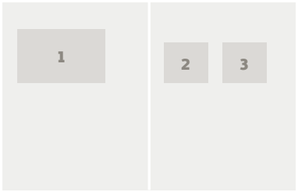
The selection on such areas, where the FUA category and urban settlement groups parallel exists according to delineation of Urban Atlas (2012), OECD (2013) and KSH (2014).[1] The analyses of spatial pattern of artificial areas were categorised according to the distribution of areas between central town and other FUA settlements. An overview was also made according to the categories of Inostroza et al. (2013): infill, axial and isolated development.

The Geographical Information Systems (GIS) – ArcMap software 10.2.2. was used to delineate, visualise and calculate the different land use change categories. Based on the Corine land use nomenclature, several categories were aggregated and grouped in order to highlight the urban sprawl (Table 1).

The direction of the changes was also detected. If the given area stayed within the category of three main land use patterns (Artificial, Agricultural and Natural). In order to determine the characteristics of urban sprawl and find explanation for the trends, artificial surfaces were divided into 5 further categories: (i) urban fabric, (ii) industrial and commercial units, (iii) transport units, (iv) mine sites, (v) urban green areas.

The spatial pattern of new artificial areas between 1990–2018 is compared to the existing urban fabric, visualised according to Urban Atlas 2012 Database (Artificial surfaces). Unfortunately, the Urban Atlas 2018 Database was not available for all analysed settlements. Also, the lowest area of artificial surfaces appeared in Dunaújváros FUA between 1990–2000, in Kaposvár FUA between 2000–2006 and in Debrecen FUA between 2006–2012 and 2012–2018.

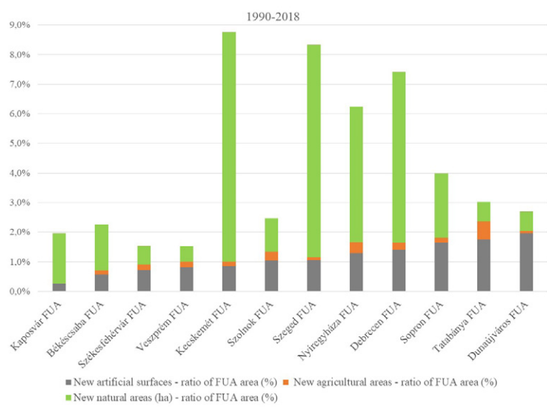
1 FUA regions are determined on the basis of population density and continuity of integration according to internationally accepted methodology (OECD 2013). According to the Hungarian methodology, the agglomeration linkage is determined by 10 indicators by KSH (2014). Urban settlement group means a tighter connection between the central town and settlements around than a neighbourhood relation, but a weaker connection than agglomeration or agglomeration area.

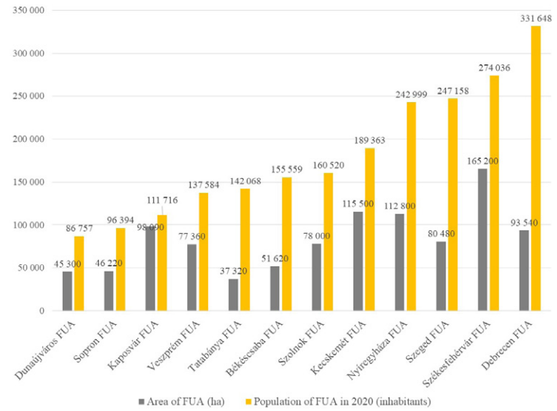


1. táblázat/ Table 1: Az elemzés során alkalmazott felszínborítási kategóriák a Corine kódok alapján nomenclature (Bossard et al. 2000; Heymann et al. 1994) / *The applied land use categories of the analyses, based on Corine nomenclature (Bossard et al. 2000; Heymann et al. 1994)*

2. ábra/Fig. 2: FVT területe és népessége / *The centre, the area and the population of analysed FUAs* (FORRÁS/SOURCE: URBAN ATLAS 2012; TERÜLETI ATLASZ KSH, 2020 / *URBAN ATLAS* 2012; *DETAILED GAZETTEER OF HUNGARY FROM KSH*, 2020)

3. ábra/Fig. 3: Az új területek a teljes FVT terület százalékában 1990 és 2018 között / *Newly appeared areas in ratio of whole FUA area between 1990 and 2018*





RESULTS

Major changes

Firstly, changes were analysed to reveal the difference between the three main categories (Table 2, Fig. 2). However, the role of new agricultural areas are marginal, the ratio of new natural areas show territorial inequalities. It is also in accordance with the FUAs, where changes are significant: Kecskemét, Szeged, Nyíregyháza and Debrecen. Appearance of new artificial surfaces (Fig. 3) is balanced in the examined regions, the values fall between 259 and 1458 hectares between 1990 and 2018. Large areas turned into artificial surfaces in the following FUAs: Dunaújváros, Kecskemét, Székesfehérvár, Debrecen and Nyíregyháza; marginal growth is experienced in this respect in Kaposvár and Békéscsaba FUAs. In different time periods, the largest area of artificial surfaces appeared in Tatabánya FUA between 1990–2000, in Nyíregyháza FUA between 2000–2006 and 2006-2012 and in Debrecen FUA between 2012–2018.

The intensity of new artificial surfaces is varying within the country. In the period after the transition (1990–2000), the newly appearing artificial surfaces were dominant in the Western Region, while the Eastern part of Hungary joined after 2000 to this trend with Nyíregyháza, Szeged and Debrecen FUAs. However, some FUAs (Békéscsaba, Kaposvár) are lagging behind the dominant ones from both parts of the country.

Within the category of artificial surfaces (Fig. 3–5) between 1990 and 2018, i.e. in the whole examined period new industrial sites were considered remarkable in the Tatabánya, the Nyíregyháza, the Székesfehérvár and the Kecskemét FUAs with the change affected more than 300 hectares. Also, with less than 50 hectares change marked as marginal in the Békéscsaba and the Kaposvár FUAs. In the Kecskemét FUA, new industrial sites give 47% of all new artificial surfaces, while in the Tatabánya FUA the same amounts to 49%.

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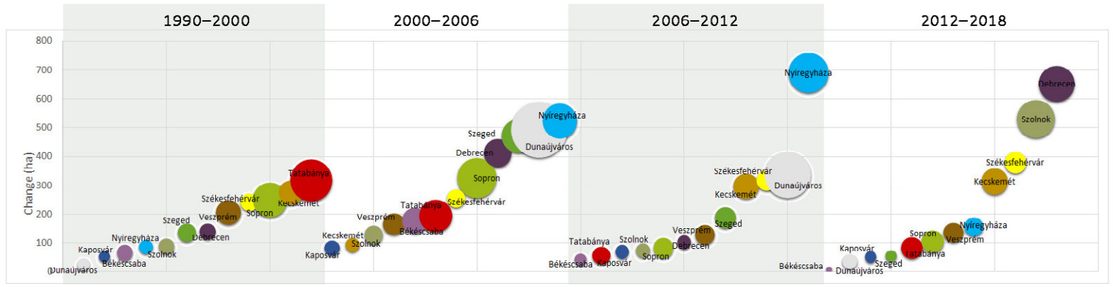
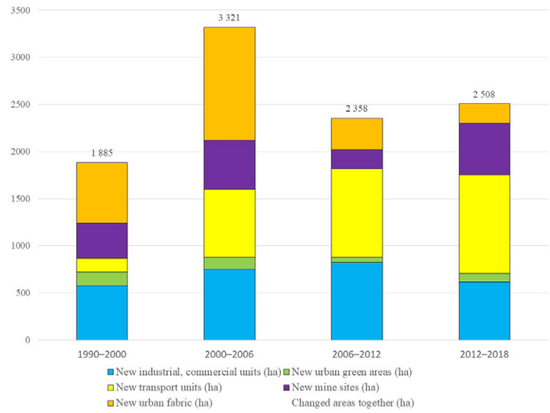
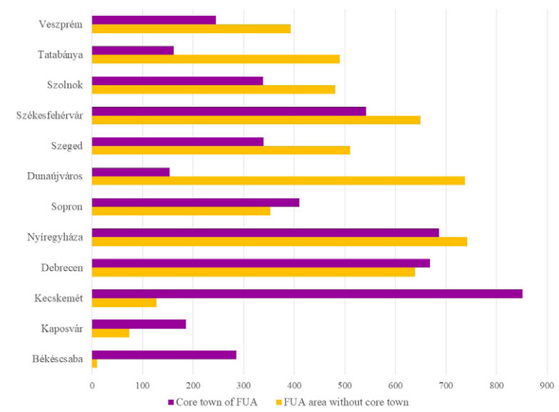
4. ábra/Fig. 4: Az FVT-k területén az új mesterséges felszín a vizsgált peródusokban / *The new artificial surfaces during the examined periods in FUA areas. The size of the bubble indicates the share of the changed areas to the FUA area*

5. ábra/Fig. 5: Az új mesterséges felszín a 12 FVT területén a vizsgált peródusokban / *New artificial surfaces in all 12 FUAs in the examined periods*

6. ábra/Fig. 6: Az új mesterszége felszín megoszlása (ha) a központi város és az FVT területén 1990 és 2018 között / *Distribution of new artificial surfaces (ha) between the core town and FUA area without core town between 1990 and 2018*







New transportation units are dominant in the following FUAs: Székesfehérvár, Szolnok, Debrecen, Dunaújváros, Nyíregyháza. In the Nyíregyháza FUA, 52% of new artificial surfaces fall into this category with 742.5 hectares, while in the Dunaújváros FUA the same value is 76%.

New mine sites appeared to a larger extent in the Szeged, Szolnok, Székesfehérvár FUAs, with more than 200 hectares, and to a smaller extent in the Sopron, Kaposvár, Kecskemét FUAs. In the Békéscsaba FUA, the area of new mine sites did not grow after 2012, but still this category gives 48% all the new artificial surfaces in the whole period. In parallel, in the Dunaújváros FUA, no new mine sites were opened during the whole period.

New urban fabric is dominant in the following FUAs, with over 200 hectares: Nyíregyháza, Kecskemét, Szeged, Sopron (60% of all new artificial surface), Debrecen (42% of all new artificial surface). In the Békéscsaba and Dunaújváros FUAs less than 50 hectares of new urban fabric appeared.

New urban green areas are not so dominant within artificial surfaces. A remarkable change was detected in Veszprém, with 111.6 hectares, but in several FUAs no new urban green areas appeared: Békéscsaba, Dunaújváros, Szolnok, Nyíregyháza, Kecskemét.

Spatial pattern of new artificial surfaces

The visual analyses of spatial pattern of new artificial surfaces is made within the area of central towns, also within the area of the whole FUA. Among the analysed areas, different limitations can be detected that may influence the spatial distribution of new artificial areas.

- Country border that is a strong barrier of FUA delineation as well. It is very spectacular in the case of Sopron, but a section of the border of the FUA is the country border at the Szeged and Debrecen FUAs as well.
- Relief, like the neighbourhood of the River Danube (Tatabánya, Dunaújváros) or the River Tisza (Szeged, Szolnok) or hills (Sopron, Kaposvár, Tatabánya, Veszprém) or plain (Szeged, Debrecen, Nyíregyháza, Szolnok, Békéscsaba) also influences development.
- Local characteristics, like settlement structure, traditional land use patterns, situation of transportation network (Cieslak et al. 2019) should also be taken into consideration.

The distribution of new artificial surfaces between the core town and agglomeration area around it (FUA area without core town) gives an overview about the centralised or scattered nature of urban sprawl (Fig. 6, Table 2). According to the results three group is seen:

- New artificial surfaces are centralised to the administrative area of core town: Békéscsaba, Kaposvár, Kecskemét
- New artificial surfaces are scattered in the settlements of FUA area: Dunaújváros, Szeged, Székesfehérvár, Szolnok, Tatabánya, Veszprém
- Balanced appearance between the areas: Debrecen, Nyíregyháza, Sopron

The spatial pattern of new artificial surfaces shows different distribution in the regions. To highlight further characteristics that are visible from the map analyses (Fig. 7,8; Table 2), the categories of Inostroza et al. (2013) were applied: infill, axial and isolated.

The most important difference is in the concentration that can caused by geographical and morphological reasons. It is clear, for example, that the new urban fabric strongly linked to the existing urban fabric. Also, the focus points of development are visible, the new automobile investment in the Kecskemét FUA. An axial development in the Dunaújváros, Nyíregyháza, Székesfehérvár or Szeged FUAs are indicated, because of the existence of the motorway network or a geographical barrier, like Danube. Also, in the case of Székesfehérvár and Veszprém, a horizontal (West–East) line (parallel to motorway 8) is dominant. In the case of Tatabánya, a vertical (North–South) line is characteristic thanks to the most important motorway (M1) line. The results are in accordance of former studies (Iváncsics and Filepné 2019a; 2019b).

CONCLUSION

Urban sprawl in Hungary shows strong regional differences, the nature of the process within FUA regions can be easily followed based on the results. The most important findings emphasise the temporal concentration of the new urban fabric to 1990 and 2006, that shows that suburbanisation process started explosively after 1990 – after the decades of socialism with controlled movement of people, and later slowed down (Enyedi, 2016) or was slightly modified. The Sopron FUA at the western border is an exception, though, where the geographical location and existence of iron curtain strongly modifies this trend. This trend is similar to Polish examples (Cieslak et al. 2019).

Important motivating forces for the emerging artificial surfaces are the growth of urban fabric (housing), industrial sites (economic development) and transportation units (motorway constructions).

Another regional characteristic is that the first wave of industrial renewal reached the western regions, and the eastern part of Hungary joined in only later. The results highlight the importance of motorway constructions in urban sprawl, which is in accordance with Eastern European tendencies (Feranec et al. 2017). The spatial pattern of new artificial areas also shows correlation with the motorway network, influences the axial development. However, in some cases the dominant role of the central town is visible, developments are scattered in most of the FUAs. The spatial pattern of urban sprawl is also influenced by settlement development characteristics and history. As we highlighted in the results, Kecskemét had a diffuse pattern of new artificial areas (except

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2. táblázat/ Table 2: Az új mesterséges felszín területi elhelyezkedése 1990 és 2018 között / *The different spatial distribution of new artificial surfaces between 1990 and 2018*

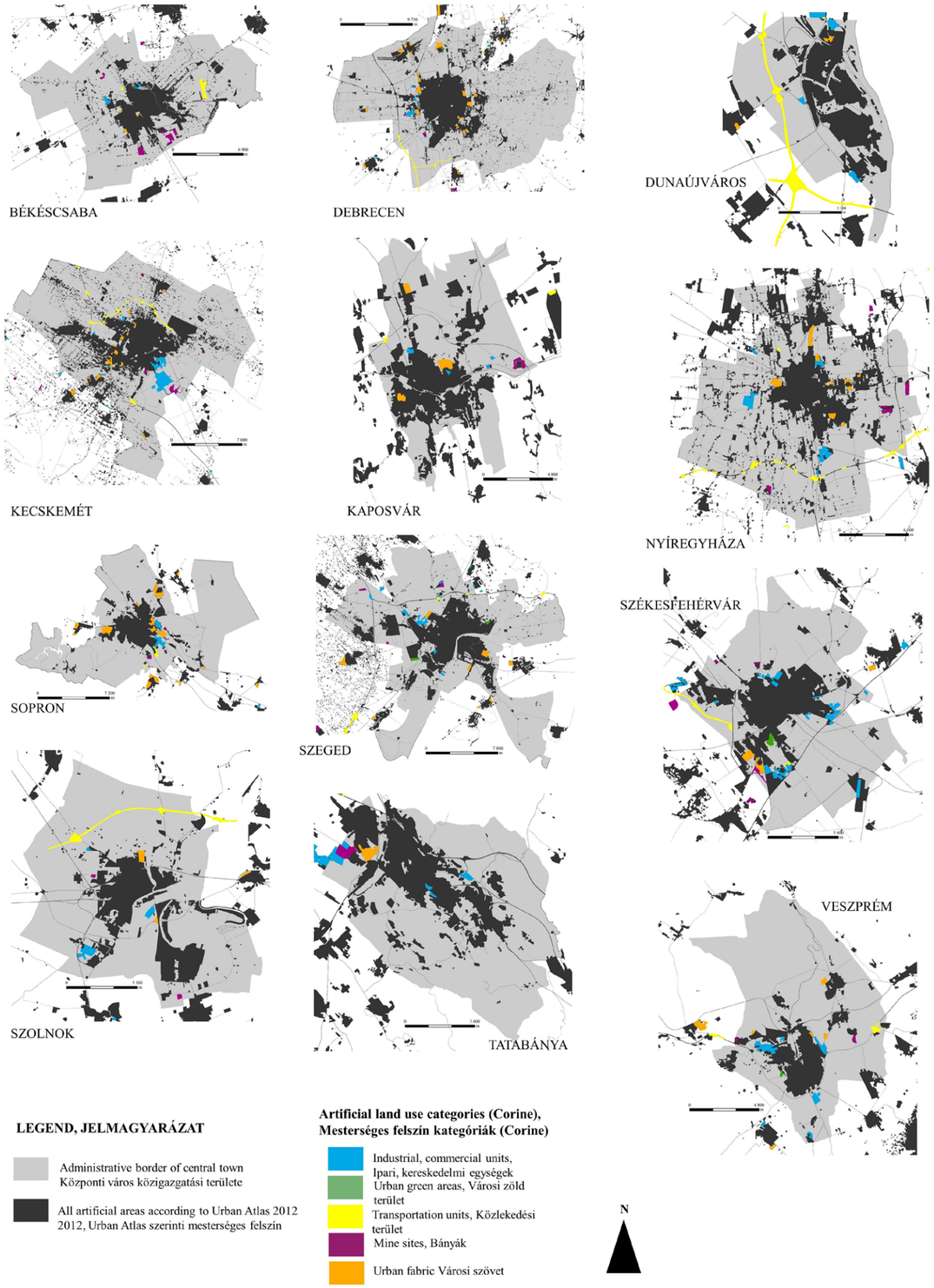
	Centralised or scattered or balanced	Infill or axial or isolated	Remarks
Békéscsaba	Centralised	Infill, isolated	Mining sites and transportation units are isolated
Kaposvár	Centralised	Infill	New developments are connected to existing ones
Kecskemét	Centralised	Infill	Except isolated investment at the South part of the town
Debrecen	Balanced	Infill and axial	Regarding new urban living areas infill, north-south axial development is seen by new industrial and transportation areas
Nyíregyháza	Balanced	Infill, axial, isolated	Infill by new urban fabric areas, axial by transportation area, isolated by industrial and some new urban fabric areas
Sopron	Balanced	Infill, isolated	infill regarding new urban fabric areas, in other FUA settlements isolated
Dunaújváros	Scattered	Axial	the direction of axial development is influenced by the north-south direction thanks to River Danube. Some new urban fabric areas infill the existing artificial surfaces.
Szeged	Scattered	Axial, infill	Industry strongly linked to road network. Infill regarding new urban fabric.
Székesfehérvár	Scattered	Axial, isolated	Industry strongly linked to road network. Isolated regarding new urban fabric.
Szolnok	Scattered	Axial, isolated	East-west axis is seen according to road network, in FUA around some isolated development.
Tatabánya	Scattered	Axial	The most important motorway (M1) influences the spatial pattern of new artificial surfaces.
Veszprém	Scattered	Axial, infill	Developments follow the transportation lines, some of them strongly connect to existing urban fabric.

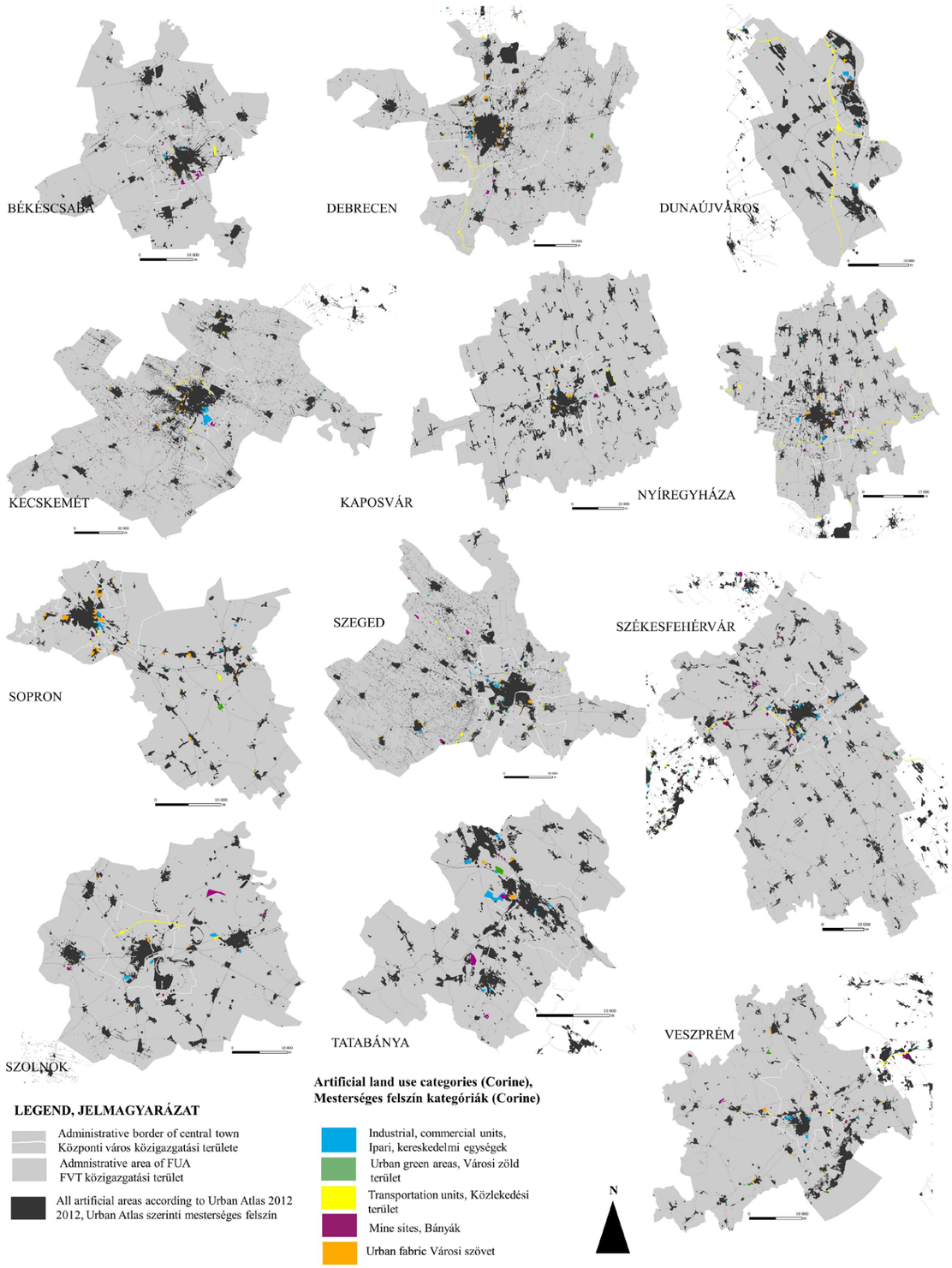
new urban fabric). This is due to the traditional urban pattern of specific regions of the Hungarian Great Plain, where sometimes 40-70% of the population of the settlement live in the outskirts in homesteads (Sikos and Beluszky 2008).

It is important to consider the limitations of the Corine database, such as errors due to scale, size of the smallest mapping unit, generalization rules (Diaz-Pacheco and Gutiérrez 2014; Mari 2010). For further analyses of spatial pattern it is need to do apply further existing calculations and methodologies. Also, overlapping areas are not detected within the category of artificial surfaces; however, within the category of new agricultural and natural areas overlapping polygons may occur.

The strong differences of urban sprawl can be explained by the late integration of the idea of "compact city" (Artmann et al. 2019), as well as by a strong influence of municipal policy making. However, legislation has an important role to control and manage urban sprawl (Geneletti et al. 2017; Ewing 2008; Antrop 2004; Allen 2003), but in Hungary national guidance for a compact city structure in the regulatory framework was pronounced only after 2018 with the Act CXXXIX of 2018 on Land Use Framework Plan of Hungary and Priority Areas. Our work draws attention to the importance of legislation both at the national and the regional levels. At the regional level, there is a relative freedom of municipalities, and they are able to influence the nature of urban sprawl with several assets, like the identification and infrastructural development of areas for urban living or industry, or long term strategic planning through land use plans (Iváncsics and Filepné Kovács 2019a; Egyedné Gergely 2014; Ricz et al. 2009). In the majority of the analysed city's strategies there is the objective of compact city development. However, these assets are just for the administrative area of the core town, they are missing from the regional perspective, due to the relatively weak role of counties or other regional public bodies.

7 ábra/Fig. 7: A központi városok területén az új felszínek elhelyezkedése 1990–2018 / *Spatial distribution of new artificial surfaces in central towns between 1990–2018*





8. ábra/Fig. 8: Az FVT-k területén az új mesterséges felszínek elhelyezkedése 1990-2018 / *Spatial distribution of new artificial surfaces in different FUAs between 1990–2018*

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ÖSSZEFOGLALÓ

A VÁROSI NÖVEKEDÉS TRENDJEI ÉS MORFOLÓGIÁJA MAGYARORSZÁGI KÖZÉPVÁROSOK VONZÁSKÖRZETÉBEN 1990 ÉS 2018 KÖZÖTT

A magyar és közép európai régióban kiemelt kutatási terület a poszt-szocialista városfejlődés. Számos tanulmány látott már napvilágot, melyek különböző aspektusokból és időben vizsgálták a jelenséget, de az középvárosok vonzáskörzetében újonnan megjelent mesterséges felületek térbeli mintázatáról még nem jelent meg átfogó tanulmány. Az írás ezt a hiányt kívánja pótolni azzal, hogy 12 hazai középváros funkcionális városi területét (FVT) elemzi a Corine Felszínborítás Adatbázis segítségével (CLC CHA, 1990-2018).

Az új mesterséges területek elhelyezkedését vizsgáltuk a központi város és a többi FVT település vetületében, továbbá elemeztük Inostroza et al. (2013) által alkalmazott kategóriákat: kitöltő, tengelymenti és izolált növekedés.

Fő célunk a változások irányának feltárása volt. Amennyiben az adott terület a három fő kategórián belül maradt (Mesterséges, Mezőgazdasági és Természetes), a változást semlegesnek minősítettük. A városi szétterülés jellegzetességeinek feltárása érdekében a mesterséges felszínt 5 alkategóriára bontottuk: (i) lakóterület, (ii) ipari és logisztikai terület, (iii) közlekedés, (iv) bánya, (v) városi zöldterület.

Az új mesterséges felszín létrejöttének aránya egyenlőtlenül oszlik el az országban. A rendszerváltozás utáni időszakban jellemzően (1990–2000) a nyugati régiókban jött létre nagyobb arányban, majd a keleti térségek 2000 után csatlakoztak ehhez a trendhez elsősorban Nyíregyháza, Szeged és Debrecen FVT térségeivel. Bár több FVT térség elmaradt a domináns változásoktól (Békéscsaba, Kaposvár) az ország mindkét részéből.

Az új mesterséges felszín kategórián belül 1990 és 2018 között jelentős ipari területek jöttek létre Tatabánya, Nyíregyháza, Székesfehérvár és Kecskemét FVT területén, több mint 300 hektár terület átalakulásával. Az új közlekedési területek létrejöttében legjelentősebb változások Székesfehérvár, Szolnok, Debrecen, Dunaújváros, Nyíregyháza térségében tapasztalhatók. Új bányaterületek legnagyobb arányban Szeged, Szolnok, Székesfehérvár FVT térségében jöttek létre, több mint 200 hektár területtel. Legnagyobb arányban új lakóterületek (200 hektár felett) Nyíregyháza, Kecskemét, Szeged, Sopron (60%-a az új mesterséges felszínnek), Debrecen (42%) térségében jöttek létre. Új városi zöldterületek létrejötte nem jellemző a mesterséges felszínen belül. Kiemelkedő Veszprém FVT, ahol 111,6 hektár új zöldterület jött létre, de több FVT területén egyáltalán nem jött létre új zöldterület (Békéscsaba, Dunaújváros, Szolnok, Nyíregyháza, Kecskemét).

A vizsgált térségekben különböző adottságok jelennek meg limitáló tényezőként a városnövekedés területi dimenziójának formálására:

- Az országhatár az FVT kiterjedését is meghatározza. Ez kiemelten látványosan megjelenik Sopron esetében, de Szeged és Debrecen FVT is az országhatár mentén helyezkedik el.
- Domborzati, földrajzi adottságok mint például Duna (Tatabánya, Dunaújváros) vagy Tisza menti elhelyezkedés (Szeged, Szolnok) vagy hegy-, dombvidéki elhelyezkedés (Sopron, Kaposvár, Tatabánya, Veszprém), síksági helyzet (Szeged, Debrecen, Nyíregyháza, Szolnok, Békéscsaba) egyaránt meghatározzák a fejlődés térbeli kereteit.
- A különböző helyi adottságokat, mint településszerkezet, hagyományos tájszerkezet, a közlekedési hálózat elhelyezkedése egyaránt fontos figyelembe venni (Cieslak et al. 2019).

Az új mesterséges felszín területek elhelyezkedése a központi város és vonzáskörzete között rávílágít a városnövekedés centralizált vagy szórt jellegére (FVT a központi város nélkül). A vizsgált területeket három csoportba tudjuk sorolni:

- Az új mesterséges felszín területek a központi város közigazgatási területéhez kapcsolódva jöttek létre: Békéscsaba, Kaposvár, Kecskemét
- Az új mesterséges felszín területek az FVT településein szórtan jelentek meg: Dunaújváros, Szeged, Székesfehérvár, Szolnok, Tatabánya, Veszprém
- Kiegyensúlyozott, mindkét jelenség erős: Debrecen, Nyíregyháza, Sopron.

A földrajzi adottságok következtében láthatunk jelentősebb különbségeket a beépített területek növekedésében. Általánosan jellemző, hogy az új lakóterületek jellemzően a meglévő lakóterületekhez kapcsolódóan épülnek ki. Továbbá jellegzetes fejlődési gócpontokat láthatunk például Kecskeméten az új autógyár. Az autópályák mint fejlődési tengely vagy a Duna vonala mint fejlődési gát Dunaújváros, Nyíregyháza, Székesfehérvár vagy Szeged FVT térségében. Székesfehérvár és Veszprém esetében, egy nyugat-keleti tengely meghatározó (M8 autópálya), míg Tatabánya térségében egy észak-déli tengely jellemző az M1 autópálya hatására.

Összegezve láthattuk, hogy a városi szétterülés mértéke jelentős regionális különbségeket mutat hazánkban, különböző hullámokban érte el a vizsgált FVT-ket. A városi szétterülés formáját számtalan sajátos földrajzi tényező, hagyományos településszerkezet befolyásolhatja.