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Rethinking the spatial transformation of postsocialist cities: Shrinking, sprawling or densifying

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ABSTRACT

This research examines the spatial transformations of postsocialist cities in the context of the polarized national urban system. Focusing on two different periods (1990–2000 and 2000–2014/2015), we study the patterns of spatial changes in 15 selected cities in Serbia in terms of urban sprawl, densification, and urban shrinkage. Using an open-source database, we analyze the relationship between the built-up area, population, and urban density to identify the types and trajectories of spatial transformations. Our results show that urban sprawl characterizes cities with growing/stable populations and those with declining populations but with different scales and dynamics over time. Despite the distinct trend of population decline, no cities were marked by compact shrinkage. Nevertheless, we identify a significant decrease in the annual change rates of the built-up area throughout the latter period in all cities, indicating a possible future decline in inefficient outward expansion. We also observed that this period gave rise to the imbalance between the pace of spatial growth of large cities and medium-sized cities. The obtained spatial patterns fit into the framework of Serbia's asymmetric urban system, with sprawl shrinkage as dominant phenomenon in urban centres ranking lower in the urban system hierarchy and less frequent sprawl growth in major urban centres. Our research results could ignite a process of redefining urban and land policies towards more efficient land use.

1. Introduction

A profound discussion about cities in the former socialist states of Central and South-Eastern Europe, commonly referred to as "post-socialist cities", reveals the complexity of this phenomenon (Ferenčuhová & Gentile, 2016; Hirt, 2013; Hirt et al., 2016; Ilchenko & Dushkova, 2018). Numerous studies analyze the impact of natural and social or only social factors on the process of their spatial transformation (Garcia-Ayllon, 2018; Kovács, 2014; Malý et al., 2020; Mihaylov, 2020; Schmidt et al., 2015; Siedentop & Fina, 2012; Stanilov, 2007; Stanilov & Sýkora, 2014a; Taubenböck et al., 2019). Special attention is paid to multiple transformation processes in capitals, which were the first to move "toward breaking out of the mold of the compact city form" (Stanilov & Sýkora, 2014b, p. 274), e.g. Ljubljana (Svirčić Gotovac & Kerbler, 2019), Zagreb and Podgorica (Svirčić Gotovac, 2016a; Svirčić Gotovac & Zlatar, 2015), Belgrade and Sofia (Slaev et al., 2018; Vuksanović-Macura et al., 2018; Zeković et al., 2015), Bucharest (Ianoş et al., 2016; Nistor et al., 2021), Budapest (Kovács et al., 2019), Bratislava (Malý et al., 2020), and Tirana (Manahasa & Manahasa, 2022). The former industrial cities, transition losers (Miletić et al., 2009), where economic power and population declined during the transition (Jaroszewska, 2019; Jigoria-Oprea & Popa, 2017; Kazimierczak & Kosmowski, 2018) are also analyzed. Limited attention is paid to the transformation of medium- and small-sized cities (Batunova & Gunko, 2018; Cercleux et al., 2019; Pirisi & Trócsányi, 2014; Siljanoska et al., 2012; Wolff & Wiechmann, 2018), though they have a major role in the establishment of polycentric urban systems, and the relationship between the development of the capital city and the cities lower in the hierarchy.

This paper adds to the international perspective of discussions about the spatial aspects of the development of post-socialist cities by revealing distinct features of their spatial transformations in the context of an unevenly developed urban system. It compares and explains the dynamics and the process of spatial transformation in selected cities in Serbia, after the end of the socialist time, using spatio-temporal indicators. Serbia is selected as the study area because it is often omitted from wider comparative analyses of European countries/cities (Schmidt et al., 2015; Siedentop & Fina, 2012; Stanilov & Sýkora, 2014a;

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Taubenböck et al., 2019), or is mentioned as a peculiar example in discussions focusing on phenomena such as urban sprawl (Slaev et al., 2018) or urban shrinkage (Mykhnenko & Turok, 2008; Stryjakiewicz, 2022; Turok & Mykhnenko, 2007; Wolff & Wiechmann, 2018).

Similarly to most postsocialist countries, Serbia's demographic development in the early 21st century is marked by depopulation (first registered in the 1991–2002 intercensus period, to become more intensive) and an accelerated population ageing, as a resultant of low of fertility levels, high mortality rates, and emigration (Kokotović Kanazir et al., 2017; Lukić, 2013; Marinković & Radivojević, 2016; Nikitović, 2022; Penev, 2014; Penev & Predojević-Despić, 2019; Spasovski & Šantić, 2016). The total population enumerated in the latest Census in 2022 is 6,647,003 (Statistical Office of the Republic of Serbia, 2023), indicating a decline of about 540,000 inhabitants compared to the 2011 Census (SORS, 2014).[1]

According to the 2011 Census, the urbanization degree in Serbia was about 60 % (SORS, 2014). Although the share of the urban population increases (Drobnjaković & Spalević, 2017; Tošić & Krunić, 2005), the share of cities with a declining population has been growing, as observed in other European postsocialist cities (Buček & Bleha, 2013; Eva et al., 2021; Haase, Rink, & Grossmann, 2016; Jaroszewska & Stryjakiewicz, 2020; Mykhnenko & Turok, 2008; Simeonova & Milkova, 2019; Turok & Mykhnenko, 2007). In Serbia, around three-quarters of urban settlements face depopulation of varying intensity. These are mainly located in the border areas or are remote from regional centres and main transport corridors (Djurkin et al., 2021). Larger urban centres are affected, too (Panić et al., 2022; Živanović et al., 2021). It is estimated that the negative demographic trends will continue and urban shrinking in Serbian cities is becoming a growing issue (Antonić & Djukić, 2018; Djurkin et al., 2021; Đukić et al., 2017; Macura, 2019; Živanović et al., 2021).

These demographic processes have resulted in an “imbalance in the spatial distribution of population i.e. spatial demographic inequality in the settlement system” (Lukić, 2013, p. 73). Belgrade dominates as the capital, together with several major urban centres, indicating that Serbia's urban system is unevenly developed (Drobnjaković & Spalević, 2017; Tošić & Krunić, 2005; Živanović et al., 2019). Similarly to the neighbouring countries (Croatia and Montenegro), Serbia is facing the processes of centralization and hierarchization in urban systems, with the capital taking the lead (Svirčić Gotovac, 2016b).

According to Li et al. (2022), city size is directly relevant for studying the land-use impacts of urbanization, and not its governmental functions or economic importance. However, in Serbia, population, functions and activities are concentrated in the capital and several major urban centres, which fosters demographic polarization (Stojanović & Vojković, 2005) and spatial (regional) disparities in terms of development levels (see Jakopin, 2014, 2018; Miljanović et al., 2010).

The previous research on urban settlements in Serbia has mostly relied on quantitative indicators (demographic and economic), tracked over particular time periods within settlements' administrative boundaries, an area larger than the city's urban area (e.g. Drobnjaković & Spalević, 2017; Kokotović Kanazir, 2016; Spasić et al., 2007; Stojanović & Vojković, 2005; Veljković et al., 1995; Živanović, 2015). These studies do not discuss the spatial dimensions of the transformation of cities' urban structure. Studies taking into account the spatio-temporal dimension of the transformation deal predominantly with the capital's urban area (Krunić et al., 2014; Slaev et al., 2018; Vuksanović-Macura et al., 2018; Zeković et al., 2015), leaving the issue of urban processes and changes in other cities in the country without answer.

This study focuses on the changes in spatial patterns of the selected cities in Serbia in relation to national urban system features. Nevertheless, the research presented in this paper does not intend to examine the driving forces that give rise to new spatial patterns of the cities but to understand relations between spatial reconfigurations of postsocialist cities and characteristics of the network of urban settlements. More specifically, by using spatio-temporal indicators, we aim to determine similarities and differences in the trajectories of spatial transformations over time, identify transformation types and differences among the trajectories. Spatial transformation is taken to mean *outward expansion* (suburbanisation and urban sprawl), *inward expansion* (densification), and *urban shrinkage*. Our research questions include the following: Which models of spatial development and transformation are present in Serbia in a situation marked by a constant nationwide population decline? What are the effects of the polarized network of urban settlements on spatio-temporal transformation of cities? Has the model of urban expansion involving suburbanization and urban sprawl become the hallmark of urban development in Serbia, or is it only typical of the capital and major urban agglomerations?

2. Theoretical and empirical background

Following the literature, the urban system represents one of the instruments for achieving sustainable spatial and balanced regional development. Scholars have studied the spatial arrangement of urban systems from monocentric to polycentric (c.f. Bartosiewicz & Marcińczak, 2020). Many studies on urban systems attempted to discover and describe the patterns of selected characteristics of cities, such as their population size (Bretagnolle et al., 2000). However, the relationships between a national urban system and the spatial transformation patterns of the cities within it are often overlooked. Siedentop and Fina (2012), in a study of 26 European countries, assumed that spatial patterns of urban growth are related to established urban systems and regional disparities by highlighting differences in urban growth patterns between countries with asymmetric or polycentric urban systems. In this context, our research looks at changes in spatial patterns and reconfigurations in selected Serbian cities in relation to asymmetric national urban system.

Compact and relatively dense urban forms marked former socialist-state cities (Kovács et al., 2019), distinguishing them from capitalist cities (Hirt, 2013). Researchers generally agree that the compactness of cities disappeared during the postsocialist transition (Manahasa & Manahasa, 2022; Stanilov & Sýkora, 2014b; Sýkora & Bouzarovski, 2012). Postsocialist urban restructuring has resulted in changed land use patterns, including a substantial increase in urbanized land and reduced urban density (Taubenböck et al., 2019). An extensive outward expansion (about inward and outward horizontal expansion patterns see Angel, Lamson-Hall, Blei, et al., 2021; Chakraborty et al., 2022; Xu et al., 2020) that started in the 1990s brought postsocialist cities to new spatial deconcentration forms (Spórna & Krzysztofik, 2020), such as suburbanization (Sýkora & Stanilov, 2014) and urban sprawl.

According to Slaev et al. (2018), suburbanization is “any growth of urbanized land and/or urban function into peripheral areas” (p. 1390). Spórna and Krzysztofik (2020) highlight non-residential suburbanisation (or “postsocialist commercial decentralization”, Stanilov & Sýkora, 2014b, p. 270), associated with the dislocation of commercial functions, and residential suburbanisation, “coinciding with the spatial deconcentration of housing developments and changes in the number and density of the population” (p. 2). According to Svirčić Gotovac (2016b), during the transition period, intensive suburbanization of the surrounding area in postsocialist cities (particularly intensive around capitals), took an even more complex form. It was multidimensional housing, job and business suburbanization, as opposed to the previous period, when it was job-related. These processes have led to changes in the compact physical morphology of the former socialist cities (Sýkora & Bouzarovski, 2012), towards urban sprawl, an “unplanned and uneven pattern of urban development” (Oueslati et al., 2015, p. 1595), an irregular discontinuous urban form (Siedentop & Fina, 2012, p. 2768),

[1] Population size is provided for the territory of Serbia without Kosovo, since SORS does not have the population data. All references to Kosovo in this paper should be understood to be in the context of United Nations Security Council Resolution No. 1244 (1999).

an "inefficient utilization of land resources" (Oueslati et al., 2015, p. 1595) by reducing population density (Chakraborty et al., 2022). The intensified commercial and residential suburbanization has caused changes in the population density curve in postsocialist metropolitan areas, which started to converge to western cities (Stanilov & Sýkora, 2014b). As an uncontrolled expansion, urban sprawl has numerous environmental negative effects (European Environment Agency & Federal Office for the Environment, 2016; Johnson, 2001).

Intensive postsocialist political, economic and social changes brought about and catalyzed another form of transformation – urban shrinkage manifested in a demographic and economic decline of cities (Döringer et al., 2020). Haase, Rink, and Grossmann (2016) see shrinkage as "a real challenge for a city, its inhabitants, and decision makers" (p. 305). Based on a literature review, Eva et al. (2021) have identified deindustrialization, suburbanization, second demographic transition and emigration, spatial peripheralization processes and policies implemented at national and local levels as the causes of urban shrinkage in Central and East Europe (CEE). The authors highlight that some causes, like deindustrialization, birth rates, emigration and spatial polarization processes in CEE are more intensive in negative terms than in other parts of the European Union. Haase, Bernt, et al. (2016) confirm the close relationship between demographic and economic processes and their feedback effect on the structure of settlements, land use patterns, socio-demographic and socio-economic population structure. In Serbia, too, the process of urban shrinkage was accelerated by the spatial, demographic and socio-economic transformation (about deindustrialization see Hadžić & Zeković, 2019; Miletić, 2022) during of postsocialist transition (Djurkin et al., 2021; Živanović et al., 2021).

The study of postsocialist urbanization patterns in CEE countries reveals another pattern of spatial reconfigurations – sprawl shrinkage, associated with the built-up area expansion despite declining populations (Schmidt et al., 2015). The built-up area expansion accompanied with a population decline leads to the paradox of "shrinking urban areas contributing to the dedensification process" (Wolff et al., 2018, p. 11), which is "the worst possible form of urban sprawl" (Guastella et al., 2019, p. 6). Sprawl shrinkage is associated with numerous negative side phenomena/processes, e.g. residential vacancy, increasing urban brownfield areas due to vacant industrial land, large-scale demolition, etc. (Reis et al., 2016), affecting the efficiency and functionality of cities infrastructure systems (Schmidt et al., 2015). Reis et al. (2016) argue that the physical patterns of shrinkage-sprawl are similar to those of sprawl growth, resulting in fragmented and low-density development.

Spatial transformation of cities can be lighted from the perspective of various indicators, especially if there is no previous research on a particular area. Depending on research questions, authors apply simple and/or complex indicators to identify spatio-temporal phenomena (Reis et al., 2016). Studies using a universal methodology (with additional indicators, in some papers) for calculating the "ratio of land consumption rate to population growth" or "land use efficiency" (SDG indicator 11.3.1) (UN-Habitat, 2018) stand out (e.g. Calka et al., 2022; Schiavina, Melchiorri, Freire, et al., 2022).

We use urban (population) density as the basis for our analysis of the spatio-temporal patterns of urban transformations in selected cities in Serbia. There are multiple methods to measure urban density. For Angel, Lamson-Hall, and Blanco (2021) urban population density is "the ratio of the total number of inhabitants living within a well-defined footprint of a city and the total area of this footprint" (p. 265). Urban (population) density is also calculated as "the ratio of the total population of city and an urban extent of city" (Angel, Lamson-Hall, Blei, et al., 2021, p. 13), where the city's urban extent includes "both its built-up area and its urbanized open space" (p. 4); or as the ratio of the population and the residential area, defined as residential density (Kasanko et al., 2006; Wolff et al., 2018); or as the ratio of the total population and the total built-up area within urban extent (Angel et al., 2010; Chakraborty et al., 2022; Schneider & Woodcock, 2008; Siedentop & Fina, 2012; Xu et al., 2020). In this study, we use the term urban density (as explained in Section 3.4.3).

Demographic changes and land use dynamics directly influence the temporal variation of urban density (Schmidt et al., 2015; Wolff et al., 2018). Therefore, we analyze the functional relations between the dynamics of urban population and the urban built-up area as the decisive parameters affecting the development trends and changes of urban patterns. This approach allows for tracing the patterns of urban transformations related to expansion, shrinkage or densification in the selected 15 cities in Serbia during the observed period.

3. Study area, data and method

3.1. Study area and selected cities

Serbia is located in Southeast Europe, in the Balkan Penninsula; it covers an area of 88,449 km^2 (SORS, 2021) (Fig. 1). The national settlements system is characterized by a large number of settlements (4709, without Kosovo), only 167 of which are urban settlements. In the group of urban settlements, the most numerous are small towns with <20,000 inhabitants (127), followed by medium-sized towns (36) between 20,000 and 100,000 inhabitants, and there are only four cities (Belgrade, Kragujevac, Niš and Novi Sad) with >100,000 inhabitants (SORS, 2014). In the formal status of the City, 28 urban settlements (without Kosovo) are classified, together with Belgrade, the capital city, which forms a distinct territorial unit (Zakon o teritorijalnoj organizaciji

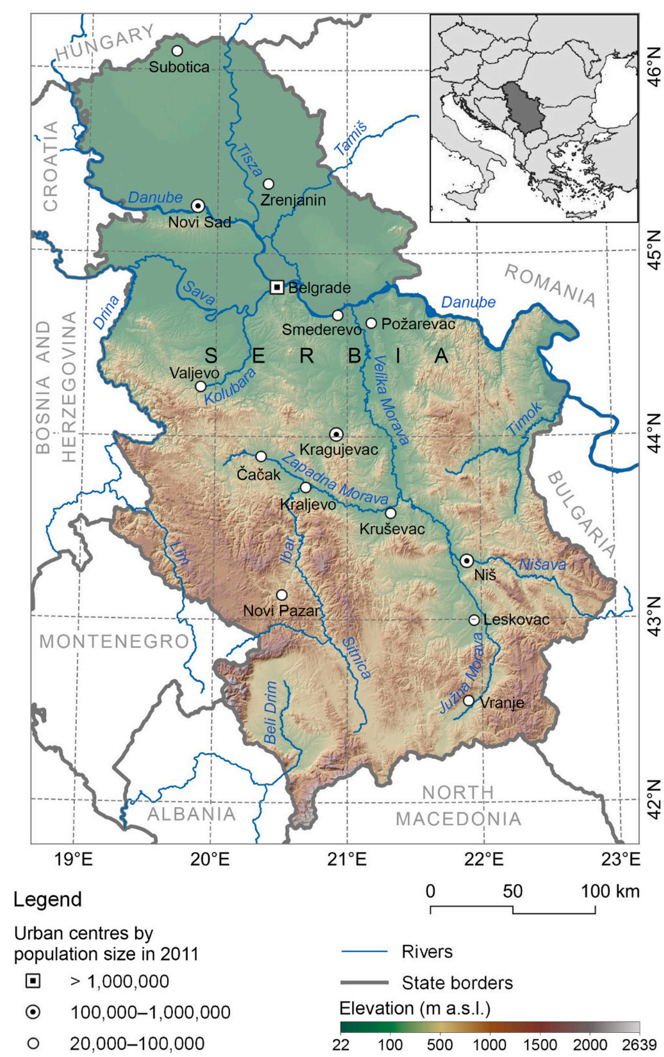

Fig. 1. Study area.

Republike Srbije, 129/2007, 18/2016, 47/2018, 9/2020).

Our analysis covers 15 cities (Table 1) out of 28 classified as cities by the law. The criterions for selecting cities included a proportional representation of cities in the hierarchy of the national urban system and from all geographic regions, namely NUTS 2 regions (Uredba o nomenklaturi statističkih teritorijalnih jedinica, 109/2009, 46/2010), as well as the availability of reliable data for both built-up area and population over a long period. Therefore, analyzed cities differ by multiple characteristics such as population size, the geographical position, the spatial extent of urban area, land-use of the areas of controlled development as well as the natural environment, which are also considered in this study to identify similarities and differences in the spatio-temporal patterns of their transformation.

Following the classifications from the previous research (Spasić et al., 2007), we identified the following categories of cities based on their population size: very large cities (> 1,000,000 inhabitants), large cities (between 100,000 and 1,000,000) and medium-sized cities (between 20,000 and 100,000). Our sample includes the cities from these three categories. Small towns (up to 20,000 inhabitants) are not covered because they do not have the status of a city. Some cities belonging to 28 cities are also excluded from the sample to balance geographic representation and representation in the urban system hierarchy.

Serbia's current urban system is marked by asymmetry and incoherence and is dominated by the capital, Belgrade, indicating that the urbanization process has not been controlled (Drobnjaković & Spalević, 2017; Tošić & Krunić, 2005; Živanović et al., 2019). According to the 2011 Census, Belgrade's population accounted for 16.23 % of the total population and 27.45 % of the urban population. The share of the urban population concentrated in three second-largest cities (Novi Sad, Niš, and Kragujevac) was 13.3 %. The degree of dominance of the capital city in the national urban system in terms of population is indicated by values of the urban primacy index (refers to the ratio of the population of Belgrade and Novi Sad, the second largest city), which ranged over and around 6 in the period 1948–2002 and slightly declined in 2011 to 5.03. (Živanović et al., 2019). Given the small number of large cities and the lack of cities between 300,000 and 1,000,000 inhabitants, scholars indicate an imbalance in the current scale of cities by population size, which is reflected in the hierarchical structure of centres in the national urban system. According to Dželebdžić and Jokić (2014), considering the size of the capital city (Rank-Size Rule), there should be 15 cities with >100,000 inhabitants, but now there are only four such cities. Krunić et al. (2022) especially highlight the insufficient number of cities above 500,000, which could mitigate Belgrade's negative polarizing effect and serve as the basis for establishing a polycentric urban system.

The asymmetry within the urban system and uneven economic and demographic development in CEE countries and Serbia is a legacy of the centrally planned economy from the socialist era and state-led investments in favour of the capital and some secondary cities (Sýkora & Stanilov, 2014; Taubenböck et al., 2019; Tošić & Krunić, 2005). In Serbia, the polarization gap further increased during the postsocialist transition (Djurkin et al., 2021).

The hierarchy of urban centres and the rank of the analyzed cities according to the strategic planning documents of Serbia are shown in Table 2. Two spatial plans covered the analyzed period, one adopted in 1996 (Zakon o Prostornom planu Republike Srbije, 13/96) and another in 2010 (Zakon o Prostornom planu Republike Srbije od 2010. do 2020. godine, 88/2010). The hierarchical structure of the urban centres is defined according to their size, the functional importance of urban centres (functional relationships between centres and their functional (urban) areas) and their level of significance in the settlements network.

Table 1
The features of the analyzed cities.

Cities	Population size/scale between 1991 and 2011	Position in the country (NUTS 2)	Land use of buffer zone as defined in current GUP	Natural environment / physical factors	Spatial extent of the GUP area (ha); percentage of the city's administrative territory (%)
Belgrade (BG)	Very large	Beogradski region [Belgrade Region]	Agricultural and forest land	Plain and undulating terrain	77,862 24.15
Čačak (ČA)	Medium	Region Šumadije i Zapadne Srbije [Region of Šumadija and West Serbia]	Agricultural and forest land	Structural basin / hilly, highland and mountainous area	4029 6.33
Kragujevac (KG)	Large	Region Šumadije i Zapadne Srbije	Agricultural, water and forest land	Structural basin / hilly area	7853 33.08
Kraljevo (KV)	Medium	Region Šumadije i Zapadne Srbije	Agricultural land	Structural basin / highland	7375 4.82
Kruševac (KŠ)	Medium	Region Šumadije i Zapadne Srbije	Agricultural and forest land	Structural basin / plan and mild slopes	7538 8.82
Leskovac (LE)	Medium	Region Južne i Istočne Srbije [Region of South and East Serbia]	Agricultural and forest land	Plain / wide structural basin	4115 4.01
Niš (NI)	Large	Region Južne i Istočne Srbije	Agricultural land and undefined green spaces without a particular role	Plain / wide structural basin	26,678 44.70
Novi Pazar (NP)	Medium	Region Šumadije i Zapadne Srbije	Agricultural and forest land	Structural basin / Mountainous area	3340 4.50
Novi Sad (NS)	Large	Region Vojvodine [Region of Vojvodina]	Agricultural and forest land	Plain	10,903 15.52
Požarevac (PO)	Medium	Region Južne i Istočne Srbije	Agricultural land	Plain	5474 11.34
Smederevo (SD)	Medium	Region Južne i Istočne Srbije	Agricultural, water and forest land	Plain	7219 14.79
Subotica (SU)	Medium	Region Vojvodine	Not zoned land and water land	Plain and a natural lake	8053 8.00
Valjevo (VA)	Medium	Region Šumadije i Zapadne Srbije	Coincide of the boundaries of GUP and construction area	Structural basin	2646 2.90
Vranje (VR)	Medium	Region Južne i Istočne Srbije	Coincide of the boundaries of GUP and construction area	Structural basin / Mountainous area	2155 2.51
Zrenjanin (ZR)	Medium	Region Vojvodine	Coincide of the boundaries of GUP and construction area	Plain	4122 3.11

Table 2
Summary of the urban system in Serbia and the rank of analyzed cities.

Spatial Plan of the Republic of Serbia, 1996[a]		Spatial Plan of the Republic of Serbia, 2010[b]	
Urban system hierarchy	Rank of analyzed cities	Urban system hierarchy	Rank of analyzed cities
Centre of State and international importance	Belgrade (BG)	Centre in European MEGA 3 category (Metropolitan Growth Area)	Belgrade (BG)
Macro-regional centres	Kragujevac (KG) Niš (NI) Novi Sad (NS)	Urban centres of international importance	Niš (NI) Novi Sad (NS)
Regional centres	Čačak (ČA) Kraljevo (KV) Kruševac (KS) Leskovac (LE) Novi Pazar (NP) Požarevac (PO) Smederevo (SD) Subotica (SU) Valjevo (VA) Vranje (VR) Zrenjanin (ZR)	Urban centres of national importance	Čačak (ČA) Kragujevac (KG) Kraljevo (KV) Kruševac (KS) Leskovac (LE) Novi Pazar (NP) Požarevac (PO) Smederevo (SD) Subotica (SU) Valjevo (VA) Vranje (VR) Zrenjanin (ZR)

[a] Zakon o Prostornom planu Republike Srbije, 13/96.
[b] Zakon o Prostornom planu Republike Srbije od 2010. do 2020. godine, 88/2010.

Both plans aimed at mitigating disparities in the urban system development. Table 2 shows that three large cities, Beograd, Niš and Novi Sad, have continually been the top cities in Serbias's urban network hierarchy. The fourth large city, Kragujevac, has changed position, dropping from second to third rank category in second period. All studied medium-sized cities were distributed within the third category in the urban system hierarchies and did not change rank during observed period.

3.2. Spatial unit for the analysis

Unlike the studies where the extent of urban areas was taken from vector datasets, e.g. the Functional Urban Areas for urban centres (Schiavina, Melchiorri, Freire, et al., 2022) or the Urban Morphological Zone for urban areas (Slaev et al., 2018), or determined using special criteria and methods (Chakraborty et al., 2022; Schneider & Woodcock, 2008; Siedentop & Fina, 2012; Wolff et al., 2018), we have adopted a different approach.

Our research focuses on the cities' urban areas, within the boundaries determined by General Urban Plan (GUP), the extent of which usually correlates with the population size categories of the analyzed cities. We track changes at the level of the cities' urban areas to obtain a more realistic idea of the relationship between the demographic component and land use changes. The GUP area covers the built-up area, the urbanized open space, and the un-built area. The built-up area contains residential, industrial and commercial zones, as well as roads, rail lines, rail yards, and airports. The urbanized open space contains public parks and urban greenery, private gardens, and cemeteries. The un-built areas include agricultural land, forests and green spaces, waterland, and vacant land for development control such as: not-allowed construction area (Deng et al., 2018), area protected from urban development (Wang et al., 2017), not zoned land or land not suitable for development (González Pérez, 2007). In other words, the GUP boundaries cover the urban population and the functional and physical areas of the city. We retained in the analysis the fixed value of spatial extent adopted from the current GUP, regardless of the increase in the GUP's spatial extent in most cities in the observed period.

3.3. Data on the built-up area and population

The selection of population and built-up land data source (multi-temporal data) is also very important. Authors rely on databases covering a longer period and offering a higher quality and reliability data. Research may be fully based on open data or, in case of population, may combine it with statistical census data (Kasanko et al., 2006; Schiavina, Melchiorri, Corbane, et al., 2022; Schneider & Woodcock, 2008; Xu et al., 2020) or data from other sources. Recent studies mostly use freely available datasets (earth observation data).

The main source of data for built-up area and urban population for our analysis is the Global Human Settlement Layer (GHSL) datasets: GHS-BU (Corbane et al., 2018) and GHS-POP (Schiavina et al., 2019), a global datasets containing information on built-up area and urban population data for 1975, 1990, 2000, 2014/2015 (widely used, e.g. Gerten et al., 2019; Gerten et al., 2022; Guastella et al., 2019; Li et al., 2022, etc.). We assume that the one-year gap in data availability for the built-up area in 2014 and population in 2015 does not have a significant impact on further calculations. However, the main data used in the analysis are related to the period after 1990. The data for 1975 are considered analytically important in comparing the development paths of the specific values with a standardized starting point (Gerten et al., 2022).

The built-up area class is defined as the union of all spatial units containing a building or part of it (Pesaresi et al., 2016). In the analysis, we used the size of the population located in the territory covered by the GUP, drawing data from GHS-POP datasets (Schiavina et al., 2019). The cross-checking of the population size was done based on the GUP data provided for each city.

3.4. Indicators

3.4.1. Built-up area

Kasanko et al. (2006) highlight that the ratio of the built-up and un-built areas reflects the city's character. The percentage of the built-up area in the studied cities is defined as Eq. (1):

$$\text{Percentage of Built}-\text{up area}\ (t) = \frac{\text{Built}-\text{up area}}{\text{GUP area}} \times 100 \tag{1}$$

where t is the time point corresponding to 1975, 1990, 2000, and 2014; Built-up area denotes the total built-up area at a distinct time point, and the GUP area is the entire urban area within the boundaries defined by the respective GUP. We also calculated the annual change rate of the built-up area, as described in Section 3.4.4.

3.4.2. Population

Based on a literature review, Dadashpoor and Malekzadeh (2020) point out that changes in population size are a major demographic factor affecting the formation and changes of spatial structures. To identify cities where the population grows, stagnates or declines, we analyzed the population dynamics within their urban areas in two periods between 1990 and 2015, using data from 1975 as a standardized starting point (for calculating the change rate see Section 3.4.4). In addition, as the overall population in Serbia has declined since the 1990s, we used a three-level classification of the dynamics of population shrinkage to determinate the analyzed cities according to the incidence of population decline: continuous shrinkage, episodic (periodic/discontinued) shrinkage, and temporary/recent shrinkage – presented by Wolff and Wiechmann (2018).

3.4.3. Urban density

This study relies on the definition of urban density as the ratio of population and the built-up area in an observed territory (Angel, Lamson-Hall, Blei, et al., 2021; Xu et al., 2020). We used the total built-up area and urban population within the same urban extent, the city's area covered by the GUP, at a distinct time point. Using the Eq. (2), we calculated urban density for four different years (i.e. 1975, 1990, 2000, 2014/2015) for all studied cities.

$$\text{Urban Density} = \frac{\text{Urban population of a given time}}{\text{Built} - \text{up area for the same time}} \quad (2)$$

3.4.4. Annual change rate

To enable a more detailed study of specific spatio-temporal patterns in individual cities, we calculated the annual change rate of the built-up area, population, and density for a specific period. Calculating the annual change rate converts a specific value into a standard metric and removes the size effect of the value to facilitate comparison across cities (Xu et al., 2020) and between periods of different length (Garcia-Ayllon, 2018; Li et al., 2022), as defined in Eq. (3).

$$\text{Annual change rate} = \left(\sqrt[n]{\frac{\text{End year}}{\text{Start year}}} - 1\right) \times 100\% \quad (3)$$

where *End year* is the respective value at the final time point, *Start year* is the respective value at the initial time point, and *n* represents the time span of the whole period in years. We calculated the annual changes rates for all three values, the built-up area, population, and density, during three time periods, i.e. 1975–1990, 1990–2000, and 2000–2014/2015 (Fig. 4).

To facilitate interpretation, we set the same threshold for variables. Taking into account the population dynamics trend in Serbia, we applied the following threshold for all variables: for shrinking – loss more than -0.15 % p.a.; for stability – change between -0.15 and + 0.15 % p.a., and for growth – increase of > +0.15 % p.a. (c.f. Wolff & Wiechmann, 2018).

To determine the variation among the cities in terms of the correlation between population and the built-up area during the studied period (at two time points – 2000 and 2014), we used the model presented by Wolff et al. (2018) for operationalizing density changes under the different constellations of the development of population and built-up area, according to which the following density change trends can be observed depending on the population and built-up area trends (increase or decrease): sprawl growth, compact growth, sprawl shrinkage, reuse, underuse, and compact shrinkage.

Furthermore, inspired by the built-up land change trajectories presented by Li et al. (2022), we correlated changes in density and population for two time periods, 1990–2000 and 2000–2014/2015, using values from 1975 to 1990 as a standardized starting point. We then analyzed potential differences among the studied cities in terms of density and population changes for each period, which made it possible to identify the fluctuation of the cities among various types of density changes and trajectories of spatial transformations over different time periods.

4. Results and discussion

4.1. Spatial expansion

It is assumed that the greater the share of the built-up area compared to the un-built land, the more compact the city's structure. According to Kasanko et al. (2006), in European cities since the 1990s, the share of the built-up area varied between 30 % and 40 %. Between 1990 and 2014, in the majority of the studied Serbian cities the share of the built-up land was below Europe's average (Fig. 2). In only five cities (ČA, VA, VR, ZR and NS), it was above or around Europe's average throughout the period. Interestingly, the share of the built-up land in Belgrade was still 20 %, although the highest absolute built-up area increase was observed in Belgrade, which, according to Slaev et al. (2018, p. 18), shows a "unique nature" of suburbanization and sprawl processes.

The obtained values need to be related to the reference spatial coverage, which is in our case the territory covered by the GUP. This is best illustrated by the data for NI, which had the smallest share of built-up land (about 10 %), though it belonged to the category of large cities. The GUP area covered 44.70 % of the city's administrative territory and included a large undeveloped area (agricultural land and undefined green spaces) which was compared to the built-up area. Quite oppositely, in cities with a large share of built-up land, the GUP coverage was <5 % of the city's administrative territory (e.g. VA, VR and ZR), or there was an overlap between the GUP boundaries and those of the construction area. Due to this, we used the annual built-up change rate (see

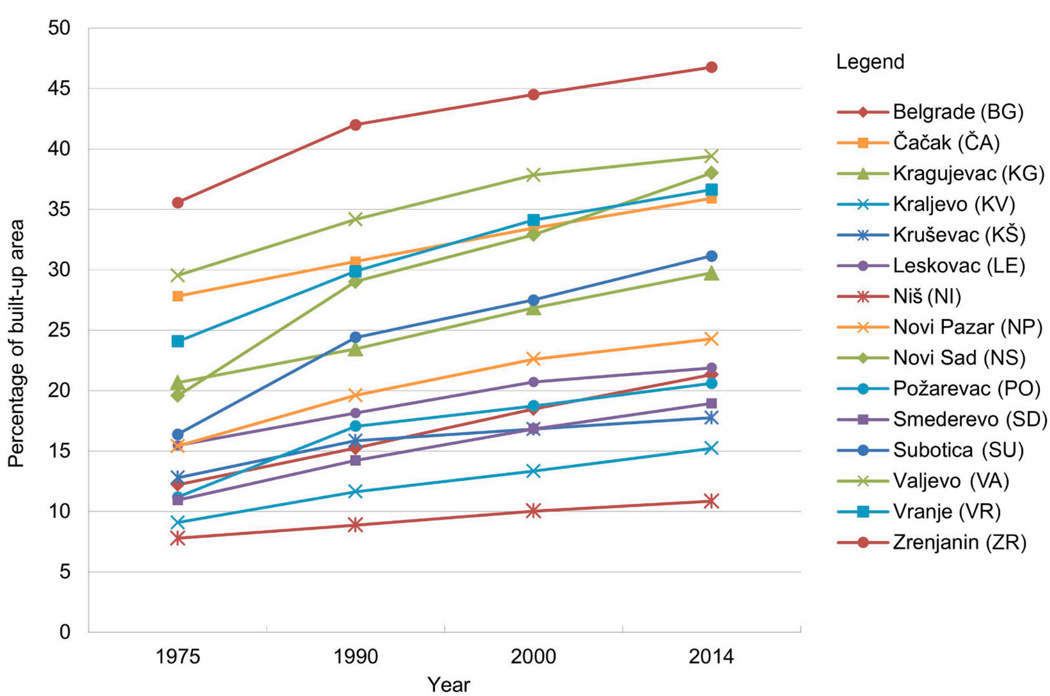

Fig. 2. The share of the built-up land in the studied cities in different time periods.

Section 4.2).

Built-up land usually expands at the expense of agricultural land (Kasanko et al., 2006). In Serbia, too, there is a practice of converting agricultural land into construction land (Veljković & Lekić, 2019), largely through spontaneous/unplanned development (Zeković et al., 2015; Živanović Miljković et al., 2022; Živanović Miljković & Čolić, 2020). The analysis of the buffer zone data from the GUPs (Table 1) shows that for most cities planning means to prevent uncontrolled development were available in the form of construction bans (agricultural or forest land). In contrast, in some cities, the GUP boundaries overlap with the construction area, which means that the former areas of controlled development are planned for conversion into construction land. The plan thereby supports sprawl, even in case of cities with constant population decline. This is contrary to the urban planning approach to protect land and prevent excessive outward expansion, while tending to densify the existing urban fabric by infilling (Angel, Lamson-Hall, Blei, et al., 2021; Chakraborty et al., 2022) and to establish a sustainable urban form, a compact city (Bibri et al., 2020; Xu et al., 2020). The results of the study by Angel, Lamson-Hall, Blei, et al. (2021), who highlight the limited success of cities worldwide in accommodating population growth through densification, should also be taken into consideration.

The natural environment in which urban centres took shape affected the expansion potential of cities, namely the quantity of newly added built-up land or the increase of built-up density due to physical barriers to expansion (Angel, Lamson-Hall, Blei, et al., 2021; Li et al., 2018). The impact of physical factors (plain, structural basin, hilly and mountainous area or natural lake – Table 1) is reflected in the built-up intensity in urban centres in Serbia, which are differently positioned in space (Krunić et al., 2022).

4.2. Patterns of transformations

Fig. 3 presents a summary graph with the average built-up area, population and density change rates for selected Serbian cities during two characteristic post-socialist periods, 1990–2000 and 2000–2014, with the 1975–1990 period as the reference starting point. For all cities together, we observed a slight decrease in the built-up area change rate while maintaining a positive growth rate during the entire period since built-up areas expanded continuously. At the same time, a significant decrease in the average population change rate is noticed over entire period, with a low positive growth rate in the early 1990s that continued to decline towards negative values by 2014 (from 0.16 to -0.69 % respectively). Although the average density change rate was negative in the 1990s (-1.04 %), our findings show that it remained constant until 2014.

In general, the trend here is decreasing in both the growth rate of the built-up area and the growth rate of population during entire period, with a more substantial population decline resulting in its negative growth rate after the early 1990s. Anyhow, we observed the stability of the average density change rate, suggesting that the pace of the decline of built-up area change rates determined the variants of urban density.

A detailed insight into the patterns of spatial transformation of the individual cities is shown in the charts in Fig. 4. In cities with population growth, mainly the large cities ranking high in the urban system hierarchy, a positive effect of population on urban expansion was observed, where there was an "increasing urban land demand to support an increasing urban population" (Li et al., 2018, p. 70). In cities with population decline, mainly medium-sized and ranking lower in the urban system hierarchy, there was an "indication of urban sprawl" (Kasanko et al., 2006, p. 126) since physical expansion deviated from the rule according to which the built-up expansion of the city reflects "the demand for it by a certain number of people" (Wolff et al., 2017, p. 2688).

In most cities, both growing and shrinking, dedensification was observed and expected because in the former case, the build-up area expanded at a faster pace than the population, while in the latter, despite the population decline, the expansion of the build-up area continued. A distinction is observed between growing cities depending on values and the growth dynamics of both variables, i.e. whether the population exceeds or not the spatial expansion. Namely, in cities with population growth rate exceeding built-up area growth rate (e.g. NP and NS) positive density growth rate is observed during entire period. In other cases, in the first period, the stronger influence of demographic factors on density dynamics is observed, while in the second period, the trends in the built-up area changes had a more substantial influence. However, the annual density change rates indicate a tendency towards a compact development of the urban area, both in some growing and shrinking cities.

4.2.1. The spatial and temporal variance of built-up area

All studied cities show a positive built-up area growth rate during the observed period (Fig. 5). However, a significant drop of this indicator can be observed in all cities in 2000–2014, when the values were almost twice lower than in the first period. In 1990–2000, the built-up area change rates for most cities (12 out of 15) were above 1 % p.a., while in 2000–2014, in only six cities the annual growth rate was still high, over 0.70 %, indicating that urban expansion continued "although at a slower pace" (Kasanko et al., 2006, p. 117). The observed trend of continued expansion with a high built-up area growth rate in both periods applies to medium-sized and large cities, regardless of status within the urban system hierarchy. The only exception here is KG which dropped in urban scale ranking, while keeping a high build-up area growth rate in the first and second periods (1.37 and 0.73 %, respectively).

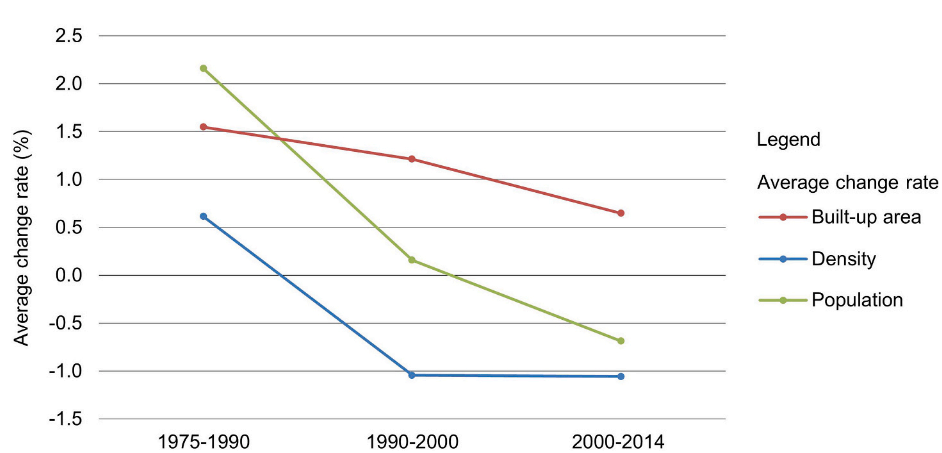

Fig. 3. Average built-up area, population and density change rates for studied cities in different time periods.

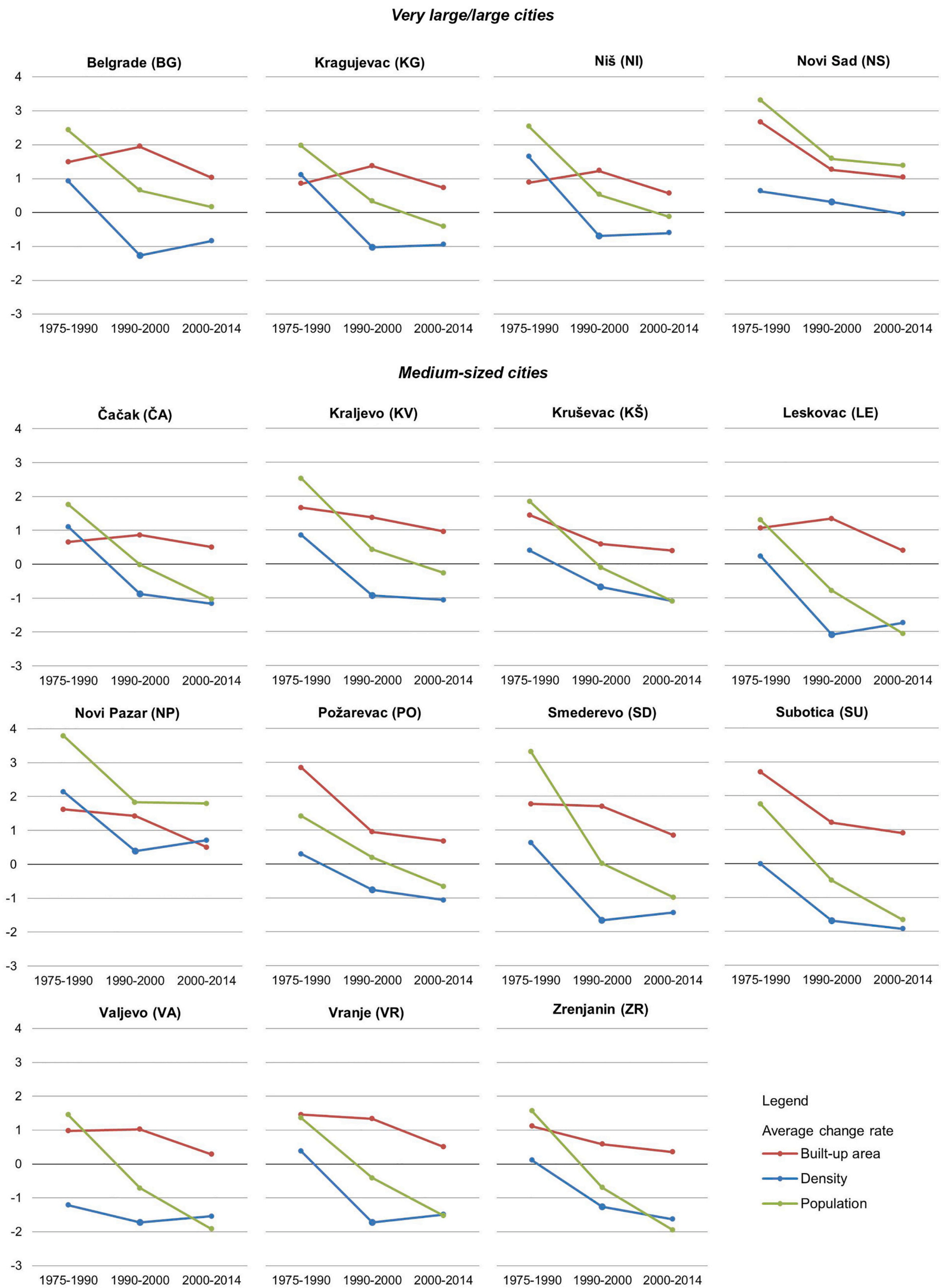

Fig. 4. Spatio-temporal distribution of the built-up area, population and density change rates for 15 studied cities.

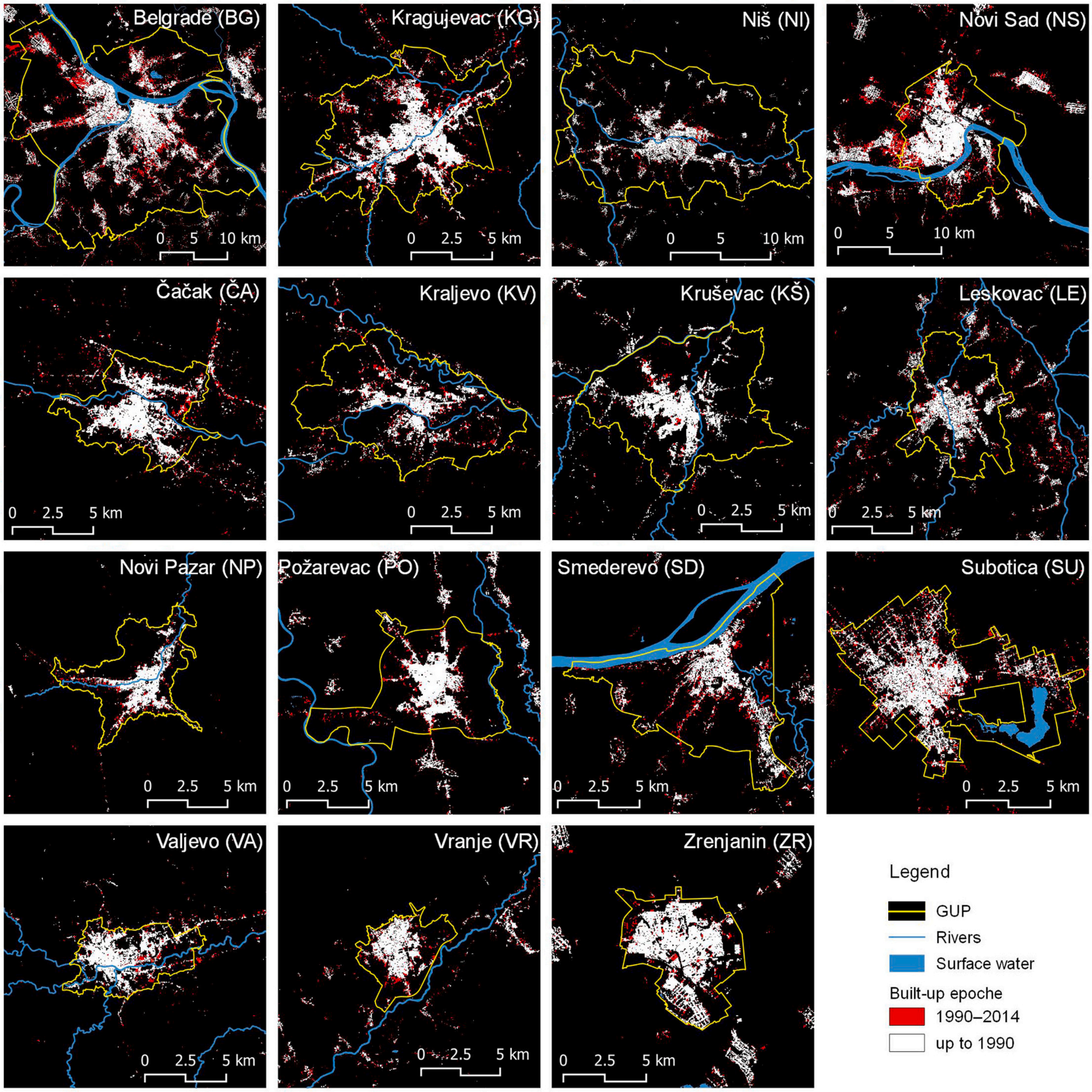

Fig. 5. GHS-BU imagery of 15 studied cities for built-up epoch up to 1990 and 1990–2014.

The high annual built-up area change rates in 1990–2000 reflect the specific circumstances for the development of the cities in Serbia, the complex socio-political and economic context (breakup of Yugoslavia, influx of refugees, transition from a planned to a market economy, privatization, deindustrialization, etc.), as well as deeply rooted practices of illegal construction of family homes (low-density) in the periurban belt as a specific urban development model (Strategija održivog urbanog razvoja Republike Srbije do 2030. godine [hereinafter Strategy], 47/2019). Widespread illegal construction in Serbia emerged with urbanization in the early 20th century (Vuksanović-Macura & Macura, 2018), to become especially intensive with accelerated industrialization since the 1960s, accompanied with a rapid growth of the urban population (Tošić & Krunić, 2005) and an increased housing demand coupled with an insufficiently efficient housing development model (Vilenica, 2017). Due to the lack of a realistic policy of construction land (Strategy, 47/2019) and urban development policy (see Zeković & Maričić, 2016), illegal development became the dominant model of providing housing in the 1990s (Zegarac, 1999) and has remained an equally relevant parallel model during the period 2000–2015 (Zeković et al., 2020), causing numerous environmental problems (Miljanović et al., 2017).

After 2000s the so-called second stage of multidimensional suburbanization has started (Svirčić Gotovac, 2016b). However, observed trend in decreasing annual built-up area change rate in 2000–2014 can be indirectly explained by the continuous population decline in urban areas (Table 3). The decline was the most prominent in LE and VA, where the annual built-up area change rate in 2000–2014 was three times lower than in the previous period, which corresponds to the decrease of the annual population change rate in the two cities in this period (cca. -2 % p.a.). Generally, medium-sized cities were more significantly affected by a decrease in spatial growth. Nevertheless, no significant regional patterns were observed in the changing rates of built-up areas among these cities.

As expected, Belgrade had the highest built-up area change rate among large and the growing cities during both periods, which confirms the assumption (in agreement with Schneider & Woodcock, 2008) that new land added correlates to the initial spatial extent of the city. However, even there, the value of this indicator was halved after 2000. The demographic factor was dominant in the first phase, to lose in

Table 3
Population absolute changes and annual change rates of the analyzed cities.

Cities	Absolute population change			Annual population change rate (%)[a]		
	1975–1990	2000–1990	2015–2000	1975–1990	1990–2000	2000–2015
Belgrade (BG)	376,946	83,572	21,287	2.43	0.65	0.16
Čačak (ČA)	19,048	−127	−8099	1.77	−0.02	−1.03
Kragujevac (KG)	37,484	4972	−6273	1.97	0.33	−0.42
Kraljevo (KV)	24,034	3337	−2138	2.53	0.43	−0.27
Kruševac (KŠ)	21,729	−938	−9318	1.85	−0.10	−1.09
Leskovac (LE)	15,121	−6504	−14,898	1.30	−0.78	−2.05
Niš (NI)	74,568	12,811	−3089	2.54	0.53	−0.12
Novi Pazar (NP)	26,312	12,242	14,380	3.80	1.83	1.80
Novi Sad (NS)	76,688	33,764	34,178	3.31	1.58	1.38
Požarevac (PO)	10,969	845	−2912	1.42	0.19	−0.66
Smederevo (SD)	18,533	142	−7575	3.32	0.02	−0.98
Subotica (SU)	23,651	−5926	−17,870	1.76	−0.50	−1.66
Valjevo (VA)	13,646	−5125	−12,159	1.45	−0.71	−1.91
Vranje (VR)	13,386	−2598	−8811	1.36	−0.41	−1.53
Zrenjanin (ZR)	18,128	−6383	−15,864	1.57	−0.69	−1.95

[a] Threshold for population change: decline $< -0.15\%$ p.a; stability (-0.15 % to $+0.15$ % p.a); growth ($> +0,15$ % p.a).

importance later (decrease in the annual population change rate from 0.65 % to 0.16 % p.a.).

The only exception in overall trend is NP (a medium-sized city), where the annual built-up area change rate decreased significantly in the 2000–2014, while the population growth rates were high in both analyzed periods. The decrease can be explained by a topographical constraint (the city is located in a structural basin), which, according to Schneider and Woodcock (2008), has an impact on "the availability of land for development" (p. 686).

4.2.2. *The spatial and temporal population variance*

In contrast to built-up change rates that remained positive during entire period in all analyzed cites, the population change rates show a more heterogeneous pattern with positive, stable and negative changes (Table 3). Our results show that all cities in our research started with a positive annual population growth rates. Population decline (negative growth rates) was taking place in the urban areas of some cities since the 1990s (Macura, 1991) (the beginning of the postsocialist period). It coincided with the overall population decline trend in Serbia (Kokotović Kanazir et al., 2017). However, negative change rate become dominant in the second period (2000–2015) with differences between the large and medium-sized cities.

Following the typology of the population growth/loss dynamics defined by Wolff and Wiechmann (2018), in the case of Serbia, we observed that the most vulnerable were medium-sized cities (LE, SU, VA, VR, and ZR). They were marked by continuous shrinkage because they were losing population throughout the study period (1990–2015).

In 2000–2015 other medium-sized urban centres (SD and PO) joined the group of shrinking cities, followed by these located along the development axis – the Zapadna Morava valley (KŠ–KR–ČA), as well as and KG, which belonged to the category of large cities. These cities were marked by periodic shrinkage (episodically shrinking cities), because in 1990–2000 they had stable (SD, KŠ and ČA) or growing population rate (KG, KR and PO), while in 2000–2015, were marked by population decline.

In terms of urban growth, the urban area of the capital (BG) stands out since its population grew during entire period, although at a significantly faster pace in the first period than in the second. The growth has also characterized other two large cities (NS and NI). Anyhow, while NS remained in the category of urban growth in both periods, NI had different demographic characteristics in the second period. In 1990–2000, NI was classified as a growing city (there was a population growth), whereas in 2000–2015, it was in the category of demographically stable cities. These three cities (BG, NS and NI) are located in the zone of Corridor X, an important international multi-modular traffic corridor, along Serbia's primary development axis (Danube-Morava development axis) and dominate in the urban system hierarchy. Among growing cities the exception is NP, the only medium-sized city that belonged to growing cities throughout the study period (1990–2015). Its population was growing at the same pace in both analyzed periods due to positive natural growth.

The presented situation regarding the share of shrinking cities indicates that it is not a temporary phenomenon, as the situation in Romania was described by Eva et al. (2021), all the more the discussed settlements in Serbia have the formal status of a city. Wolff and Wiechmann (2018) have observed the presence of episodically shrinking cities in post-socialist countries, including Serbia. Antonić and Djukić (2018), who have drawn attention to the shrinking of illegal suburbs around three growing cities – especially in NS (26 %) and NI (22 %), but also in Belgrade's suburbs (9 %) – demonstrate that the situation is becoming more complicated. They believe that the analysis of stagnant suburbs would result in even more unfavourable findings and that the share of suburbs with demographic problems will increase.

A comparison between the estimated expected population decline/growth in the GUPs and the annual population change rates in our study shows that a realistic demographic perspective was taken into considerations in some GUPs only (e.g. for NS and SU). Unrealistic projections can be found among the cities affected by continuous shrinkage for which GUPs predicted population growth or stagnation (ZR and LE stand out, along with VA). Such projections indicate that the problem of urban shrinkage is not addressed appropriately, both by the authors of the GUPs and the local authorities adopting them; this is especially relevant for the cities' urban areas constantly affected by population decline. In addition, the issue of city shrinkage was not even mentioned in the national spatial planning documents (Živanović et al., 2021). Batunova and Gunko (2018, Russian cities) and Buček and Bleha (2013, Slovak cities) also recognise ignorance and underestimation of the urban shrinkage phenomenon in planning documents.

4.3. *Trajectories of transformation*

Based on different constellations of the population and built-up area changes (according to Wolff et al., 2018) at two time points, in 2000 and 2014, we determined different types of density changes (Fig. 6).

In 2000, almost half of the cities (BG, KG, KV, NI, NP, NS and PO) had a positive population growth trend along with the positive growth rate of the built-up area, and thus belonging to the compact growth or sprawl growth groups. The other half (ČA, KŠ, LE, SD, SU, VA, VR and ZR) were among the sprawl shrinkage cities, with a population declining or stagnating while the build-up area increased. At this time point, the phenomenon of compact/sprawl growth dominantly marked large cities ranking high in the urban system hierarchy.

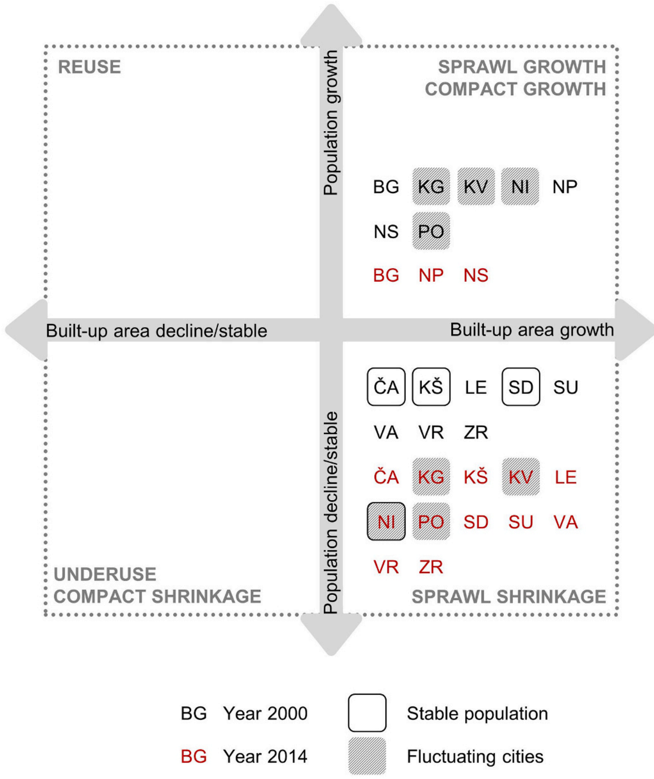

Fig. 6. Types of density changes.

In 2014, a "regrouping" was observed. The sprawl shrinkage group increased significantly to include twelve cities, while only three cities (NP, NS and BG) remained in the compact/sprawl growth group. No cities marked by compact shrinkage/underuse or reuse were observed among the analyzed cities in either of the two periods. Due to the continuous growth of built-up land, there were no situations when a decreasing/stable built-up expansion rate was coupled with a population increase or with a decreasing/stable population rate.

Based on the correlation between density and population changes, it is possible to trace density change trajectories (inspired by Li et al., 2022; see Section 3.4.4) for the analyzed cities in two time periods.

In 1990–2000, five cities (BG, KG, KV, NI and PO) were affected by sprawl growth, i.e. population growth coupled with dedensification due to an intensive growth of the built-up land. Compact growth, as a resultant of a population growth that is more intensive than built-up expansion, was observed in only two cities (NP and NS). Three cities (ČA, KŠ and SD) were affected by sprawl shrinkage, i.e. sprawl without growth (Siedentop & Fina, 2012; Wolff et al., 2018), coupled with population stagnation and dedensification due to built-up expansion. The other five cities (LE, SU, VA, VR and ZR) faced shrinkage, due to simultaneous population decline and dedensification (significant population decline coupled with built-up expansion). This observation shows that cities that were either large or ranked high within urban system hierarchy, were predominant marked by sprawl growth in this period. Two medium-sized cities also faced sprawl growth because of specific population dynamics, i.e. due to internal migrations in KV and positive natural growth in NP.

In 2000–2014/2015, the variants of trajectories diversified and increased in the number, along with the fluctuation of the cities from one group to another. This is consistent with Wolff and Wiechmann's (2018) conclusion that "urban trends are hardly evolving in a linear way but rather fluctuate and show changes" (p. 123). In this period, only the largest city (BG) continued to develop in line with sprawl growth, as observed in urban centres throughout Europe (Schiavina, Melchiorri, Freire, et al., 2022), as its population continued to grow due to the influx of migration and the rates of built-up expansion exceeded population growth. Two large cities marked by sprawl growth in the previous period moved to sprawl shrinkage category (NI) and proportional growth (NS), the newly defined trajectory variant marked by a stagnating density and population growth. Only one city (NP) maintained compact growth, where the population growth and built-up land trends still had the same direction, with a significantly slower built-up expansion. Densification there could be explained by the lack of available land for expansion because the city is in a structural basin. The remaining 11 cities faced shrinkage, but, compared to the previous period, there were additional six cities in this group (ČA, KG, KV, KŠ, PO and SD), three of which (KG, KV and PO) had previously been marked by sprawl growth.

The clustering of medium-sized cities around "unfavourable spatial patterns" in terms of land use and their "domination" in the second period are expected, bearing in mind that these cities faced continuous or periodic population decline, coupled with a continuous built-up expansion. In this period, the sprawl without growth and sprawl shrinking ("spatially dispersed pattern", Siedentop & Fina, 2012, p. 2776) also affected large cities. In Serbia, urban sprawl, both sprawl growth and sprawl without growth (sprawl shrinkage), is a result of uncontrolled development of cities, and especially their periurban or suburban belt.

Our results regarding the decreased urban density in the selected cities in Serbia are in agreement with the findings of some studies in CEE countries (Schmidt et al., 2015; Taubenböck et al., 2019; Wolff et al., 2018), although this trend is present worldwide (Angel et al., 2010; Gerten et al., 2019). Similarly to the results of Wolff et al. (2018), our findings show a strong impact of shrinking urban areas on dedensification process, as the number of shrinking cities increased over time.

The identified spatial patterns fit into the "framework" of the asymmetric urban system in Serbia. Deviations from sprawl shrinkage, the dominant model in the second period, were observed only in larger urban centres affected by population and physical growth. In addition, the exception among medium-sized cities is NP where the vital population (continuous population growth), on the one hand, and physical factor, on the other, resulted in the compact growth model. The results can be related to the already-mentioned demographic polarization into a zone of demographic expansion (with a small spatial coverage) and a zone of constant depopulation (Stojanović & Vojković, 2005), or the polarization between prosperous urban centres and an economically lagging periphery (Siedentop & Fina, 2012).

5. Conclusion

The study seeks to identify the types and trajectories of change in the spatial patterns of 15 selected cities in Serbia in the postsocialist period (between 1990 and 2014/2015) by understanding the differences from the perspective of national urban system features. Based on the analysis, it was determined that there was a difference in the spatial patterns of transformation between medium-sized and large cities, as well as between shrinking and growing cities. The assumption of Schmidt et al. (2015) that larger cities, which also attract foreign investment and population, experienced different growth patterns compared to medium-sized cities, has been confirmed in our research. The expected polarization turned out to be real. Our results show a link between the asymmetric urban system and cities' growth and shrinking intensity. As a rule, cities ranking higher in the hierarchy of the urban system spatially grow with a higher intensity.

Interesting to note how the asymmetric urban system has had a more significant impact on cities' spatial reconfiguration than their geographical distribution. This suggests that economic growth, political power, and social dynamics are more substantial in shaping a city's transformation than its physical location. Therefore, planners and decision-makers need to consider this when designing future national spatial planning documents and policies.

Our results are consistent with the findings of Schmidt et al. (2015)

related to eastern Germany (in contrast to the other CEE countries), which indicate that the social context has a significant impact on the course (beginning/duration) of urban transformations. Therefore, in case of Serbia, in the first phase mainly residential suburbanization (involving illegally built facilities in particular; see Zegarac, 1999; Zeković et al., 2020), was more intensive, uncontrolled, and present in most of the selected cities, regardless of size and rank. These processes generated social and environmental problems and shortages in infrastructures and facilities in the sectors created under the logic of urban informality. The imbalance between the pace of growth of major cities and lower level cities in the urban system was also brought about during this period.

After 2000 (transition period), when commercial suburbanization emerged along with residential suburbanization, suburbanization weakened significantly, persisting mainly around larger urban centres (especially BG), which were more attractive for investment and living. Commercial suburbanization was also directed towards peripheral and un-built areas of urban settlements with good traffic accessibility and lower land costs. This favouring greenfield (Strategy, 47/2019) over brownfield development as an essential model to curb sprawl (Mustafa et al., 2018), supported suburban expansion (Stanilov & Sÿkora, 2014b), and encouraged urban sprawl (Zeković et al., 2015).

Based on the correlation of annual change rates of the built-up area and population, we identified two dominant models of spatial development in Serbia: sprawl/compact growth and sprawl shrinkage. The results of our research show that outward expansion, or urban sprawl, is the dominant feature of physical expansion in the majority of the analyzed cities in Serbia, and not only in the capital and large urban agglomerations as we hypothesized at the beginning. This is a consequence of the continuous increase in the absolute values of the built-up land in all of the analyzed cities, both growing and shrinking.

The "reuse" model, i.e. urban renewal and recycling of previously used locations in the form of the conversion of industrial zones into parks or commercial zones in Serbia is rarely used. According to the Strategy (47/2019), there are numerous reasons for this, namely complex environmental, economic, social and other "burdens" on the site. Solving them requires huge investment to reactivate brownfield sites (Strategy, 47/2019) and a more responsible planning approach (Vuksanović-Macura et al., 2020).

Similarly to other authors (Schmidt et al., 2015; Schneider & Woodcock, 2008; Siedentop & Fina, 2012), and based on the obtained results, we can conclude that spatial growth is present despite population decline. In other words, the decreased density and the domination of various sprawl spatial patterns cannot be related to the analyzed demographic changes. As the drivers of the spatial patterns of transformation in the analyzed cities are not discussed in the paper, we can accept the explanation of Schneider and Woodcock (2008) that urban land conversion "may instead be caused by a number of proximate and indirect drivers unrelated to population changes" (p. 682).

However, the pronouncedly declining annual change rates of the built-up area in all examined cities in Serbia and our results show that in the second period this indicator was almost two times lower than in the first period. This may indicate that the trend of urban population decline, accompanied with population decline at the national level, is becoming increasingly visible in the spatial "footprint" of cities in Serbia, along with the growing number of cities marked by continuous shrinkage. The limitation of this study is that we have only observed the densification processes that take place in the analyzed cities, without specifying the spatial forms of densification like infilling and upward expansion. These changes are particularly pronounced in the capital and related to the period after 2016, which goes beyond the time frame covered in this study. However, this points to potential directions of future research.

Authors statement

We confirm that this work is original and has not been published elsewhere, nor is it currently under consideration for publication elsewhere.

CRediT authorship contribution statement

Dragana Miljanović: Term, Methodology, Formal analysis, Writing - Original Draft, Writing - Review & Editing.
Zlata Vuksanović-Macura: Conceptualization, Methodology, Formal analysis, Writing - Original Draft, Writing - Review & Editing.
Dejan Doljak: Methodology, Data Curation, Visualization.

Declaration of competing interest

We have no conflicts of interest to disclose.

Data availability

Data will be made available on request.

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References

Angel, S., Lamson-Hall, P., & Blanco, Z. G. (2021). Anatomy of density: Measurable factors that constitute urban density. *Buildings and Cities, 2*(1), 264–282. https://doi.org/10.5334/bc.91
Angel, S., Lamson-Hall, P., Blei, A., Shingade, S., & Kumar, S. (2021). Densify and expand: A global analysis of recent urban growth. *Sustainability, 13*(7). https://doi.org/10.3390/su13073835. Article 3835.
Angel, S., Parent, J., Civco, D. L., & Blei, A. M. (2010). The persistent decline in urban densities: Global and historical evidence of "sprawl". In *Working paper*. Lincoln Institute of Land Policy. https://www.lincolninst.edu/sites/default/files/pubfiles/1834_1085_angel_final_1.pdf.
Antonić, B., & Djukić, A. (2018). The phenomenon of shrinking illegal suburbs in Serbia: Can the concept of shrinking cities be useful for their upgrading? *Habitat International, 75*, 161–170. https://doi.org/10.1016/j.habitatint.2018.03.010
Bartosiewicz, B., & Marcińczak, S. (2020). Investigating polycentric urban regions: Different measures – Different results. *Cities, 105*. https://doi.org/10.1016/j.cities.2020.102855. Article 102855.
Batunova, E., & Gunko, M. (2018). Urban shrinkage: An unspoken challenge of spatial planning in Russian small and medium-sized cities. *European Planning Studies, 26*(8), 1580–1597. https://doi.org/10.1080/09654313.2018.1484891
Bibri, S. E., Krogstie, J., & Kärrholm, M. (2020). Compact city planning and development: Emerging practices and strategies for achieving the goals of sustainability. *Developments in the Built Environment, 4*. https://doi.org/10.1016/j.dibe.2020.100021. Article 100021.
Bretagnolle, A., Mathian, H., Pumain, D., & Rozenblat, C. (2000). Long-term dynamics of European towns and cities: Towards a spatial model of urban growth. *Cybergeo: European Journal of Geography*. https://doi.org/10.4000/cybergeo.566
Buček, J., & Bleha, B. (2013). Urban shrinkage as a challenge to local development planning in Slovakia. *Moravian Geographical Reports, 21*(1), 2–15. https://doi.org/10.2478/mgr-2013-0001
Calka, B., Orych, A., Bielecka, E., & Mozuriunaite, S. (2022). The ratio of the land consumption rate to the population growth rate: A framework for the achievement of the spatiotemporal pattern in Poland and Lithuania. *Remote Sensing, 14*(5). https://doi.org/10.3390/rs14051074. Article 1074.
Cercleux, A.-L., Merciu, F.-C., Bogan, E., & Merciu, G.-L. (2019). Demographic transformations after 1990 in Romanian small and medium-sized industrial towns. *Analele Universitatii Bucuresti: Geografie (Annals of the University of Bucharest – Geography Series)*, 165–180. https://doi.org/10.5719/aub-g/68.1/10
Chakraborty, S., Maity, I., Dadashpoor, H., Novotný, J., & Banerji, S. (2022). Building in or out? Examining urban expansion patterns and land use efficiency across the global sample of 466 cities with million+ inhabitants. *Habitat International, 120*. https://doi.org/10.1016/j.habitatint.2021.102503. Article 102503.
Corbane, C., Florczyk, A., Pesaresi, M., Politis, P., & Syrris, V. (2018). *GHS built-up grid, derived from Landsat, multitemporal (1975-1990-2000-2014), R2018A*. European Commission, Joint Research Centre (JRC). https://doi.org/10.2905/jrc-ghsl-10007

Dadashpoor, H., & Malekzadeh, N. (2020). Driving factors of formation, development, and change of spatial structure in metropolitan areas: A systematic review. *Journal of Urban Management, 9*(3), 286–297. https://doi.org/10.1016/j.jum.2020.06.005

Deng, Y., Fu, B., & Sun, C. (2018). Effects of urban planning in guiding urban growth: Evidence from Shenzhen, China. *Cities, 83*, 118–128. https://doi.org/10.1016/j.cities.2018.06.014

Djurkin, D., Antić, M., & Budović, A. (2021). Demographic and economic aspects of urban shrinkage in Serbia – Typology and regional differentiation. *Bulletin of the Serbian Geographical Society, 101*(2), 43–78. https://doi.org/10.2298/GSGD2102043D

Döringer, S., Uchiyama, Y., Penker, M., & Kohsaka, R. (2020). A meta-analysis of shrinking cities in Europe and Japan. Towards an integrative research agenda. *European Planning Studies, 28*(9), 1693–1712. https://doi.org/10.1080/09654313.2019.1604635

Drobnjaković, M., & Spalević, A. (2017). Naselja Srbije [Settlements of Serbia]. In M. Radovanović (Ed.), *Geografija Srbije (Posebna izdanja, Knjiga 91) [The Geography of Serbia (Special Issues, No 91)]* (pp. 566–613). Geographical Institute "Jovan Cvijić" SASA.

Đukić, A., Antonić, B., & Vujičić, T. M. (2017). Urban shrinkage in a 'shrinking' Serbia – The approach to a global phenomenon in a local context. *Geodetski vestnik, 61*(4), 614–629. https://doi.org/10.15292/geodetski-vestnik.2017.04.614-629

Dželebdžić, O., & Jokić, V. (2014). Pravilo "reda veličine" naselja u Srbiji – prilog za ocenu policentričnosti prostornog razvoja [A rank size rule in urban system in Serbia – Contribution to the discussion of polycentricity –]. In J. Petrić, M. Vujošević, M. Hadžić, & B. Bajat (Eds.), *Obnova strateškog prostornog mišljenja, istraživanja i upravljanja – Knjiga 2 [Renewal of strategic spatial thinking, research and management – Book 2], Posebna izdanja br. 74 [Special issues No. 74, pp. 138–154]*. Institute of Architecture and Urban & Spatial Planning of Serbia.

European Environment Agency, & Federal Office for the Environment. (2016). Urban sprawl in Europe. In *EEA report no 11/2016*. European Environment Agency. https://www.eea.europa.eu/publications/urban-sprawl-in-europe.

Eva, M., Cehan, A., & Lazăr, A. (2021). Patterns of urban shrinkage: A systematic analysis of Romanian cities (1992–2020). *Sustainability, 13*(13). https://doi.org/10.3390/su13137514. Article 7514.

Ferenčuhová, S., & Gentile, M. (2016). Introduction: Post-socialist cities and urban theory. *Eurasian Geography and Economics, 57*(4–5), 483–496. https://doi.org/10.1080/15387216.2016.1270615

Garcia-Ayllon, S. (2018). Urban transformations as indicators of economic change in post-communist Eastern Europe: Territorial diagnosis through five case studies. *Habitat International, 71*, 29–37. https://doi.org/10.1016/j.habitatint.2017.11.004

Gerten, C., Boyko, D., & Fina, S. (2022). Patterns of post-socialist urban development in Russia and Germany. *Frontiers in Sustainable Cities, 4*. https://doi.org/10.3389/frsc.2022.846956. Article 846956.

Gerten, C., Fina, S., & Rusche, K. (2019). The sprawling planet: Simplifying the measurement of global urbanization trends. *Frontiers in Environmental Science, 7*. https://doi.org/10.3389/fenvs.2019.00140. Article 140.

González Pérez, J. M. (2007). Urban planning system in contemporary Spain. *European Planning Studies, 15*(1), 29–50. https://doi.org/10.1080/09654310601016481

Guastella, G., Oueslati, W., & Preglio, S. (2019). Patterns of urban spatial expansion in European cities. *Sustainability, 11*(8). https://doi.org/10.3390/su11082247. Article 2247.

Haase, A., Bernt, M., Großmann, K., Mykhnenko, V., & Rink, D. (2016). Varieties of shrinkage in European cities. *European Urban and Regional Studies, 23*(1), 86–102. https://doi.org/10.1177/0969776413481985

Haase, A., Rink, D., & Grossmann, K. (2016). Shrinking cities in post-socialist Europe: What can we learn from their analysis for theory building today? *Geografiska Annaler: Series B, Human Geography, 98*(4), 305–319. https://doi.org/10.1111/geob.12106

Hadžić, M., & Zeković, S. (2019). Rethinking deindustrialization, and the reindustrialization policy in Serbia. *Spatium, 41*, 14–22. https://doi.org/10.2298/SPAT1941014H

Hirt, S. (2013). Whatever happened to the (post)socialist city? *Cities, 32*, S29–S38. https://doi.org/10.1016/j.cities.2013.04.010

Hirt, S., Ferenčuhová, S., & Tuvikene, T. (2016). Conceptual forum: The "post-socialist" city. *Eurasian Geography and Economics, 57*(4–5), 497–520. https://doi.org/10.1080/15387216.2016.1271345

Ianoş, S., Sîrodoev, I., Pascariu, G., & Henebry, G. (2016). Divergent patterns of built-up urban space growth following post-socialist changes. *Urban Studies, 53*(15), 3172–3188. https://doi.org/10.1177/0042098015608568

Ilchenko, M., & Dushkova, D. (2018). Editorial: In search of the post-socialist urban geography. How do we see the post-socialist city today? *Belgeo, 4*, 1–16. https://doi.org/10.4000/belgeo.31467

Jakopin, E. (2014). Regional inequalities and transition: The case of Serbia. *Ekonomika preduzeća, 62*(1–2), 117–133. https://doi.org/10.5937/ekopre1402117J

Jakopin, E. (2018). Regional structural imbalance of Serbia as a consequence of applied transitional model of economic growth. *Ekonomika preduzeća, 66*(7–8), 371–385. https://doi.org/10.5937/EKOPRE1808371J

Jaroszewska, E. (2019). Urban shrinkage and regeneration of an old industrial city: The case of Wałbrzych in Poland. *Quaestiones Geographicae, 38*(2), 75–90. https://doi.org/10.2478/quageo-2019-0023

Jaroszewska, E., & Stryjakiewicz, T. (2020). Drivers, scale, and geography of urban shrinkage in Poland and policy responses. *Journal of Urban Planning and Development, 146*(4). https://doi.org/10.1061/(ASCE)UP.1943-5444.0000601. Article 05020021.

Jigoria-Oprea, L., & Popa, N. (2017). Industrial brownfields: An unsolved problem in post-socialist cities. A comparison between two mono industrial cities: Reşiţa (Romania) and Pančevo (Serbia). *Urban Studies, 54*(12), 2719–2738. https://doi.org/10.1177/0042098016655057

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. https://doi.org/10.1068/a3327

Kasanko, M., Barredo, J. I., Lavalle, C., McCormick, N., Demicheli, L., Sagris, V., & Brezger, A. (2006). Are European cities becoming dispersed?: A comparative analysis of 15 European urban areas. *Landscape and Urban Planning, 77*(1–2), 111–130. https://doi.org/10.1016/j.landurbplan.2005.02.003

Kazimierczak, J., & Kosmowski, P. (2018). Post-industrial urban areas in the context of ruination, demolition and urban regeneration in a post-socialist city: Experiences of Łódź, Poland. *Finistera, 53*(109), 35–51. https://doi.org/10.18055/Finis12092

Kokotović Kanazir, V. (2016). *Mali gradovi - demografski potencijal Srbije* [Small cities - demographic potential of Serbia]. In *Posebna izdanja, Knjiga 90 (Special Issues, No. 90)*. Geographical Institute "Jovan Cvijić" SASA.

Kokotović Kanazir, V., Stojilković Gnjatović, J., Filipović, M., Babović, S., Ivković, M., & Lović Obradović, S. (2017). Stanovništvo Srbije [Population of Serbia]. In M. Radovanović (Ed.), *Geografija Srbije (Posebna izdanja, Knjiga 91) [The Geography of Serbia (Special Issues, No. 91)]* (pp. 506–613). Geographical Institute "Jovan Cvijić" SASA.

Kovács, Z. (Ed.). (2014). *Hungarian Geographical Bullten, 63*(3). https://ojs.mtak.hu/index.php/hungeobull/issue/view/311.

Kovács, Z., Farkas, Z. J., Egedy, T., Kondor, A. C., Szabó, B., Lennert, J., … Kohán, 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

Krunić, N., Gajić, A., & Tošić, D. (2022). Development challenges faced by cities in Serbia. In E. Manić, V. Nikitović, & P. Djurović (Eds.), *World Regional Geography Book Series, Springer, ChamGeography of Serbia. Nature, people, economy* (pp. 279–287). Cham: Springer. https://doi.org/10.1007/978-3-030-74701-5_21 (Chapter 21).

Krunić, N., Maksin, M., Milijić, S., Bakić, O., & Đurđević, J. (2014). Population dynamics and land cover changes of urban areas. *Spatium, 31*, 22–29. https://doi.org/10.2298/SPAT1431022K

Li, G., Sun, S., & Fang, C. (2018). The varying driving forces of urban expansion in China: Insights from a spatial-temporal analysis. *Landscape and Urban Planning, 174*, 63–77. https://doi.org/10.1016/j.landurbplan.2018.03.004

Li, M., Verburg, P. H., & van Vliet, J. (2022). Global trends and local variations in land take per person. *Landscape and Urban Planning, 218*. https://doi.org/10.1016/j.landurbplan.2021.104308. Article 104308.

Lukić, V. (2013). Population trends in Serbia and the implications for settlement system. *Forum geografic, 12*(1), 67–74. https://doi.org/10.5775/fg.2067-4635.2013.070

Macura, V. (1991). Tipovi naselja gradskog karaktera, njihove odlike i glavni problemi [Types of urban settlements in Serbia, their characteristics and main problems]. *Zbornik Matice srpske za društvene nauke, 91*, 101–114. https://www.maticasrpska.org.rs/zmsdn91/.

Macura, V. (2019). Opadanje gradova i opština, izumiranje sela, promene u sistemu naselja – Kakva je budućnost prostora Srbije? [The shrinking cities and municipalities, the extinction of villages, changes in the system of settlements - what is the future of the territory of Serbia?]. In B. Stojkov, & M. Pantić (Eds.), *Gradovi Srbije u budućnosti [Cities of Serbia in the future]* (pp. 36–39). Akademija inženjerskih nauka Srbije, Akademska misao.

Malý, J., Dvořák, P., & Šuška, P. (2020). Multiple transformations of post-socialist cities: Multiple outcomes? *Cities, 107*. https://doi.org/10.1016/j.cities.2020.102901. Article 102901.

Manahasa, E., & Manahasa, O. (2022). Nostalgia for the lost built environment of a socialist city: An empirical study in post-socialist Tirana. *Habitat International, 119*. https://doi.org/10.1016/j.habitatint.2021.102493. Article 102493.

Marinković, I., & Radivojević, B. (2016). Mortality trends and depopulation in Serbia. *Geographica Pannonica, 20*(4), 220–226. https://doi.org/10.5937/GeoPan1604220M

Mihaylov, V. (Ed.). (2020). *Spatial conflicts and divisions in post-socialist cities*. Cham: Springer. https://doi.org/10.1007/978-3-030-61765-3.

Miletić, R. (2022). Regional specialization in Serbia during the period 2001–2015. *Journal of Geographical Institute "Jovan Cvijić" SASA, 72*(1), 67–83. https://doi.org/10.2298/IJGI2201067M

Miletić, R., Miljanović, D., & Todorović., M.. (2009). Industrijski gradovi u tranziciji – problemska područja [Industrial cities in transition – problem areas]. *Bulletin of the Serbian Geographical Society, 89*(3), 191–206. https://doi.org/10.2298/GSGD0903191M

Miljanović, D., Miletić, R., & Đorđević, J. (2010). Regional inequality in Serbia as a development problem. *Acta Geographica Slovenica, 50*(2), 253–275. https://doi.org/10.3986/AGS50204

Miljanović, D., Panić, M., & Jojić Glavonjić, T. (2017). Životna sredina, upravljanje otpadom i zaštita prirode u Srbiji [Environment, waste management and nature protection in Serbia]. In M. Radovanović (Ed.), *Geografija Srbije (Posebna izdanja, Knjiga 91) [The Geography of Serbia (Special Issues, No. 91)]* (pp. 298–381). Geographical Institute "Jovan Cvijić" SASA.

Mustafa, A., Van Rompaey, A., Cools, M., Saadi, I., & Teller, J. (2018). Addressing the determinants of built-up expansion and densification processes at the regional scale. *Urban Studies, 55*(15), 3279–3298. https://doi.org/10.1177/0042098017749176

Mykhnenko, V., & Turok, I. (2008). East European cities – Patterns of growth and decline, 1960–2005. *International Planning Studies, 13*(4), 311–342. https://doi.org/10.1080/13563470802518958

Nikitović, V. (2022). Demography – Part III. In E. Manić, V. Nikitović, & P. Djurović (Eds.), *Geography of Serbia. Nature, people, economy* (pp. 133–181). Cham: Springer.

Nistor, C., Vîrghileanu, M., Cârlan, I., Mihai, B.-A., Toma, L., & Olariu, B. (2021). Remote sensing-based analysis of urban landscape change in the City of Bucharest, Romania. *Remote Sensing, 13*(12). https://doi.org/10.3390/rs13122323. Article 2323.
Oueslati, W., Alvanides, S., & Garrod, G. (2015). Determinants of urban sprawl in European cities. *Urban Studies, 52*(9), 1594–1614. https://doi.org/10.1177/0042098015577773
Panić, M., Drobnjaković, M., Stanojević, G., Kokotović Kanazir, V., & Doljak, D. (2022). Nighttime lights—Innovative approach for identification of temporal and spatial changes in population distribution. *Journal of Geographical Institute "Jovan Cvijić" SASA, 72*(1), 51–66. https://doi.org/10.2298/IJGI2201051P
Penev, G. (2014). Population ageing trends in Serbia from the beginning of the 21st century and prospects until 2061: Regional aspect. *Zbornik Matice srpske za društvene nauke, 148*, 687–700. https://doi.org/10.2298/ZMSDN1448687P
Penev, G. D., & Predojević-Despić, J. R. (2019). The population change in Serbia in the post-Yugoslav period (1991-2017): Significant demographic aspects. *Sociološki pregled/Sociological Review, 53*(3), 1183–1216. https://doi.org/10.5937/socpreg53-21902
Pesaresi, M., Ehrlich, D., Ferri, S., Florczyk, A., Carneiro Freire, S., Halkia, S., Julea, A., Kemper, T., Soille, P., & Syrris, V. (2016). *Operating procedure for the production of the Global Human Settlement Layer from Landsat data of the epochs 1975, 1990, 2000, and 2014 (EUR 27741)*. Publications Office of the European Union.
Pirisi, G., & Trócsányi, A. (2014). Shrinking small towns in Hungary: The factors behind the urban decline in "small scale". *Acta Geographica Universitatis Comenianae, 58*(2), 131–147. http://actageographica.sk/stiahnutie/58_2_02_Pirisi_a_Trocsanyi.pdf.
Reis, J. P., Silva, E. A., & Pinho, P. (2016). Spatial metrics to study urban patterns in growing and shrinking cities. *Urban Geography, 37*(2), 246–271. https://doi.org/10.1080/02723638.2015.1096118
Schiavina, M., Freire, S., & MacManus, K. (2019). *GHS population grid multitemporal (1975-1990-2000-2015), R2019A*. European Commission, Joint Research Centre (JRC). https://doi.org/10.2905/0C6B9751-A71F-4062-830B-43C9F432370F.
Schiavina, M., Melchiorri, M., Corbane, C., Freire, S., & Batista e Silva, F.. (2022). Built-up areas are expanding faster than population growth: Regional patterns and trajectories in Europe. *Journal of Land Use Science*. https://doi.org/10.1080/1747423X.2022.2055184
Schiavina, M., Melchiorri, M., Freire, S., Florio, P., Ehrlich, D., Tommasi, P., Pesaresi, M., & Kemper, T. (2022). Land use efficiency of functional urban areas: Global pattern and evolution of development trajectories. *Habitat International, 123*. https://doi.org/10.1016/j.habitatint.2022.102543. Article 102543.
Schmidt, S., Fina, S., & Siedentop, S. (2015). Post-socialist sprawl: A cross-country comparison. *European Planning Studies, 23*(7), 1357–1380. https://doi.org/10.1080/09654313.2014.933178
Schneider, A., & Woodcock, C. E. (2008). Compact, dispersed, fragmented, extensive? A comparison of urban growth in twenty-five global cities using remotely sensed data, pattern metrics and census information. *Urban Studies, 45*(3), 659–692. https://doi.org/10.1177/0042098007087340
Siedentop, S., & Fina, S. (2012). Who sprawls most? Exploring the patterns of urban growth across 26 European countries. *Environment and Planning A, 44*(11), 2765–2784. https://doi.org/10.1068/a4580
Siljanoska, J., Korobar, V. P., & Stefanovska, J. (2012). Causes, consequences and challenges of shrinkage: The case of small cities in a transition society. *Built Environment (1978–), 38*(2), 244–258. http://www.jstor.org/stable/23799123.
Simeonova, V., & Milkova, K. (2019). "Shrinking cities" in Bulgaria: An attempt for defining the models of "urban shrinkage". In S. Nedkov, G. Zhelezov, N. Ilieva, M. Nikolova, B. Koulov, K. Naydenov, & S. Dimitrov (Eds.), *Smart geography. Key challenges in geography* (pp. 143–153). Cham: Springer. https://doi.org/10.1007/978-3-030-28191-5_12.
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. https://doi.org/10.1080/09654313.2018.1465530
Spasić, N., Petrić, J., & Filipović, M. (2007). *Small and medium towns in Central Serbia – Standpoints and assumptions on development perspectives* (No. 55). Institute of Architecture and Urban & Spatial Planning of Serbia.
Spasovski, M., & Šantić, D. (2016). Migracije stanovništva kao determinanta razvitka i razmeštaja stanovništva Srbije u poslednjih pola veka [Population mobility as a determinant of development and spatial distribution of population in Serbia in the last fifty years]. *Glasnik Etnografskog instituta SANU, 64*(3), 453–467. https://doi.org/10.2298/GEI151019006S
Spórna, T., & Krzysztofik, T. (2020). 'Inner' suburbanisation – Background of the phenomenon in a polycentric, post-socialist and post-industrial region. Example from the Katowice conurbation, Poland. *Cities, 104*. https://doi.org/10.1016/j.cities.2020.102789. Article 102789.
Stanilov, K. (Ed.). (2007), *Vol. 92. The post-socialist city: Urban form and space transformations in central and Eastern Europe after socialism*. Dordrecht: Springer.
Stanilov, K., & Sýkora, L. (Eds.). (2014a). *Confronting suburbanization: Urban decentralization in postsocialist central and Eastern Europe* (1st ed.). John Wiley & Sons, Ltd.
Stanilov, K., & Sýkora, L. (2014b). Postsocialist suburbanization patterns and dynamics: A comparative perspective. In K. Stanilov, & L. Sýkora (Eds.), *Confronting suburbanization: Urban decentralization in postsocialist central and Eastern Europe* (1st ed., pp. 256–295). John Wiley & Sons, Ltd.. https://doi.org/10.1002/9781118295861.ch9 (Chapter 9).
Statistical Office of the Republic of Serbia. (2014). *Popis stanovništva, domaćinstava i stanova 2011. u Republici Srbiji: Knjiga 20. Uporedni pregled broja stanovnika 1948, 1953, 1961, 1971, 1981, 1991, 2022 i 2011, podaci po naseljima* [2011 Census of Population, Households and Dwellings in the Republic of Serbia, Book 20. Comparative overview of the number of population in 1948, 1953, 1961, 1971, 1981, 1991, 2002 and 2011 – Data by settlements]. https://pod2.stat.gov.rs/ObjavljenePublikacije/Popis2011/Knjiga20.pdf.
Statistical Office of the Republic of Serbia. (2021). *Statistički godišnjak Republike Srbije 2021* [Statistical yearbook of the republic of Serbia 2021]. https://publikacije.stat.gov.rs/G2021/Pdf/G20212054.pdf.
Statistical Office of the Republic of Serbia. (2023). Popis stanovništva, domaćinstava i stanova 2022. u Republici Srbiji: Nacionalna pripadnost [2022 Census of Population, Households and Dwellings in the Republic of Serbia, Ethnicity]. https://publikacije.stat.gov.rs/G2023/Pdf/G20234001.pdf.
Stojanović, B., & Vojković, G. (2005). Urbane aglomeracije na glavnim razvojnim osovinama kao polovi demografske revitalizacije Srbije [Urban agglomerations on main development areas as poles of demographic revitalization of Serbia]. *Stanovništvo, 43*(1–4), 61–79. https://doi.org/10.2298/STNV0504061S
Strategija održivog urbanog razvoja Republike Srbije do 2030a godine [Strategy of Sustainable Urban Development until 2030]. Službeni glasnik Republike Srbije, No. 47/2019.
Stryjakiewicz, T. (2022). Shrinking cities in postsocialist countries of central-eastern and South-Eastern Europe - A general and comparative overview. In C.-T. Wu, M. Gunko, T. Stryjakiewicz, & K. Zhou (Eds.), *Postsocialist shrinking cities* (1st ed., pp. 235–255). Routledge (chapter 16).
Svirčić Gotovac, A. (2016a). Postsocijalistička transformacija Zagreba i Podgorice kao glavnih gradova [Post-socialist transformation of two capital cities, Zagreb and Podgorica]. In A. Svirčić Gotovac, & R. Šarović (Eds.), *Tranzicijska preobrazba glavnih gradova, Zagreba i Podgorice, kao sustava naselja: bilateralni projekt između Hrvatske i Crne Gore (2015. –2016.) [Transitional transformation of the capital cities, Zagreb and Podgorica, as a settlement system: a bilateral project between Croatia and Montenegro (2015–2016)]* (pp. 201–231). Institute for Social Research in Zagreb (Chapter 8).
Svirčić Gotovac, A. (2016b). Uvod u komparaciju urbanih sustava glavnih gradova Zagreba i Podgorice [Zagreb and Podgorica, two capital cities: an introduction to the comparison of their urban systems]. In A. Svirčić Gotovac, & R. Šarović (Eds.), *Tranzicijska preobrazba glavnih gradova, Zagreba i Podgorice, kao sustava naselja: bilateralni projekt između Hrvatske i Crne Gore (2015. –2016.) [Transitional transformation of the capital cities, Zagreb and Podgorica, as a settlement system: a bilateral project between Croatia and Montenegro (2015 –2016)]* (pp. 7–23). Institute for Social Research in Zagreb (Chapter 1).
Svirčić Gotovac, A., & Kerbler, B. (2019). From post-socialist to sustainable: The city of Ljubljana. *Sustainability, 11*(24). https://doi.org/10.3390/su11247126. Article 7126.
Svirčić Gotovac, A., & Zlatar, J. (2015). Urban processes in Zagreb. Residential and Commercial Developments. *Hrvatski geografski glasnik, 77*(1), 29–45. https://doi.org/10.21861/HGG.2015.77.01.02
Sýkora, L., & Bouzarovski, S. (2012). Multiple transformations: Conceptualising the post-communist urban transition. *Urban Studies, 49*(1), 43–60. https://doi.org/10.1177/0042098010397402
Sýkora, L., & Stanilov, K. (2014). The challenge of postsocialist suburbanization. In K. Stanilov, & L. Sýkora (Eds.), *Confronting suburbanization: Urban decentralization in postsocialist central and Eastern Europe* (1st ed., pp. 1–32). John Wiley & Sons, Ltd.. https://doi.org/10.1002/9781118295861.ch1 (Chapter 1).
Taubenböck, H., Gerten, C., Rusche, K., Siedentop, S., & Wurm, M. (2019). Patterns of eastern European urbanisation in the mirror of Western trends – Convergent, unique or hybrid? *Environment and Planning B: Urban Analytics and City Science, 46*(7), 1206–1225. https://doi.org/10.1177/2399808319846902
Tošić, D., & Krunić, N. (2005). Urbane aglomeracije u funkciji regionalne integracije Srbije i Jugoistočne Evrope [Urban agglomerations in the function of regional integration of Serbia in South-Eastern Europe]. *Bulletin of the Serbian Geographical Society, 85*(1), 137–148. https://doi.org/10.2298/GSGD0501137T
Turok, I., & Mykhnenko, V. (2007). The trajectories of European cities, 1960–2005. *Cities, 24*(3), 165–182. https://doi.org/10.1016/j.cities.2007.01.007
UN-Habitat. (2018). SDG Indicator 11.3.1. Training Module: Land Use Effiency. United Nations Human Settlement Programme (UN-Habitat). https://unhabitat.org/sites/default/files/2021/08/indicator_11.3.1_training_module_land_use_efficiency.pdf.
United Nations Security Council Resolution No. 1244. (1999). https://unmik.unmissions.org/sites/default/files/old_dnn/Res1244ENG.pdf.
Uredba o nomenklaturi statističkih teritorijalnih jedinica [Regulation on Nomenclature of Statistical Territorial Units], Službeni glasnik Republike Srbije, No. 109/2009, 46/2010.
Veljković, A., Jovanović, R., & Tošić, B. (1995). Gradovi Srbije: Centri razvoja u mreži naselja [Towns of Serbia: The centres of development in the network of settlements]. In *Posebna izdanja, Knjiga 44 [Special Issues, No. 44]*. Geografski institut "Jovan Cvijić" SANU.
Veljković, N., & Lekić, D. (Eds.). (2019). *Životna sredina u Srbiji: 2004–2019 [Environment in Serbia 2004 – 2019]*. Ministarstvo zaštite životne sredine Republike Srbije. Agencija za zaštitu životne sredine [Ministry of Environmental Protection of Republic of Serbia, Environmental Protection Agency]. http://www.sepa.gov.rs/download/FIN_JubilarnaPublikacija.pdf.
Vilenica, A. (2017). Contemporary housing activism in Serbia: Provisional mapping. *Interface: A Journal for and about Social Movements, 9*(1), 424–447. http://www.interfacejournal.net/wordpress/wp-content/uploads/2017/07/Interface-9-1-Vilenica.pdf.
Vuksanović-Macura, Z., Gvozdic, M., & Macura, V. (2020). Continuous planning: Innovations from practice in Stavanger (Norway) and Belgrade (Serbia). *Planning Theory & Practice, 21*(5), 727–747. https://doi.org/10.1080/14649357.2020.1849776
Vuksanović-Macura, Z., & Macura, V. (2018). The right to housing: Squatter settlements in interwar Belgrade—The defense and demolition of Jatagan-mala. *Journal of Urban History, 44*(4), 755–774. https://doi.org/10.1177/0096144216632747

Vuksanović-Macura, Z., Radulović, S., & Macura, V. (2018). Land cover changes of the Belgrade area over the past three centuries. *Spatium, 40*, 42–50. https://doi.org/10.2298/SPAT1840042V
Wang, M., Krstikj, A., & Koura, H. (2017). Effects of urban planning on urban expansion control in Yinchuan City, Western China. *Habitat International, 64*, 85–97. https://doi.org/10.1016/j.habitatint.2017.04.008
Wolff, M., Haase, A., Haase, D., & Kabisch, N. (2017). The impact of urban regrowth on the built environment. *Urban Studies, 54*(12), 2683–2700. https://doi.org/10.1177/0042098016658231
Wolff, M., Haase, D., & Haase, A. (2018). Compact or spread? A quantitative spatial model of urban areas in Europe since 1990. *PLoS One, 13*(2). https://doi.org/10.1371/journal.pone.0192326. Article e0192326.
Wolff, M., & Wiechmann, T. (2018). Urban growth and decline: Europe's shrinking cities in a comparative perspective 1990–2010. *European Urban and Regional Studies, 25*(2), 122–139. https://doi.org/10.1177/0969776417694680
Xu, G., Zhou, Z., Jiao, L., & Zhao, R. (2020). Compact urban form and expansion pattern slow down the decline in urban densities: A global perspective. *Land Use Policy, 94*. https://doi.org/10.1016/j.landusepol.2020.104563. Article 104563.
Zakon o Prostornom planu Republike Srbije [The Law on Spatial Plan of the Republic of Serbia]. Službeni glasnik Republike Srbije, No. 13/1996.
Zakon o Prostornom planu Republike Srbije od 2010. do 2020a. godine [The Law on Spatial Plan of the Republic of Serbia from 2010 to 2020], Službeni glasnik Republike Srbije, No. 88/2010.
Zakon o teritorijalnoj organizaciji Republike Srbije [Law on the Territorial Organization of the Republic of Serbia]. Službeni glasnik Republike Srbije, No. 129/2007, 18/2016, 47/2018, 9/2020.
Zegarac, Z. (1999). Illegal construction in Belgrade and the prospects for urban development planning. *Cities, 16*(5), 365–370. https://doi.org/10.1016/S0264-2751(99)00033-5
Zeković, S., & Maričić, T. (2016). A historical prolegomenon of the legal framework and urban land policy in Serbia as a basis for urban development. *Spatium, 36*, 67–74. https://doi.org/10.2298/SPAT1636067Z
Zeković, S., Petovar, K., Nor-Hisham, B. M., & S.. (2020). The credibility of illegal and informal construction: Assessing legalization policies in Serbia. *Cities, 97*. https://doi.org/10.1016/j.cities.2019.102548. Article 102548.
Zeković, S., Vujošević, M., & Maričić, T. (2015). Spatial regularization, planning instruments and urban land market in a post-socialist society: The case of Belgrade. Habitat International, 48, 65–78. https://doi.org/https://doi.org/10.1016/j.habitatint.2015.03.010.
Živanović Miljković, J., & Čolić, N. (2020). Obim promena načina korišćenja poljoprivrednog zemljišta – iskustva i preporuke za lokalni nivo planiranja i upravljanja [Extent of agricultural land use changes – experiences and recommendations for local level of planning and management]. In J. Petrić, & M. Vujošević (Eds.), *Teorijska, razvojna i primenjena istraživanja prostornih procesa za obnovu strateškog mišljenja i upravljanja u Srbiji (Posebna izdanja, br. 88) [Theoretical, developmental and applied research of spatial processes for the renewal of strategic thinking and management in Serbia, Special Issues, No. 88]* (pp. 87–103). Institute of Architecture and Urban & Spatial Planning of Serbia.
Živanović Miljković, J., Popović, V., & Gajić, A. (2022). Land take processes and challenges for urban agriculture: A spatial analysis for Novi Sad, Serbia. *Land, 11*(6). https://doi.org/10.3390/land11060769. Article 769.
Živanović, Z. (2015). *Gradovi srednje veličine - razvojni centri na području Centralne Srbije [Medium-Sized Cities – Developping Centers on the Territory of Central Serbia]*. Geografski fakultet: Univerzitet u Beogradu.
Živanović, Z., Tošić, B., Nikolić, T., & Gatarić, D. (2019). Urban system in Serbia—The factor in the planning of balanced regional development. *Sustainability, 11*(5). https://doi.org/10.3390/su11154168. Article 4168.
Živanović, Z., Tošić, B., Nikolić, T., Samardžić, I., Dabović, T., & Jeftić, M. (2021). Urban shrinkage in Serbia: The domination of economic over environmental causes. *Fresenius Environmental Bulletin, 30*(12), 13437–13452.

General urban plans

Generalni plan Beograda. (2021). [General Plan of Belgrade 2021]. *Službeni list grada Beograda*. No. 27/2003.
Generalni urbanistički plan Valjeva [General Urban Plan of Valjevo]. Službeni glasnik grada Valjeva, No. 05/2013.
Generalni urbanistički plan Vranja [General Urban Plan of Vranje]. Službeni glasnik grada Vranja, No. 37/2018.
Generalni urbanistički plan Grada Čačka 2015 [General Urban Plan of Čačak 2015]. Službeni list grada Čačka, No. 25/2013.
Generalni urbanistički plan Kragujevac 2015 [General Urban Plan of Kragujevac 2015]. Službeni list grada Kragujevca, No. 07/2010, 16/2012.
Generalni urbanistički plan Kraljevo 2020b [General Urban Plan of Kraljevo 2020]. Službeni list grada Kraljeva, No. 13/2013.
Generalni urbanistički plan Kruševca 2025 [General Urban Plan of Kruševac 2025]. Službeni list grada Kruševca, No. 03/2015.
Generalni urbanistički plan Leskovca od 2010. do 2020. godine [General Urban Plan of Leskovac from 2010 to 2020]. Službeni list grada Leskovca, No. 04/2013.
Generalni urbanistički plan Niša 2010–2025 [General Urban Plan of Niš 2010–2025]. Službeni list grada Niša, No. 43/2011.
Generalni urbanistički plan Novi Pazar 2020 [General urban plan of Novi Pazar 2020]. Službeni list grada Novog Pazara, No. 02/2014.
Generalni plan grada Novog Sada do 2021. godine. [General Plan of the City of Novi Sad to 2021]. Službeni list Grada Novog Sada, No. 39/2006.
Generalni urbanistički plan Požarevca [General Urban Plan of Požarevac]. Službeni list grada Požarevca, No. 13/2014.
Generalni urbanistički plan Smederevo 2020 [General Urban Plan Smederevo 2020]. Službeni list grada Smedereva, No. 19/2009.
Generalni urbanistički plan Subotica-Palić do 2030b [General Urban Plan of Subotica-Palić to 2030]. Službeni list Grada Subotice, No. 29/2018.
Generalni plan Zrenjanina 2006-2026 [General Plan of Zrenjanin 2006-2026]. Službeni list opštine Zrenjanin, No. 19/2007, 01/2008.