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Environmental Consequences of the Urban Sprawl in the Suburban Zone of Nitra. An Analysis Based on Landcover Data

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Abstract

One of the most important territorial processes in the highly urbanised continent of Europe is suburbanisation, urban sprawl which occurs in a gradual manner over long periods and is not perceived as dramatic. Nevertheless the built-up urban areas and the urban lifestyle occupy step by step the periurban territories. Urban sprawl affects the essential environmental, economic and social functions of the impacted settlements. In the last decades these processes reached the less urbanised Central European region, leading to very fast and less planned changes in its settlement system. The research deals with these processes in the Central European non-metropolitan areas, around regional centres, and with their environmental impacts. The aim of this paper is, based on theoretical and empirical knowledge, to point out to spatial patterns of urban sprawl and suburbanisation in functional urban areas (FUA). This paper examines the urban sprawl and its impacts in Slovakia in the case of Nitra Functional Urban Area, in the agglomeration of an economically growing regional centre. The research is based on standard geographical methods including field research. Desktop and field empirical researches were conducted, with different methods such us GIS analysis of land use change. The analysis shows then to what extent cities and urban areas grow, from which one can conclude to how landscape surrounding the urban residential areas has changed, how the proportion of non-permeable surfaces increased, basically influencing the runoff of precipitation. The data demonstrate, moreover, how artificial patches and barriers fragment landscape more and more, endangering thereby biodiversity and decreasing green surfaces. The examination covers the 2000-2018 period, using the CORINE CLC 2000, 2006, 2012 and 2018 databases. Thereby the authors are able to examine changes in a longer period of almost two decades, and three internal periods. All this is compared to the demographic changes of the urban area of Nitra as well, in order to see to what extent the change in the number of population contributes to the transformation of land cover and thereby to environmental impacts. The characteristic features of Nitra and its hinterland within this are analysed, then the Nitra FUA and within that the suburban zone is examined in detail. Nitra and its area feature high enlargement dynamics looking at the whole of the period, compared to other FUAs. It is typical almost everywhere that the enlargement of areas surrounding cities is more intensive than the growth of the city itself, which demonstrates general suburbanisation.

Keywords: Suburbanisation; urban sprawl; land cover change; environmental impact; Slovakia; Nitra

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Introduction

One of the important features of the urban development and urbanisation processes is that the space of the city, moreover the areas used as urban space are growing, spreading and this process is also changing the use of areas and landscape, which were previously in rural and close-to natural condition (EEA report, 2006, 2016; Enyedi, 2012; Ilbery, 1999; Kovács, 2014; Sturm & Cohen, 2004; Van den Berg, 1982).

The growth of the population of cities and urban regions is fast in Europe, and the demand for space by new residential places and other functions is very rapidly increasing. We can refer to the Marshall's equation, according to which a 3% population increase will determine a 9% increase in area used by urban functions (Gardi, 2017). The rapid changes of 'urban metabolism' pose a challenge for spatial planning and urban development that are often unable to control processes even in the developed countries, not to mention the least advanced ones, and so the environmental impacts are intensifying. Johnson (2001) and Kahn (2000) summarised environmental impacts of urban sprawl which had been identified in the literature. On the basis of this, the environmental impacts are the following: loss of environmentally fragile lands; reduced regional open space; greater air pollution; higher energy consumption; decreased aesthetic appeal of landscape; loss of farmland; reduced diversity of species; increased runoff of stormwater; increased risk of flooding; excessive removal of native vegetation; monotonous (and regionally inappropriate) residential visual environment; absence of mountain views; presence of ecologically wasteful golf courses; ecosystem fragmentation.

Literature offers two directions for finding the answers to the issue: a) one that keeps the tendency of suburban development (Van der Valk & Faludy, 1992) but controls that more adequately with the tools of planning; and b) one that recommends the more practical and denser building up of urban spaces, with a more effective use of the space (compact city theory) (Breheny, 1992). We cannot make a stand in this issue but it is a fact that planning based on better recognition may reduce the negative environmental impacts of urban sprawl.

Residential suburbanisation and urban sprawl are currently the most important urbanisation processes in European post-socialist countries, especially in Central Europe (Bajmóczy, 2012; Csapó–Balogh, 2012; Hirt, 2007, 2012; Karwińska et al., 2018; Kubeš, 2013, 2015; Leetmaa–Tammaru, 2007; Tímár & Váradi, 2001). In addition to the large number of case studies we also find works that compare the processes in the West and the East (Szirmai, 2011). The European, especially Central European and Southeast European researches have primarily focused on the suburban zones of the capital cities (Kovács et al., 2019; Lennert et al., 2020; Slaev et al., 2018), and paid little attention to the processes of the rural centres (Kubeš & Nováček, 2019). The specific features of the urban network of this macro-region make the survey of this set of cities important, especially of the dynamic elements thereof, exploring the special characteristics (Hardi, 2010, 2012; Hardi & Nárai, 2005).

Over the past decade and a half, peri-urban development has enormously changed the traditional cultural landscape, land use, and settlement functions of villages around regional centres (EEA report, 2006), and around many other cities in Central Europe (Antrop, 2004, 2005; Székely–Michniak, 2009). This process has intensified in the former socialist countries after the 2000's and it led to a number of problems, which became apparent during the eighties and nineties in Western countries, and in the fifties-sixties in the USA. The urban sprawl took place without effective control and planning. The extent of spatial growth often exceeds the rate of population growth; it is taking place even in the lack of population growth (urban sprawl). The administrative areas of several settlements are affected by these processes; thus, the lack of coordination is often characteristic (Ehrlich et al., 2012).

Urban sprawl causes numerous landscape-ecological problems. Spatial planners, self-governments and building officials who should regulate the residential suburbanisation are still quite passive in this question, as are local citizens (Kubeš, 2015). Suburbanisation brings irreversible changes in the landscape. An increasing number of publications analysed the environmental, ecological and agricultural consequences of population, suburbanisation, the land take, land consumption of this process, but mainly in the cases and by authors of the USA and East-Asia. The subjects of these works cover several disciplines and professions from urban planning to microbiology. We see that in American literature environmental and climate change issues dominate the research of the phenomenon of suburbanisation.

On the other hand, the European, especially the Central European literature (Kubeš, 2013) focuses on the transformation of the physical and functional spatial structure; housing structure/policy/market; social spatial structure of the city and of the suburbs. The environmental impacts of suburbanisation are under-explored and only a few works deal with it (e.g. Čepelová & Münzbergová, 2012; Repaská et al., 2017; Vaszócsik, 2017).

Residential suburbanisation significantly changes the morphology of the target settlements, their proportions, base plan and villagescape, and the typical means of land use in the inner areas. This will lead to the transformation of the traditional land- and villagescape.

The aim of this paper is, based on theoretical and empirical knowledge, to point out to spatial patterns of urban sprawl and suburbanisation in functional urban areas (FUA).

This paper examines the urban sprawl and its impacts in Slovakia in the case of Nitra Functional Urban Area, in the agglomeration of an economically growing regional centre. The transformation of the landscape is caused as a consequence of the environmental impacts of suburbanisation (increased proportion of non-permeable surfaces, decreasing green surfaces...), but is also due to population changes. The paper is meant to highlight that researchers have to focus not only on the big cities, capitals but on the smaller cities, towns as well, because these urban areas, despite the small scale population growth (sometimes declining population), could reach a significant change in the landscape and in the share of natural/built-up areas.

Urbanisation, suburbanisation and urban sprawl in Slovakia

The suburbanisation phase in Slovakia is characterised by a kind of belatedness compared to the processes in Western Europe. Industry and service sector made cities grow large (more jobs = increase in population), housing blocks were built (uniformity and large series production). Real estate prices in the rural areas and accommodation prices in the cities were the same. Suburbanisation processes appeared in Slovakia after 1989. The state offered attractive financing solutions, and so the residents bought land plots and houses from credit in the peri-urban areas and the countryside. The countryside offered cheaper land and cleaner environment than cities did. The inhabitants preferred detached houses offering more private life, instead of the apartments in the pre-fabricated housing blocks. Outmigration to the countryside and the urbanisation of the rural areas started.

The most important process in urbanisation was urban sprawl in the 20th century. As a definition, it is an economic and socio-spatial process when urbanised areas spread to formerly rural areas around the proper core, creating low-density urban fabric. It may cover many aspects from suburbanisation to decentralisation, from desurbanisation to rurbanisation and the emergence of edge cities (Kocsis, 2015). Thus, it seems to cover too much, but on the other hand, it has a strong explanatory power in interpreting the processes. It enables to link and separate processes. Because of its strength, it is to be found in most places, but as a major process, it is the first to be distorted by policy-makers and local features. Socialism brought about significant alteration in the process inasmuch as many scholars even denied the very existence of the urban sprawl, especially suburbanisation, which was regarded as a negative process. Dense, compact developments, such as housing estates, were favoured and the size of the capital city was seen as too big for the country, thus policies thwarted any significant development in most of the settlements of the agglomeration. Nonetheless, the processes continued, although in an almost unrecognisable way. The actual forms changed, but the driving forces and the desires of the strata remained continual within the strict constraints of the socialist system. The middle-class out-newcomers were replaced by lower class newcomers; it was a process that further propelled the process and led to substantial transformation of the core in the 1960s and 1970s. The process of suburbanisation sped up in the 1990s and flooded farther areas in the early 2000s.

At the beginning of the first stage of urbanisation (i.e. 1869-1918), at the time of the first modern census in 1869, the territory of Slovakia had a predominantly rural character. The degree of urbanisation achieved only 10.1%. In this period, cities with population over 50,000 inhabitants were still absent. Only two cities had higher population than 20,000 inhabitants – Bratislava and Košice. In the years 1948-1989 the urbanisation process occurred simultaneously with the industrialisation process. The number of inhabitants living in the cities increased from 857,000 to almost 2,990,000. The degree of urbanisation increased from 24.9% in 1950 up to 56.7% in 1989. Among others, the integration process – the attachment of communes to cities – considerably contributed to this growth. Within the given urbanisation stage, cities achieved the highest intensity of growth in 1970–1980, while the dynamics of urbanisation in the last decade was sensibly reduced. Only in this stage, the category of big cities was formed; 11 cities had higher population than 50,000 inhabitants (Slavík et al., 2011).

Intense change occurred after 1989 when there was also a change in the values of the society. By the transformation of the economy to market conditions, there was not only restriction of industrial production, but also housing in towns and cities. Mortgage loans appeared which enabled also the population of middle-class society to buy their own family houses and estates. Cheaper estates in cleaner environment of rural areas resulted in the depopulation of towns and cities. There was an intense movement of population to the countryside. The unpreparedness of a large part of rural population to changes and the dynamics of

these changes opened the gap between the technical and economic aspects of modernisation and between the cultural and social processes. New relationships between town and countryside began, which started the so-called urbanisation of the countryside by immigrated population from the towns. In many rural villages, the original architecture, indigenous traditions, and indigenous culture began to vanish as well as the bonds of a man to his residence and rural "genius loci" (Repaská, 2012).

Since 1989, the process of suburbanisation has reached to the post-socialist cities and markedly influences also the cities of Slovakia (Bratislava and Košice) (Czaková, 2010; Dická, 2007; Gajdoš & Moravanská, 2013; Slavík et al., 2011). After the year 2000, this process began to show also in large cities of Slovakia (Nitra, Prešov) (Ferťalová & Sedláková, 2006; Repaská, 2012; Repaská et al., 2015;). For the given cities, the authors analysed residential suburbanisation using mainly the dynamics of population growth and net migration as indicators. All analyses corroborated a certain time shift in suburbanisation. On the basis of the intensity of the observed indicators in Nitra city the authors arrived at the identification of the suburban zone. This is usually formed by only a narrow or mosaic ring of communes in the immediate hinterland.

Research on "cross-border suburbanisation" has intensified, especially in the selected locations of Bratislava, Hungary and Austria (Baj, 2010; Hardi, 2010; Jagodič, 2010; etc.).

Suburbanisation around Nitra

The city of Nitra is administratively incorporated into the district of Nitra, which is one of the districts of the Nitra self-governing region. Nitra is a regional city, it has an important transit position in the centre of Western Slovakia and it has good transport links to Bratislava, Banská Bystrica and Komárno. It is connected to the D1 highway Trnava– Bratislava by the R1 expressway. The airport in Nitra-Janikovce allows air connections with the region and in 1998 it gained the status of an international airport for non-scheduled air transport. Nitra has 76,655 inhabitants (31.12.2018) and it is the 5th largest city in Slovakia. The total area of the city is 100.48 km^2, the population density is 801.40 inhabitants/km^2. The city concentrates 47.6% of the population of the district, 11.3% of the population of the region and 1.4% of the population of Slovakia.

The important location of Nitra conditioned the development of central functions of the city (cultural, educational, service etc.) that are also reinforced in the contemporary period. In the landscape structure, we observe the loss of agricultural land and growth of commercial areas which is connected also with an increase in car and public transport in the city. The construction of commercial buildings was most often carried out "on a green field". In this way, there has been a significant change in land use at the expense of its agricultural function. In the socialist period before 1989 with a centrally managed economy in Nitra, retail was concentrated mainly in the city centre and in housing estates, where it was easily accessible to residents. After the advent of the market economy after 1989 and the change in the socio-economic situation, ownership relations changed, business development, restitution and privatisation took place. It was under this influence that commercialisation began to manifest in the territory of the city of Nitra, which initially affected the inner parts of the city through the emerging smaller retail outlets. Later, multifunctional buildings with a larger number of retail outlets and services, as well as supermarkets (mainly with foodstuffs), were established in the area of housing estates. The year 2006 was characterised by the arrival of multinational retail chains. Shopping centres with their own marketing concepts entered the city of Nitra. In the vicinity of already built and existing commercial buildings, the residential construction also strengthened, through which the residential suburbanisation, which is reflected in the construction of residential areas, also intensified. Residential suburbanisation began in the city of Nitra after 2000 (Repaská, 2012), when the city registered a decrease in population. While 87,575 inhabitants lived in Nitra in 2000, in 2018 there were only 76,655, which is a decrease by 12.5% (Fig. 1).

This decrease was caused mainly by the total decrease of population with a significant share of emigration. While in 2000 the proportion of emigrants from the city was 10.9‰, in 2018 it rose to 21.7‰. The survey of suburbanisation going on the city of Nitra was realised through a few indicators: *Population decline in the city, population increase in the countryside,*

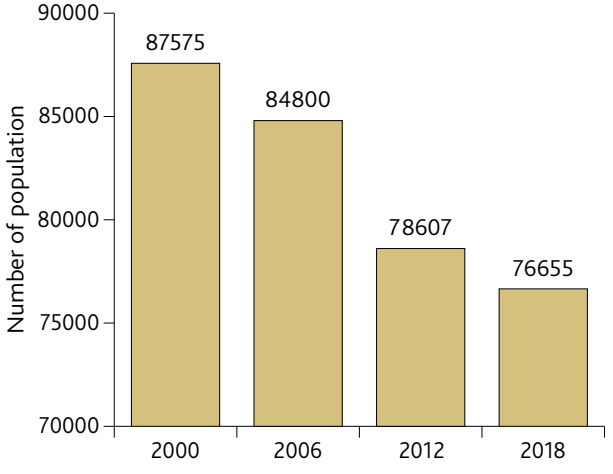

Figure 1. Population dynamics in Nitra city
Source: own work, based on data of Slovak Statistical Office

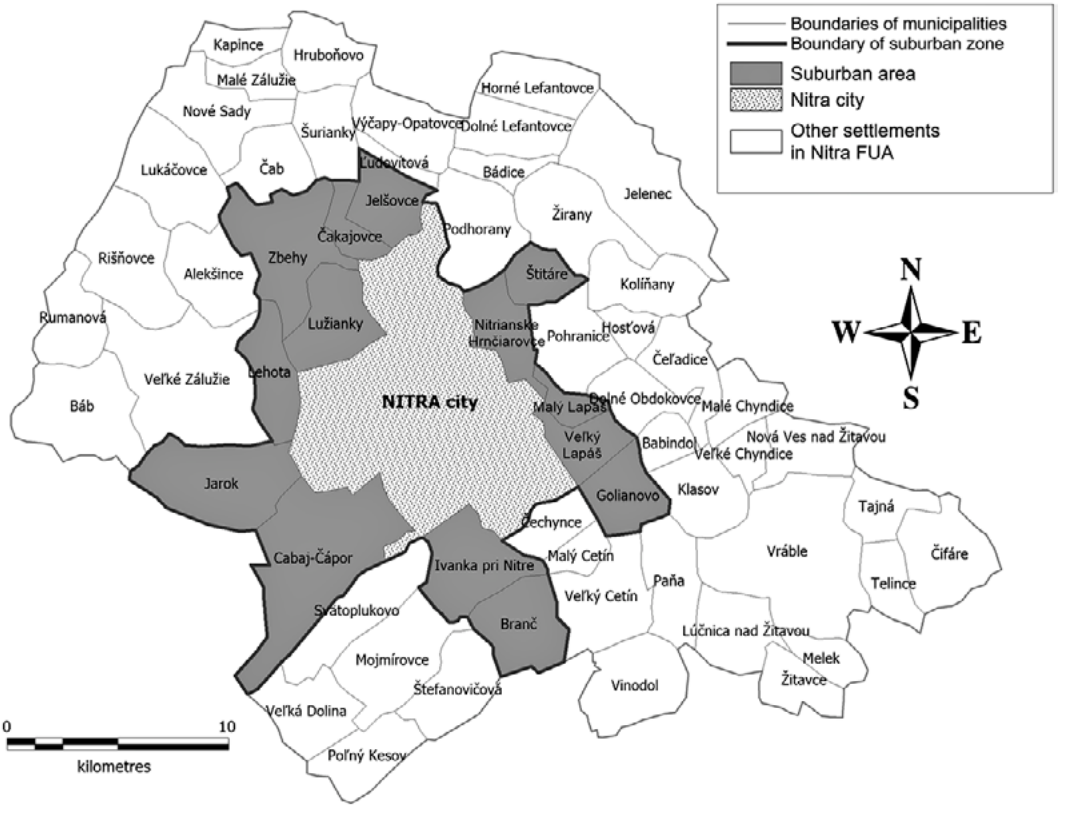

Figure 2. The Structure of the Territory of Nitra Functional Urban Area*
Source: own work
** According to Urban Atlas*

negative migration balance in the city, positive migration balance in the villages. Population decline in the city, population increase in the countryside, negative migration balance in the city and positive migration balance in the villages are no evidences for the process of suburbanisation, only assumptions thereof. A population decline in cities can also be the consequence of the change in the number of births. The negative and positive migration balance shows moving from city to city, from village to village, from city to village and from village to city. The direction of the process of suburbanisation, on the other hand, is a one-way direction from the city to the village. Thus, the *proportion of in-migrants from Nitra in the respective village* was the indicator used to survey migration from the city to the village, only. The proportion of newcomers from Nitra must be higher than the proportion of in-migrants coming from other settlements. According to Repaská (2012), the suburban zone of Nitra City consists of 14 rural villages that surround the city from all cardinal points (Fig. 2).

Between 2000 and 2018, the biggest increase in population was recorded by the municipality of Malý Lapáš (175%), the lowest increase (7%) was in the municipality of Zbehy. In the suburban zone of Nitra city the increase of population is 35%, Nitra showed a decrease of the population by 12% (Fig. 3–4).

The positive migration balance in the municipalities of the suburban zone and the negative migration balance in the city of Nitra point to an increase in the number of inhabitants in rural municipalities at the expense of depopulation of Nitra city.

The migration of the population to the rural municipalities was influenced mainly by cheaper real estate prices; the important factor was the proximity of Nitra city and its good transport accessibility and the attractiveness of the hill Zobor too.

According Repaská et al. (2015), in the municipalities of the suburban zones a decrease of arable land and the expansion of land for constructions took place. In the suburban villages of Nitra detached single unit houses, detached houses, duplexes, and atrium houses are represented. In the villages of the suburban area, the increase in housing units from 2000 to 2018 was most pronounced in the village of Malý Lapáš, where it reached almost 150% (Fig. 5).

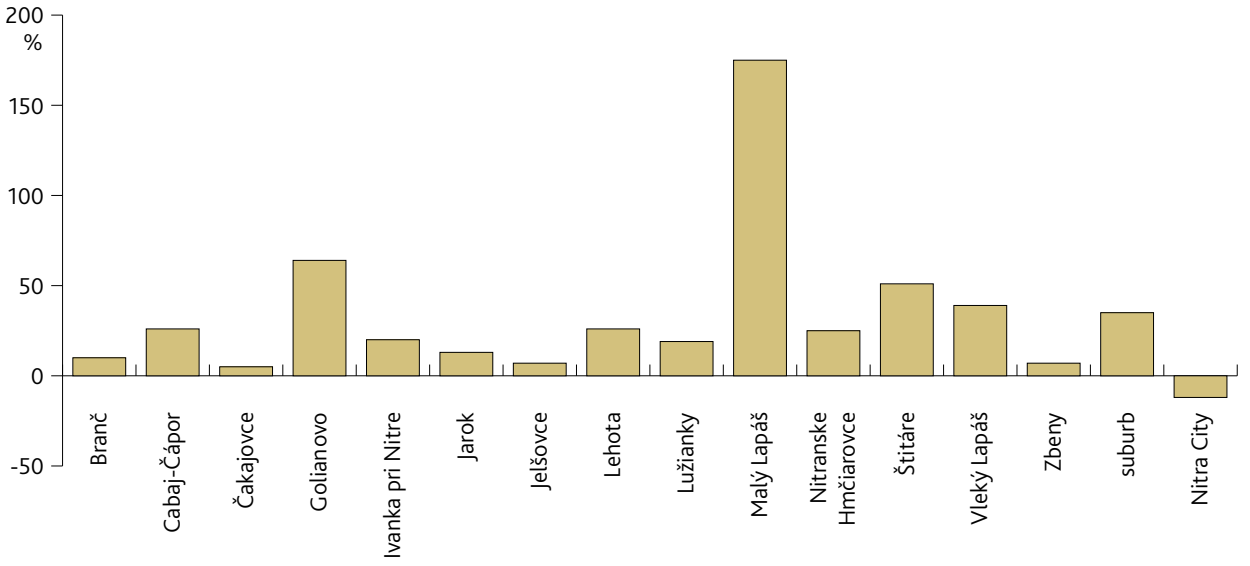

Figure 3. Increase/decrease in the number of population in the suburban area of Nitra city from 2000–2018
Source: own work, based on data of Slovak Statistical Office

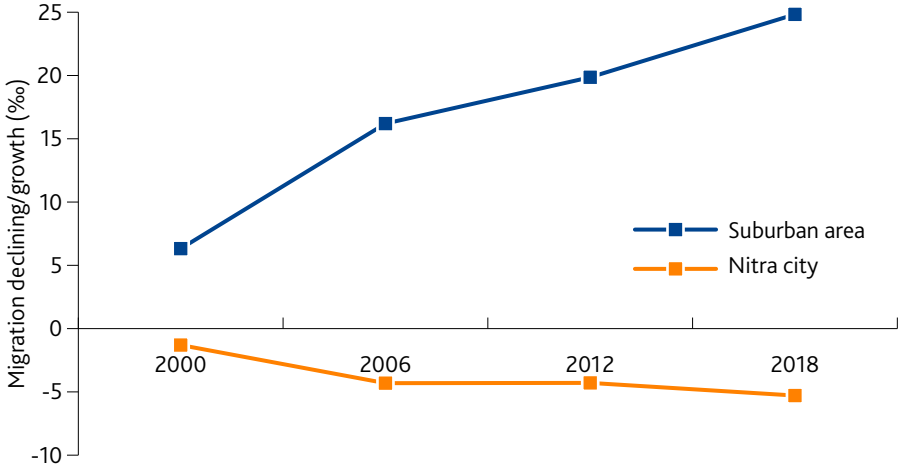

Figure 4. Migration decrease in Nitra city and the migration increase in the suburban area of Nitra city in 2000–2018
Source: own work, based on data of Slovak Statistical Office

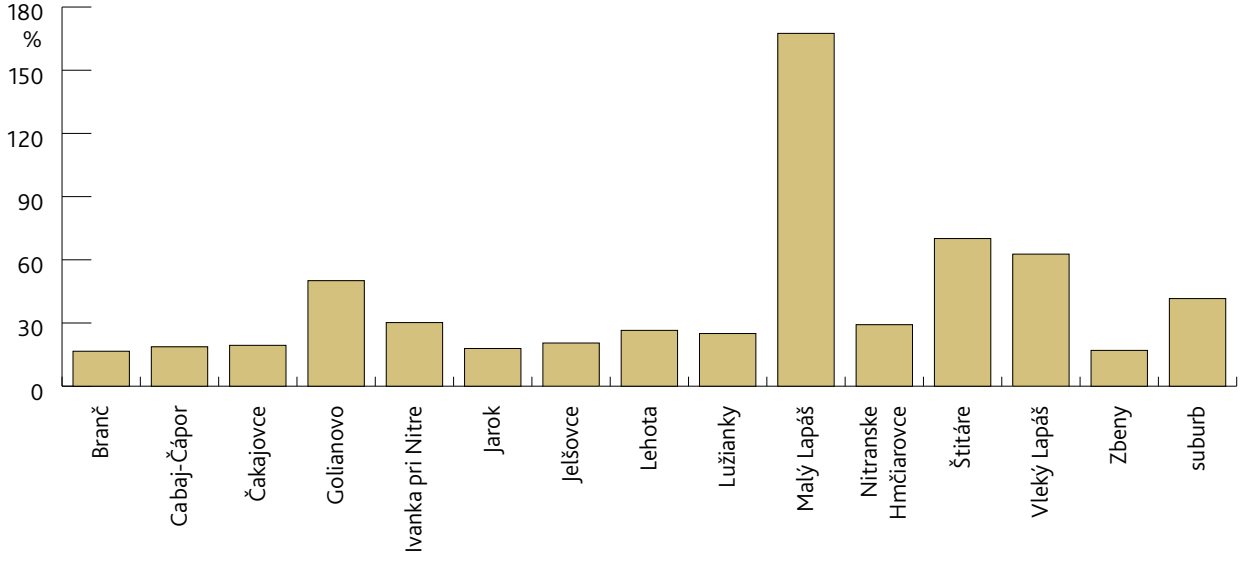

Figure 5. Increase in the number of houses in suburban area of Nitra city
Source: own work, based on data of Slovak Statistical Office

Material and methods

Examination of landcover change caused by suburbanisation and urban sprawl

The spatial unit for assessing the spatial structures of urban sprawl and suburbanization are functional urban areas (FUAs).The European Union and the OECD have jointly developed a methodology to define functional urban areas in a consistent way across countries. FUAs are defined in several steps. First, a population grid makes it possible to define 'urban centres' independently from administrative or statistical boundaries. An urban centre is a pure grid-based concept, a cluster of contiguous cells of high density and with more than 50,000 inhabitants. This means that an urban centre inside a large local unit and one spread out over multiple local units could be easily identified using the same approach, something which is very difficult to do with definitions relying only on local unit data. Subsequently, in this sense, urban centre is adapted to the closest local units to define a city. Next, commuting flows are used to identify which of the surrounding, less densely populated local units were parts of the city's labour market (commuting zone). Commuting flows are based on travel to work i.e. the travel that employed residents in a local unit make to reach the place of work. However, commuting flows also capture some of the flows to access education, health, culture, sports or shops. FUAs are a powerful tool to compare socio-economic and spatial trends in cities and to design urban development policy. Based on the above, we chose FUA to assess the spatial structures of urban sprawl and suburbanization in Slovakia. Although the major concept of functional urban regions (FUR) is quite popular in Slovakia (Bezák 2000, Bezák 2014), we chose OECD and EU regionalisation for research. This paper forms the basis for the development of other similar papers in the individual countries of Central Europe. Therefore, it is essential that an international categorisation is used that is comparable to other countries in Central Europe that the authors will be working on in the future. The region of Nitra FUA and the region of Nitra FUR are not same; Nitra FUA contains 62 municipalities and Nitra FUR 71 municipalities.

Changes in land cover can show visible and generally the impacts of the new built areas and loss of the green territories and it summarises the main effects on the landscape. That is why this methodology is popular among the authors dealing with the impacts of urban expansion and landscape change (Ahrens-Lyons 2019; Feranec et al., 2007; Feranec et al. 2009; Hu et al. 2017; Lennert et al. 2020; Oueslati et al 2015). At European level there are various datasets which can be used as a starting point to explore the spatial patterns of urban sprawl and suburbanisation in functional urban areas[1] (FUA). In the urban sprawl literature one of the most widely used databases is the Corine Land Cover (EEA 2006; EEA 2016) which geographical coverage extends to 39 EEA member and collaborating countries. Another dataset is the Urban Atlas (UA) which contains land use and land cover data for 695 FUA's throughout Europe. These two datasets have standard mapping methodology and nomenclature, which makes the comparative analysis of different FUA's in various countries possible. The verification and qualitative evaluation of the Urban Atlas layers in Slovakia was developed by Szatmári, Kopecká and Feranec (2019).

In their analysis the authors used the Corine Land Cover and Urban Atlas products of the Copernicus Land Monitoring Service. Corine is an acronym which means 'Coordination of information on the environment', and it is part of the European environmental monitoring system. The programme started in 1985, and it provides a common methodological framework to collect and analyse environmental data. The Corine Land Cover (CLC) and Land Cover Change (CHA) datasets are available from 1990 to 2018 at five dates: 1990, 2000, 2006, 2012 and 2018.

CORINE CLC database classifies, on the basis of satellite photos, 0.1 hectare units of the surface into 44 various land cover categories, depending on what is most typical of the surface of the respective square. These categories range from 'Continuous urban fabric' to 'Sea and ocean', and include artificial, agricultural, natural and wetlands categories. There are 11 categories that can be taken as 'ARTIFICIAL SURFACES'.

- Continuous urban fabric (1.1.1)
- Discontinuous urban fabric (1.1.2)
- Industrial or commercial units (1.2.1)
- Road and rail network and associated land (1.2.2)
- Port areas (1.2.3)
- Airports (1.2.4)
- Mineral extraction sites (1.3.1)
- Dump sites (1.3.2)
- Construction sites (1.3.3)
- Green urban areas (1.4.1)
- Sport and leisure facilities (1.4.2)

For their survey the authors selected those land cover categories that best characterise the phenome-

[1] A functional urban area consists of a city and its commuting zone. Functional urban areas therefore consist of a densely inhabited city and a less densely populated commuting zone whose labour market is highly integrated with the city (EUROSTAT 2016, 27).

non of urban sprawl. They examined the changes of 'Discontinuous urban fabric' (1.1.2); 'Industrial, commercial and transport units' (1.2 contains categories 1.2.1-1.2.4) and 'Sport and leisure facilities' (1.4.2).

The change of 'Discontinuous urban fabric' (Most of the land is covered by structures, buildings, roads and artificially surfaced areas associated with vegetated areas and bare soil, which occupy discontinuous but significant surfaces) is mostly due to the enlargement of residential areas where the constructed units do not make contiguous spaces like in inner cities. Accordingly, they can also be seen as the change of settlement patches. The category 'Industrial, commercial and transport units' typically marks the locations of residential areas, infrastructure elements situated outside closed settlement parts (road, railways etc.), and shopping centres, warehouses, factories. These well demonstrate the fragmentation of landscape around settlements, because especially due to the linear infrastructure they make significant barriers in the landscape, compared to the size of the areas covered, and even their patches more remote from settlements considerably disintegrate landscape that typically used to be land of agricultural production.

The examination of the category 'Sport and leisure facilities' (1.4.2) was found important because it is part of the spread of urban lifestyle that occupy ever larger parts of former agricultural, semi-natural and natural areas that are cut out for the population pursuing an urban lifestyle and transformed into park forests, sport fields etc.

Although categories 1.3 are also taken as 'artificial surface', they were not examined, because mines and working areas are to a large extent independent of urban spaces, and so they do not characterise adequately the phenomenon of urban sprawl. The category 'Continuous urban fabric' (1.1.1) was not examined, either. This category refers to the inner, most closed, mostly contiguous areas of towns and cities. The proportion of these in the settlements examined is negligible, typical of the big cities in the first place and their spread takes place within the city, which makes them less relevant from the aspect of urban sprawl.

The analysis shows then to what extent cities and urban areas grow, from which one can conclude to how the urban residential areas have changed, how the proportion of non-permeable surfaces increased, basically influencing the runoff of precipitation. The larger the proportion of such surface, the larger the share of the precipitation flowing off, and the smaller the proportion and quantity of water filtering into the soil. This increases the threat of floods, the pollution of waters, and decreases the amount of subsoil water and evaporation. The data demonstrate, moreover, how artificial patches and barriers fragment landscape more and more, endangering thereby biodiversity and decreasing green surfaces.

The authors' examination covers the 2000-2018 period, using the CORINE CLC 2000, 2006, 2012 and 2018 databases. Thereby they are able to examine changes in a longer period of almost two decades, and three internal periods. All this is compared to the demographic changes of the urban area of Nitra as well, in order to see to what extent the change in the number of population contributes to the transformation of land cover and thereby to environmental impacts.

In the territory of Slovakia, the Urban Atlas database designates eight functional urban areas (FUAs) (Fig. 6). The characteristic features of Nitra and its hinterland within this are analysed, then the Nitra FUA and within that the suburban zone is examined in detail.

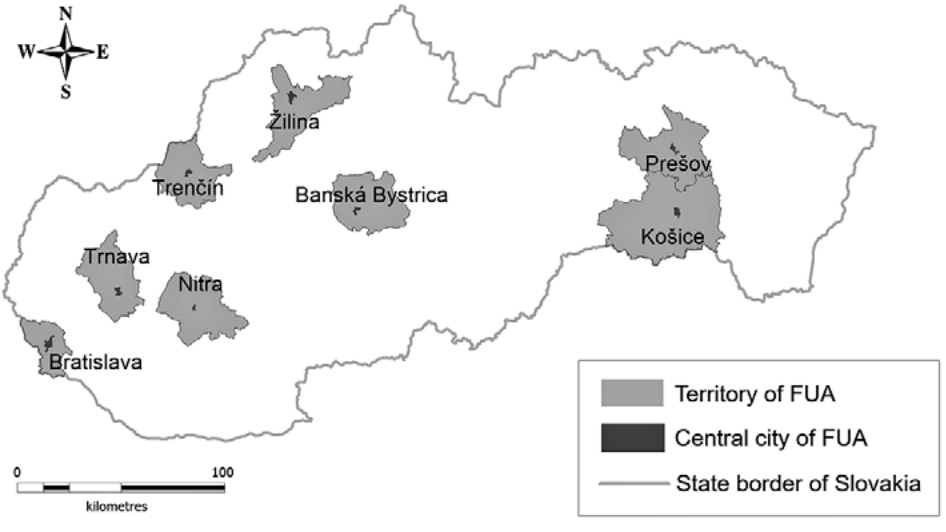

Figure 6. Overview map about the Slovak FUA's locations
Source: Own elaboration based on the data of the Urban Atlas.

Results

In 2000, 25,861.4 hectares from the territory of Slovakia were covered by artificial surface types (i.e. 5.3% of the territory of the country), which grew to 28,850.6 hectares (i.e. 5.9% of the territory of the country) by 2018, which is a growth of 11.6% in 18 years. In the territories of FUAs the share in this period grew on the average from 8.1% to 9.4%, which is an increase by 16.6% (Fig. 7).

Nitra and its area have a visibly higher proportion of built-up areas compared to other FUAs. The proportion of artificial areas is close to the figures of Bratislava, i.e. the highest among the cities, apart from the capital city, and follows Zilina as regards the extent of growth. If we look at the respective FUAs from the aspect of how the proportion of built-up areas changed in the territory of the central city and the other parts

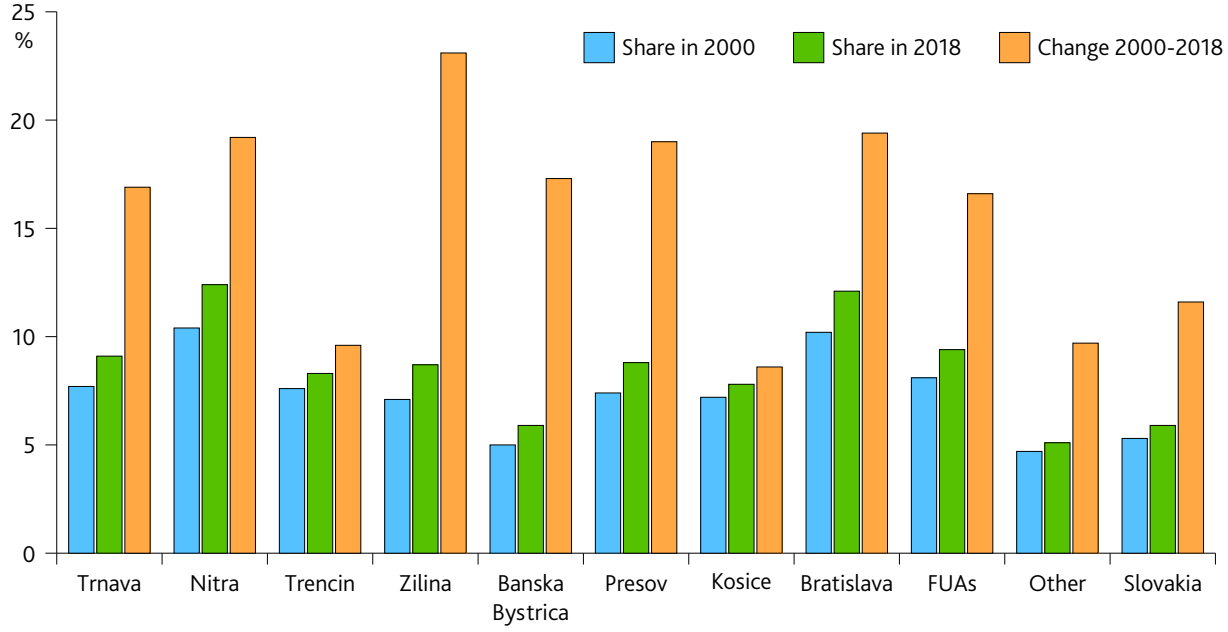

Figure 7. Proportions of the surface coverage categories examined and the extent of change from 2000 to 2018 in Slovakia, in the territories of the respective FUAs, in the average of the FUAs and in areas outside the FUAs
Source: own work based on EU Copernicus data.

Table 1. Extension of examined land cover categories in the territories of FUAs, and its change

FUA		Coverage (ha)		Change (%)			
		2000	2018	2000-2018	2000-2006	2006-2012	2012-2018
Trnava	City	144.9	186.7	28.8	22.2	2.7	2.7
	Other*	424.0	478.6	12.9	8.1	3.7	0.7
Nitra	City	269.7	310.8	15.2	10.1	1.0	3.6
	Other	643.2	777.5	20.9	6.3	4.8	8.5
Trencin	City	156.3	173.3	10.9	3.3	3.3	4.0
	Other	356.7	389.2	9.1	3.0	5.0	0.9
Zilina	City	222.9	238.6	7.0	3.7	2.9	0.4
	Other	352.3	469.6	33.3	29.4	2.6	0.4
Banska Bystrica	City	200.2	222.8	11.3	7.5	3.5	0.0
	Other	218.5	268.3	22.8	7.0	14.6	0.1
Presov	City	201.8	227.3	12.6	6.1	4.2	1.9
	Other	477.2	580.9	21.7	15.4	3.5	1.8
Kosice	City	603.8	620.7	2.8	-0.3	1.3	1.8
	Other	690.2	784.4	13.6	11.2	1.3	0.9
Bratislava	City	1,003.1	1,123.5	12.0	9.5	0.1	2.2
	Other	1,024.9	1,297.2	26.6	8.3	11.1	5.2

**Other: the commuting zone of the FUA; Source: own work based on EU Copernicus data.*

Table 2: Changes in the population and surface coverage in different zones of Nitra FUA

	Area, km²	Population		Relative change 2000-2018				Absolute change 2000-2018		
		2000	2018	Population	Artificial coverage	From which		Artificial coverage	From which	
						Discontinuous urban fabric (1.1.2)	Other examined surfaces		Discontinuous urban fabric (1.1.2)	Other examined surfaces
		Number of inhabitants		%				ha		
NITRA FUA	870.4	162,095	161,120	-0.6	19.2	15.5	48.4	175.4	126	49.4
Nitra city	100.47	87,575	76,655	-12.5	15.2	10.0	36.1	41.1	21.5	19.6
Other*	769.93	74,520	84,465	13.3	20.9	17.6	62.3	134.3	104.5	29.8
Suburbia**	183.9	22,149	28,218	27.4	45.9	43.7	72.5	83.7	73.7	10
Slovakia	49036	5,343,645	5,443,120	1.9	11.6	9.6	22.1	2,989.2	2,081.1	908.1

**= commuting zone of the NITRA FUA;*

***=suburban settlements within the commuting zone*

Source: own work, based on data of Slovak Statistical Office.

of the FUA, it is Nitra again that is characteristically different from the other Slovak urban areas (Table 1).

Nitra and its area feature high but not the highest enlargement dynamics looking at the whole of the period, compared to other FUAs. It is typical almost everywhere that the enlargement of areas surrounding cities is more intensive than the growth of the city itself, which demonstrates general suburbanisation. A characteristic feature of Nitra is that while in the first half of the 2000s growth was relatively high everywhere, especially in territories around the city, and growth slowed down by the third period, Nitra showed a rapid growth within 2012 and 2018 too, in fact, the enlargement of both the city and its environs was the highest among all FUAs, even preceding the capital city.

If the internal changes in the total of the Nitra FUA are examined, one can see that the enlargement of artificial areas was significant in the recent decades. Parallel to an increase of the built-up areas by 19.2%, the number of population decreased by 0.6%. Significant differences can be seen, however, if the data of 1) the central city (Nitra), 2) other parts of the FUA, and 3) the suburban zone within the FUA are separately analysed (Table 2).

One can clearly see the spatial rearrangement of the population within the FUA. The population of the city continuously declined in the examined period (from 87,575 to 76,655), as did that of the FUA as a whole (from 162,095 to 161,120 inhabitants). The population of areas outside the city significantly grew (from 74,520 to 84,465 inhabitants), within that suburban area increased their population from 22,149 to 28,218. Previous surveys prove that approximately half of the increase had come from other cities, the other half from other regions of the country, also, when comparing the data of the settlements we must also take into consideration some migrations of other (rural to rural) direction within the FUAs.

The dynamism of the growth of artificial surfaces (Fig. 8), however, exceeds to a large extent the growth of the number of population in all observed territorial units. In fact, in the cities we can register a rapid territorial increase besides falling population numbers. This is true not only for the residential zones but also for other artificial categories. As regards the central city, it must be emphasised that significant industrial investments were made that occupied territories of former agricultural lands.

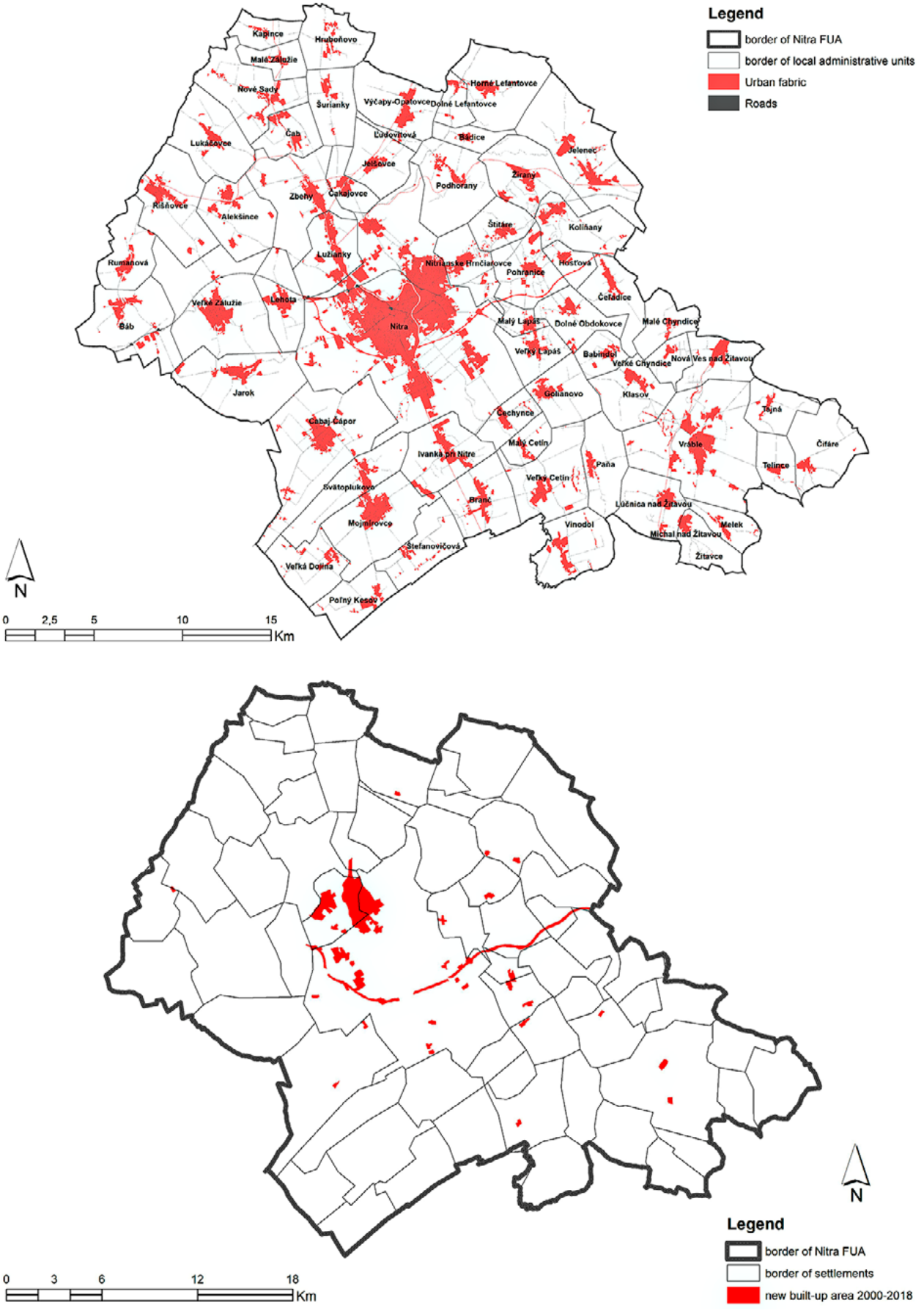

Figure 8. Urban fabric areas in 2018 and Changes in the extension of artificial surfaces in the Nitra FUA (2000–2018)
Source: own work based on EU Copernicus data.

Discussion

Nitra is an important industrial centre in Slovakia. It is a typical Central European industrial centre where growth is primarily due to the expansion of automotive industry. Growing industry attracts a large number of migrants from other parts of the country and even from abroad. It is visible that in the 2000s the city and its suburbia entered the period of suburbanisation, and the central city has been losing its population, parallel to the rapid growth of a suburban zone outside the city. At the same time we can witness the traditional suburbanisation tendency of growing industry attracting inhabitants from other rural areas, who settle down either in the city or in the suburban zones around it.

The authors' in-field experiences show that this results in a spectacular territorial expansion and the transformation of the landscape, the villagescape. It is typical that a large part of the newly settling in-migrants buy newly built homes in residential places created in villages around the city. These new residential zones are usually created by the transformation of agricultural areas. While the construction of detached houses was typical in the beginning of the period, in the last decade terraced houses built for commercial/investment purposes are typical. This increased the density of population and the proportion of built-up parts of the land plots also in suburban areas, while the average size of land plots decreased and there are less and less green surfaces. Exceptions from this are residential areas with higher prestige, which usually occupy hillside areas of higher elevation, and are often enlarged to the detriment of pastures and semi-natural areas, creating homes with a larger proportion of green surfaces on larger land plots. This is also indicated by a paper by the authors Izakovičová, Mederly and Petrovič (2017). According to the authors, urbanisation is typified by conversion of productive agricultural land and semi-natural ecosystems into built-up area accompanied by the negative ecological impacts of habitat deterioration and fragmentation. The rapidly changing consumption patterns of luxury living, transportation and leisure have increased the negative consequences on ecosystems and these compound the negative environmental trends.

Looking at the data of surface coverage the assumption can be justified that during urban sprawl and suburbanisation the increase of artificial surfaces is faster than the growth in the number of population. The growth dynamism of residential areas is less, anyway, than the triple value defined in the preface (Marshall's equation). Looking at the newly built real estates the authors believe that the reason for this is the shortage of capital, as most of the homes were built for families with more modest incomes. Investors wanted to build the largest possible number of homes on relatively small areas, leaving little space for both green areas and auxiliary roads. Knowing the examples from Western Europe (Haase & Nuissl, 2007) it is thought to be an important feature of suburbanisation in the Central European macro-region. The proportions of residential areas of higher prestige are compatible with the building up proportions of an average suburban zone in Germany. This results in the higher proportion of non-permeable surfaces within residential zones, with all of its environmental consequences (unfavourable changes in the proportions of runoff, infiltration and evaporation). According to Kopecká and Rosin (2015), urbanisation can be perceived from an economic point of view as streamlining the use of space. Intensive urban growth associated with an increase in impermeable surfaces is one of the most significant threats to biodiversity and soils. This is exacerbated by the lack of gardens in the new land plots, and the very low proportion of green surfaces, and even those are typically mowed lawn with a few ornamental plants and bushes, the majority of which are non-indigenous species. No fruit trees and other tress with larger foliage can be seen in the newly built-up areas – partly because they typically were plough lands before and partly due to the density of building up.

Urban sprawl is even more characterised by the enlargement of artificial surfaces outside residential areas: territories used for industrial, commercial and transportation purposes, or for recreation and sport. The increase of these areas is much more dynamic, as they only partly depend on the growth in the number of population. It can be connected to economic growth, transformation of the lifestyle of the population, the penetration of extra-urban shopping centres and the new ways of passing leisure time. It is also related, on the other hand, to the inconsiderate planning of the growth of residential areas, as the appearance of new residential zones does not always take place in areas most suitable from transportation aspects, and so the number and capacity of the network elements is continuously growing too. All this leads to the ever more serious fragmentation of the landscape and the habitats, the appearance of an increasing number of degraded surfaces and vegetations, the disappearance of alleys and groups of trees beside the roads, which makes the landscape more homogenous and boring, and thereby less valuable. We agree with Haladová and Petrovič (2015) who monitored the land use changes in the model area of Nitra.

Agriculture in this region has been gradually declining and disappearing in the past years. On the other side, urbanisation, technicisation and industrialisation are highly supported.

It is visible that the volume of urban sprawl and suburbanisation in our rural towns is not really significant on the whole. It concerns a relatively small number of population and area even in our case where economic growth induces a considerable in-migration and there is a relatively high solvent demand. The impacts on the environment and the landscape, on the other hand, are more considerable, and in the middle run even real estate problems are expected, as the residential zones are built relatively homogeneously and at the same time are more susceptible to market impacts than areas with diverse real estate structures.

Conclusions

The paper presents the spatial processes of a Slovakian urban area during the last period of almost two decades. This period resulted in significant changes in the lives of cities and their peri-urban areas. Migrating out from the cities, the changes in building up and lifestyle to such extent had been untypical formerly. The large number of out-migrants and the transforming economy together impact the landscape and surface of peri-urban areas and the proportions and styles of building up, which may result in obvious environmental problems in the coming decades. In the authors' opinion the transformation taking place in Central Europe is similar to the urbanisation processes of Western Europe, but traditionally belated compared to those and with more limited assets of capital; also, the transformation is smaller in volume because of the lower density of population. It is definitely worth surveying these processes and exploring their characteristic features, as these are the most significant settlement development processes of our time and the decades to come, and their environmental impacts may be important not only in themselves but are also given a special emphasis by the expected climate change.

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References

Ahrens, A. & Lyons, S. (2019). Changes in Land Cover and Urban Sprawl in Ireland From a Comparative Perspective Over 1990–2012. Land, 8(1), 16; doi:10.3390/land8010016

Antrop, M. (2004). Landscape change and the urbanization process in Europe. *Landscape and Urban Planning*, 67(1–4), 9–26. DOI: 10.1016/S0169-2046(03)00026-4

Antrop, M. (2005). Why landscapes of the past are important for the future? *Landscape and Urban Planning*. 70(1–2), 21–34. DOI: 10.1016/j.landurbplan.2003.10.002

Baj, G. (2010). A területhasználat átlalakulása - Zmeny vo využívaní pôdy [Changes in land use]. In T. Hardi, M. Lados, & K. Tóth (Eds.), *Magyar-szlovák agglomeráció Pozsony környékén = Slovensko-maďarská aglomerácia v okolí Bratislavy* [Hungarian-Slovak agglomeration around Bratislava] (pp. 182–194). Győr–Samorin: MTA RKK Nyugat-magyarországi Tudományos Intézet; Fórum Kisebbségkutató Intézet. (in Hungarian and Slovak with English summary)

Bajmócy, P. (2012). Suburbanisation and suburban regions in Hungary after 1990. In T. Csapó, & A. Balogh (Eds.), *Development of the Settlement Network in the Central European Countries: Past, Present, and Future* (pp. 207-221). Heidelberg: Springer. DOI: 10.1007/978-3-642-20314-5

Bezák, A. (2000). Funkčné mestské regióny na Slovensku [Functional urban regions in Slovakia]. *Geographia Slovaca*, 15, 1-89. (in Slovak with English summary)

Bezák, A. (2014). Funkčné mestské regióny na Slovensku v roku 2001 [Functional urban regions in Slovakia in 2001]. In V. Lauko (Ed.), *Regionálne dimenzie Slovenska* [Regional dimensions of Slovakia]. (pp. 169-198). Bratislava: Univerzita Komenského. (in Slovak with English summary)

Breheny, M. J. (1992). The contradiction of compact city: A review. In M. J. Breheny (Ed.), *Sustainable*

Development and Urban Form (pp. 138–159). London: Pion Limited.

Čepelová, B., & Münzbergová, Z. (2012). Factors determining the plant species diversity and species composition in a suburban landscape. *Landscape and Urban Planning,* 106(4), 336–346. DOI: 10.1016/j.landurbplan.2012.04.008

Csapó, T., & Balogh, A. (Eds.) (2012). *Development of the Settlement Network in the Central European Countries: Past, Present, and Future.* Springer, Heidelberg. DOI: 10.1007/978-3-642-20314-5

Czaková, G. (2010). Az urbanizációs folyamat Szlovákiában [Urbanization processes in Slovakia]. In I. Mezei, T. Hardi, B. Koós, D. Barabas, M. Gallay, & V. Kandráčová, (Eds.), *Földrajzi szemelvények határok nélkül* [Geographical studies without border] (pp. 206–210). Pécs: MTA Regionális Kutatások Központja. (in Hungarian with English summary)

Dická, J. (2007). Diferenciácia sociálno-demografickej *štruktúry v zázemí* mesta Košice z aspektu suburbanizácie (Differentiation of Social-Demographic Structure in Hinterland of the City Košice in Terms of Suburbanisation). *Geographia Cassoviensis*, 1, 19–25. (in Slovak with English summary)

EEA (European Environment Agency) (2006). *Urban sprawl in Europe – The ignored challenge*. EEA Report 2006 No 10/2006 Luxembourg: Office for Official Publications of the European Communities. https://www.eea.europa.eu/publications/eea_report_2006_10/eea_report_10_2006.pdf

EEA (European Environment Agency) (2016). *Urban sprawl in Europe.* Joint EEA-FOEN report. Luxembourg: Office for Official Publications of the European Communities. https://www.eea.europa.eu/publications/urban-sprawl-in-europe/at_download/file

Ehrlich, K., Kriszan, A., & Lang T. (2012). Urban Development in Central and Eastern Europe – Between Peripheralization and Centralization. *Planning Review*, 48(2), 77–92. https://doi.org/10.1080/02513625.2012.721611

Enyedi, GY. (2012). *Városi világ [Urban world].* Budapest: Akadémiai Kiadó. https://doi.org/10.17649/TET.27.3.2584 (in Hungarian with English summary)

EUROSTAT (2016). *Urban Europe — Statistics on cities, towns and suburbs*. Eurostat statistical books. Luxembourg: EU.

Feranec, J., Hazeu, G., Christensen, S., & Jaffrain, G. (2007). Corine land cover change detection in Europe (case studies of the Netherlands and Slovakia). *Land Use Policy,* 24(1), 234–247. https://doi.org/10.1016/j.landusepol.2006.02.002

Feranec, J., Kopecká, M., Vatseva, R., Stoimenov, A., Oťaheľ, J., Beták, J., & Husár, K. (2009). Landscape change analysis and assessment (case studies in Slovakia and Bulgaria). *Central European Journal of Geosciences,* 1(1), 106–119. DOI: 10.2478/v10085-009-0005-8

Ferťalová J., & Sedláková A. (2006). Kvalita bývania v urbánnom a suburbánnom priestore mesta Prešov. Problémy geografického výskumu Ceska a Slovenska [The quality of housing in the urban and suburban area of the city of Prešov. Problems of geographical research in the Czech Republic and Slovakia]. *Geografické informácie,* 11, 68-73. (in Slovak with English summary)

Gajdoš, P., & Moravanská, K. (2013). *Suburbanizácia a jej podoby na Slovensku* [Suburbanization and its forms in Slovakia]. Bratislava: Slovenska Akademia Vied. (in Slovak with English summary)

Gardi, C. (2017). Is urban expansion a problem? In C. Gardi (Ed.), *Urban expansion, landcover and soil ecosystem services* (pp. 1–18). London and New York: Routledge.

Haase, D., & Nuissl, H. (2007). Does urban sprawl drive changes in the water balance and policy? The case of Leipzig (Germany) 1870–2003. *Landscape and Urban Planning,* 80(1–2), 1–13. https://doi.org/10.1016/j.landurbplan.2006.03.011

Haladová, I., & Petrovič, F. (2015). Classification of Land Use Changes (Model Area: Nitra Town). *Ekologia Bratislava,* 34(3), 249-259. DOI: 10.1515/eko-2015-0024 (

Hardi, T. (2010). A szuburbanizáció jelensége és hatásai - határon innen és túl = Výskyt suburbanizácie a jeho vplyv u nás a v zahraničí In T. Hardi, M. Lados, & K. Tóth (Eds.), *Magyar-szlovák agglomeráció Pozsony környékén = Slovensko-maďarská aglomerácia v okolí Bratislavy* [Hungarian-Slovak agglomeration around Bratislava] (pp. 11–26). Győr–Samorin: MTA RKK Nyugat-magyarországi Tudományos Intézet; Fórum Kisebbségkutató Intézet. (in Hungarian and Slovak with English summary)

Hardi, T. (2012). Cross-border suburbanisation: The case of Bratislava. In T. Csapó, & A. Balogh (Eds.), *Development of the Settlement Network in the Central European Countries: Past, Present, and Future.* Springer Verlag, Berlin; Heidelberg. 193-206. DOI: 10.1007/978-3-642-20314-5

Hardi, T., & Nárai, M. (2005). Szuburbanizáció és közlekedés a győri agglomerációban [Suburbanization and traffic in the agglomeration of Győr city]. *Tér és Társadalom,* 19(1), 81–101. doi: 10.17649/TET.19.1.985 (in Hungarian with English summary)

Hirt, S. (2007). Suburbanizing Sofia: Characteristics of Post-Socialist Peri-Urban Change. *Urban Geography,* 28(8) 755–780. DOI: 10.2747/0272-3638.28.8.755

Hirt, S. (2012). *Iron Curtains: Gates, Suburbs and Privatization of Space in the Post-socialist City.* Chichester: Wiley & Sons Ltd. DOI: 10.1002/9781118295922

Hu, X., Zhou,W., Qian,Y., & Yu,W. (2017). Urban expansion and local land-cover change both significantly contribute to urban warming, but their relative importance changes over time. *Landscape Ecology*, 32(4), 763–780. DOI: 10.1007/s10980-016-0484-5

Ilbery, B. (Ed.) (1999). *The Geography of Rural Change*. Essex: Longman. https://doi.org/10.4324/9781315842608

Izakovičová, Z., Mederly, P., & Petrovič, F. (2017). Long-term Land Use Changes Driven by Urbanisation and Their Environmental Effects (Example of Trnava City, Slovakia). *Sustainability*, 9(9), 1–28. DOI: 10.3390/su9091553

Jagodič, D. (2010). Határon átnyúló lakóhelyi mobilitás az Európai Unió határai mentén - Cezhraničná rezidenčná mobilita v blízkost ivnútorných hraníc Európskej *Únie*. In T. Hardi, M. Lados, & K. Tóth (Eds.), *Magyar-szlovák agglomeráció Pozsony környékén = Slovensko-maďarská aglomerácia v okolí* Bratislavy [Hungarian-Slovak agglomeration around Bratislava] (pp. 27–40). Győr–Samorin: MTA RKK Nyugat-magyarországi Tudományos Intézet; Fórum Kisebbségkutató Intézet. (in Hungarian and Slovak with English summary)

Johnson, M. P. (2001). Environmental impacts of urban sprawl: a survey of the literature and proposed research agenda. *Environment and Planning A*, 33(4), 717–735. DOI: 10.1068/a3327

Kahn, M. E. (2000). Environmental Impact of Suburbanization. *Journal of Policy Analysis and Management,* 19(4), 569–586. DOI: 10.1002/1520-6688(200023)19:4<569::AID-PAM3>3.3.CO;2-G

Karwińska, A., Böhm, A, & Kudłacz, M. (2018). The phenomenon of urban sprawl in modern Poland: Causes, effects and remedies. *Zarządzanie Publiczne Public Governance,* 45(3), 26-43. doi: 10.15678/ZP.2018.45.3.02

Kocsis, J. (2015). Patterns of Urban Development in Budapest after 1989. *Hungarian Studies,* 29(1–2) 3–20. DOI: 10.1556/044.2015.29.1-2.1

Kopecká, M., & Rosina, K. (2014). Identifikácia zmien urbanizovanej krajiny na báze satelitných dát s veľmi vysokým rozlíšením (VHR): záujmové územie Trnava [Identification of Changes in Urbanized Landscape Based on VHR: Study Area of Trnava]. *Geografický časopis*, 66(3), 247-267. (in Slovak with English summary)

Kovács, Z. (2014). New post-socialist urban landscapes: The emergence of gated communities in East-Central Europe. Guest Editorial. *Cities*, 36, 179–181. https://doi.org/10.1016/j.cities.2013.09.001

Kovács, Z., Farkas, J. Zs., Egedy, T., Kondor, A. Cs., Szabó, B., Lennert, J., Bakad, D., & Kohánd, B. (2019). Urban sprawl and land conversion in post-socialist cities: The case of metropolitan Budapest. *Cities*, 92, 71-81. https://doi.org/10.1016/j.cities.2019.03.018

Kubeš, J. (2013). European post-socialist cities and their near hinterland in intra-urban geography literature. *Bulletin of Geography. Socio-economic Series,* 19(19), 19–43. DOI: 10.2478/bog-2013-0002

Kubeš, J. (2015). Analysis of regulation of residential suburbanisation in hinterland of post-socialist 'one hundred thousands' city of České Budějovice. *Bulletin of Geography. Socio-economic Series,* 27(27), 109–131. DOI: 10.1515/bog-2015-0008

Kubeš, J., & Nováček, A. (2019). Suburbs around the Czech provincial city of České Budějovice – territorial arrangement and problems. *Hungarian Geographical Bulletin,* 68(1), 65–78. DOI: 10.15201/hungeobull.68.1.

Leetmaa, K. & Tammaru, T. (2007). Suburbanization in Countries in Transition: Destinations of Suburbanizers in the Tallinn Metropolitan Area. *Geografiska Annaler. Series B, Human Geography,* 89(2), 127-146. https://doi.org/10.1111/j.1468-0467.2007.00244.x

Lennert, J., Farkas, J. ZS., Kovács, A. D., Molnár, A., Módos, R., Baka, D., & Kovács, Z. (2020). Measuring and Predicting Long-Term Land Cover Changes in the Functional Urban Area of Budapest. *Sustainability*, 12(8), 3331; doi:10.3390/su12083331

Oueslati, W., Alvanides, S., & Garrod, G. (2015). Determinants of urban sprawl in European cities. *Urban Studies*, 52(9), 1594–1614. DOI: 10.2139/ssrn.2397141

Repaská, G. (2012). *Rezidenčná suburbanizácia miest Nitrianskeho samosprávneho kraja (empirický príklad mesta Nitra)* [Residential suburbanization of the cities in the Nitra self-governing region (empirical example of the city of Nitra)]. Univerzita Konštantína Filozofa v Nitre: Nitra. (in Slovak with English summary)

Repaská, G., Vilinová, K., Dubcová, A., & Kramárekeová, H. (2015). Sídelná identita ako fenomén v kontexte suburbanizácie (prípadová *štúdia suburbia mesta Nitra*) [Residential identity as a phenomenon in the context of suburbanization (case study of suburbs of the city of Nitra)]. *Geografický časopis*, 67(2), 107-126. (in Slovak with English summary)

Repaská, G., Vilinová, K., & Šolcová, L. (2017). Trends in Development of Residential Areas in Suburban Zone of the City of Nitra (Slovakia). *European Countryside,* 9(2), 287–301. DOI: 10.1515/euco-2017-0018

Slaev, A. D., Nedović-Budić, Z., Krunić, N., Petrić, J., & Daskalova, D. (2018). Suburbanization and sprawl in post-socialist Belgrade and Sofia. *European Planning Studies*, 26(7), 1389-1412. DOI: 10.1080/09654313.2018.1465530

Slavík, V., Grác, R., Klobučník, M., & Kohútová, K. (2011). Development of Suburbanization of Slovakia on the Example of the Bratislava Region. In T. Marszal (Ed.), *Urban Regions as engines of Development* (pp. 35-38). Warsaw: Polish Academy of Science, Committee for Spatial Economy and regional Planning.

Sturm, R., & Cohen, D. A. (2004). Suburban sprawl and physical and mental health. *Public Health*, 118(7), 488–496. DOI: 10.1016/j.puhe.2004.02.007

Szatmári, D., Kopecká, M., & Feranec, J. (2019). Verifikácia a kvalitatívne hodnotenie vrstiev Urban Atlas na Území Slovenska [Verification and Qualitative Evaluation of the Urban Atlas layers in Slovakia]. *Cartographic letters*, 27(1), 25–33. (in Slovak with English summary)

Székely, V., & Michniak D. (2009). Rural municipalities of Slovakia with a positive commuting balance. *Rural Areas and Development*, 6, 1–17, DOI:10.22004/ag.econ.157620

Szirmai, V. (2011). *Urban sprawl in Europe.* Budapest: Aula Kiadó.

Timár, J., & Váradi, M. M. (2001). The uneven development of suburbanization during transition in Hungary. *European Urban and Regional Studies,* 8(4), 349–360. DOI: 10.1177/096977640100800407

Van den Berg, L., Drewett, R., Klaassen, L. H., Rossi, A., & Vijverberg, C. H. T. (1982). *Urban Europe: vol.1.: Study of Growth and Decline.* New York, Oxford: Pergamon Press.

Van der Valk, A. J, & Faludi, A. (1992). Growth regions and the future of Dutch Planning Doctrine. In M. J. Breheny, (Ed.), *Sustainable Development and Urban Form* (pp. 122–137). London: Pion Limited.

Vaszócsik, V. (2017). Meddig nőhetnek a városok? – A területhasználat-változási folyamatok modellezése [How Far Can Cities Grow? Modeling of Processes in Land Use Change]. *Területi Statisztika*, 57(2), 205–223. DOI: 10.15196/TS570205 (in Hungarian with English summary)