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Spatial Analysis of the Possible First Serbian Conurbation

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Abstract
After the breakup of the former Republic of Yugoslavia, the number of inhabitants in newly formed state of Serbia has been in constant decrease. On the other hand, the number of urban areas has been growing. One of the main goals of former Socialist Federal Republic of Yugoslavia was the development of all the areas, including the rural ones. In the '60s and the '70s, the land with special purpose was supposed to be of the utmost importance. Urban regions were to be better connected and enlarged. The main reason for it was the distribution of economic activities as well as the process of deagrarization which had already been in progress. In 1966, the first spatial plan of a special-purpose area, being the outset of an idea in a Socialist country, was in fact the proposition of the first Yugoslav conurbation. The long forgotten project was about to be reinforced in 1996, when thirty years later the country was in a transitional period, heading towards market capitalization. After the final breakup of Yuoslavia, there was a growing need for preservation of the urban areas and large trade centers, along with the necessity of better communication among municipalities. The ambitious project in question called "Morava city", has never been brought to life. The main purpose of this manuscript is to answer the question of the actual necessity of this potential conurbation by means of GIS methodology, qualitative and quantitative techniques, and demographic and sociological factors. Accordingly, by means of spatial analysis, the communist project is placed into post-communist environment. Finally, the manuscript focuses on the relationship between rural and urban areas, traffic connectivity, geographical position, and most importantly on the sustainability and profitability of the first Serbian conurbation.

Keywords Serbia · GIS analysis · Quantitative and qualitative methods · Urbanization · Land use · Spatial analysis

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Introduction

The increasing scale of urbanization, urban growth and development in the national urban systems have given rise to several different forms of urbanized regions. In Serbia, which is still in the transitional period, there are prominent processes of urbanization, still being in progress in urban areas. In accordance with the definition of urban processes, regional urban centers in the Republic of Serbia are those with population of 300,000 inhabitants. Well known conurbation, at the same time being the largest in the country, is within the capital city, Belgrade. Other, strikingly urban zones are in bigger cities, such as Novi Sad, Kragujevac, Niš. Due to the limited number of inhabitants in Serbia, these urban zones will not turn into megalopolises, that being the case with some parts of Western Europe, South -East Asia, the East coast of America, East Africa, Japan, and South-East Australia (Champion 2000; Frey and Speare, 1988). The most urbanized areas in Serbia are regions comprising multiple municipalities. All the spatial plans issued after 2000 note that all the regions, which are being depopulated, should be merged and concentrated. Potential conurbation named “Morava City” would consist of three municipalities – Jagodina, Ćuprija and Paraćin. The need for merging these three municipalities is based on historical, sociological, urban, transitory, demographic and political necessity. Excellent geographical position, transit of international corridor 10, along with the small distance between the three municipalities are all good potential predispositions for the creation of the first Serbian conurbation (Strategic document of the municipality Ćuprija 2015; Strategic document of the municipality Jagodina 2013; Stamenković and Bačević 1992). Conurbation zones in the Netherlands, Czech Republic and Germany were inspiration for this potential conurbation. Apart from historical, conurbations are also of economic importance. The biggest problems of the future world are overpopulated cities, uneven distribution of population, unplanned cities. It is expected that more than 70% of population will be living in cities by 2050 (The United Nations, 2007). In China, particularly in the urban area of Beijing, transport and large emissions of CO2 may be the main problem. One of the solutions is forming of green corridors, and vehicles using renewable energy resources. Despite these ambitious plans, Beijing today abounds in unprofitable and unplanned construction (Zhao 2010). Some cities in China have new form of conurbation, named “city within a city” (Lin and Gaubetz 2016). In the UK, many conurbations were made of leading industrial cities (Johnson and Xie 2013). In West Europe conurbations may develop new regions with novel economic activities. (Fielding 1982). Unfortunately, many megalopolises, such as Chongqing, Shanghai, Delhi, Mumbai, Lagos, Karachi, Guangzhou, Istanbul, Tokyo, Tianjin, Moscow, Cairo, Kinshasa, New York City, Hyderabad, Bangkok have similar problems. The problem is the lack of energy, sustainable development, traffic, infrastructure, overpopulation, and the lack of green corridors. On the territory of Balkan Peninsula there are no big cities except for Athens which may form a megalopolis. According to the UN data, majority of Balkan countries will mark a significant rise in depopulation in the near future (United Nations, 2017). The regions in Bulgaria, Romania, North Macedonia, Bosnia and Herzegovina, Croatia and Slovenia are going to have the process of migrations toward international corridors (Hetziprokopiou 2004). Apart from traffic, taking place along the main corridors within these large urban areas, regional and local analysis of traffic, performed by means of GIS methods, would be of great significance (Klatko et al. 2017). Nowadays, the development of traffic within urban zones represents an inseparable part of urban development planning. There is a specific part of urban development related to traffic, within the plans of infrastructure development (Ognjenović et al. 2015). Beside traffic, being of great significance within conurbations, energy is an essential element of a conurbation sustainability. Local agendas and regional agreements may reduce the emission of CO2 and increase the resources of renewable energy (Bennett and Newborough, 2001). The energy of transport may completely determine the sustainability of the city itself as well as the urban zones. The traffic within urban zones depends on three main factors, them being the distance, density and the relations among the traffic areas. The three factors together affect the energy consumption within the city (Banister et al. 1997). All conurbations and developing cities must also have the specific ratio in percentage of rural and urban areas. The rural areas within conurbations could be the base for food production, thus for the sustainable development of a conurbation (Jamshidi et al. 2007; Filimonau and Gherbin 2017). The idea for the first Serbian conurbation dates back to the ‘60s of the last century. The main argument for the formation of conurbation is the distance among the three settlements which is no bigger than 20 km (Statistical office of the Republic of Serbia, 2016). The spatial plan of the Republic of Serbia for the period between 2010 and 2020, defines the conurbation “Morava” as the area of functional urban purpose (Djordjevic 2009). According to that spatial plan, Jagodina would become a functional urban zone of particular interest. It would cover the area of 751km^2 i.e. 2.2% of the territory of Serbia with 164,384 inhabitants i.e. 2.3% of the whole country’s population. Potential conurbation Morava would be at the distance of 135 km from Belgrade, the capital of the country, 190 km away from Niš, the second largest city in the country. Central geographical position, favourable natural characteristics, traffic connectivity with European corridors, and demographic and economic potential would make this conurbation very important. The importance and profitability of the conurbation in question is being investigated by means of spatial, numerical and GIS analysis.

Urban Planning of the Municipalities in the Former Republic of Yugoslavia

In the past, Serbia was a constituent part of the Former Socialist Federative Republic of Yugoslavia.

After the Second World War, Yugoslavia made a very ambitious plan, consisting of five phases. The first phase took place in the period between 1946 and 1949. The first phase of spatial planning was finished in this period, relying on the experience of the Soviet Union. From 1949 to 1960, Yugoslavia developed its own urban plans. In that period, each of the six Republics of Yugoslavia made their own spatial plans. Jagodina, Ćuprija and Paraćin were municipalities which actively participated in the planning, and during that period more than 60% of facilities was constructed. Despite that the planning was active and ample, it lacked scientific and economic justification. The first general urban plan for the territory of whole country appeared in 1955, whereas the first detailed spatial plan for the three municipalities of future conurbation appeared in 1966. Yugoslavia, in that period, was undergoing the process of industrialization, urbanization, planned spatial arrangement and deagrarization (Piha 1986). The most active period of capital infrastructure construction was between 1960 and 1966. The period still emanated the communist components in planning. By the '90s, the society was being gradually democratized, therefore the local population started participating in planning. The outcome is that all the municipalities today have their own spatial and urban plans. (Čobeljić, 1967; Čobeljić, 1963; Ristić et al. 2019; Gigović et al. 2016).

Review of the Cities

Jagodina Municipality

This largest settlement is the centre of Pomoravlje district and the center of future conurbation. According to the census and the estimate from 1837, Jagodina had 5220 inhabitants. By 1867, Jagodina was still a typical agricultural settlement. According to the census from 1930, Jagodina had 6590 inhabitants, and after the continual rise, by 1961, the number of inhabitants reached 19,769. By 1971, the number rose to 25,700 and by 1991 to 36,000. Today, there are 48,777 inhabitants living in the urban area, and the total number in the municipality is 72,999 (see Fig. 1).

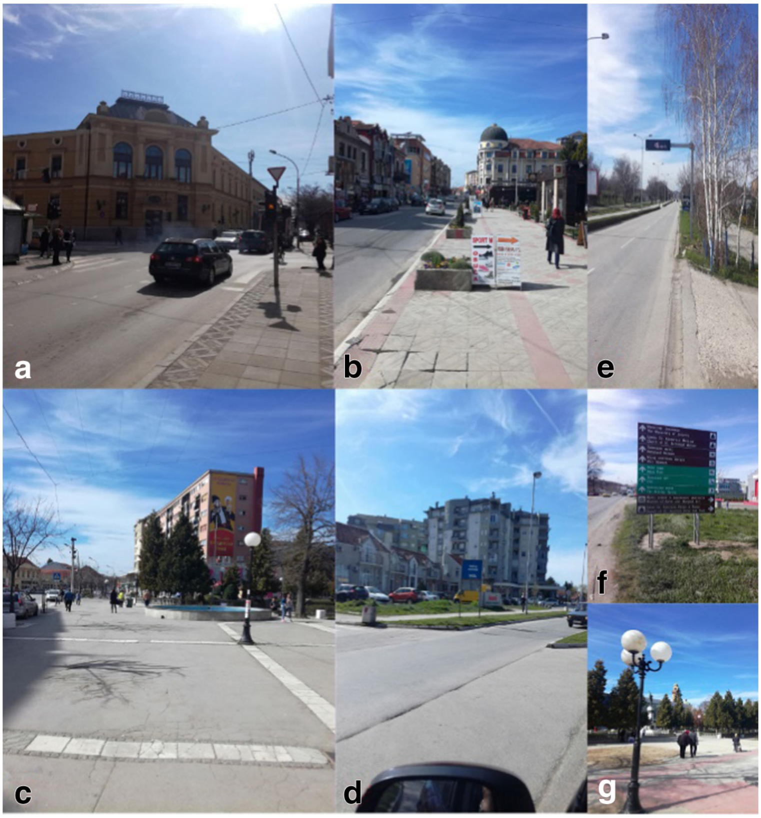

Fig. 1 Jagodina - central point of the future conurbation. The main buildings were built in communist period in Yugoslavia. The photo was taken by the author a.Valjarević

Jagodina is the biggest city in the upper Great Morava basin. It is located in the northern half of the basin, along its North-west part and in the vicinity of the entrance of the Morava into Bagrdan gorge. Jagodina is at 116 m of elevation, along the river Belica (Marković 1971; Municipalities of Serbia 2006). In the village Belica, close to Jagodina, there is one of the oldest cemeteries in Europe. In the early Neolith, Jagodina had a number of settlements close to the river Belica. At this archaeological site, numerous artifacts were discovered along with 100 figures which bear witness to the life in that period. According to the estimate, the location dates back to 8000 BC. On the top of Juhor mountain, there was a Celtic complex, close to the village Novo Lanište. In 74 BC Jagodina fell under the rule of Roman Empire, and after 1458 became the part of the Ottoman Empire (Milanovic et al. 2016). Between 1553 and 1557, travel writers were describing Jagodina as a magnificent place with 2 mosques and 4 caravan stations. After the decline of Ottoman Empire, Serbia became the Kingdom. The construction of first factories and larger urban areas started in the city. In the period between 1929 and 1941, Jagodina was a part of the Morava Banovina. After the Second World War, the city underwent tha rapid process of industrialization. 90% of industry was built in the period of Socialism, some of the objects still existing today. After the Second World War, Jagodina moved northward, to the Great Morava, so today it lies at the distance of 3 to 4 km on the right bank. According to the census from 1971, Jagodina had 6132 residential units, 121 streets of overall length of 58 km. the total green area surface is 51,000 m^2. Today Jagodina has 8123 residential units, 135 streets 71 km long. Green area surface amounts to 61,500 m^2. In 1971, the water supply network was 10 km long, whereas today its length is 27 km. Before the Second World War, Jagodina was exporting agricultural products to Switzerland, Germany and the UK. The biggest factories, constructed in the period of Socialism were Cable Factory and Delicatessen Factory „ Yuhor“. In the transitional period after 1991, Jagodina had low economic development and industrial production. The greatest advantage of Jagodina as the centre of future conurbation is its favourable position in terms of transport. Electrified railway of European corridor 10 connects Jagodina with Belgrade and Niš. High-way E-75 connects Jagodina with Central and West Europe, as well as with Asia. The overall length of railways in the territory of the municipality is 34 km. In Jagodina, today, there are 16,255 employees (Fig. 1).

Paraćin Municipality

Paraćin is located in the Pomoravlje district in central Serbia, in the valley of Great Morava. The Crnica river runs through the city. According to the newest data, Paraćin has 28,992 inhabitants.In terms of history, Paraćin is a settlement older than Jagodina, dating back to Neolith (Zorkić 2017; Avramovic 2016). Paraćin is mentioned as a larger settlement in the vicinity of the Great Morava in Justinian records from the Byzantium age, in 1375. In the Roman era, the settlement was Roman station, (*Mutatio Sarmatorum*). In the 1492 charter, Paraćin square is mentioned as a well known trading spot. In the period of the Ottoman Empire, Paraćin was known as a big, classy place where the Turks and the Gypsies lived. In 1886, the city had 4302 inhabitants, in 1910 5843, in 1921 5191 and a decade later 7192 inhabitants. In 1948, the population increased to 10,110, and further to 15,648 inhabitants according to the census from 1971. Industrialization started in the nineteenth century. In 1907, the first Serbian glass factory was opened, and in 1921 a textile factory. According to the data from 1971, there were more than 9000 employees in Paraćin. In the neighbouring Popovac, which belongs to the municipality of Paraćin, one of the bigger cement factories was constructed. 85% of industry was built in the Socialist Republic of Serbia. The city is at 3 km distance from the Great Morava. It is situated near international railway Belgrade–Niš, and close to E-75 highway. Paraćin is a lowland city, at the elevation of 130 to 135 m. The municipality of Paraćin has 10,569 employees and 34,566 inhabitants (Fig. 2).

Ćurpija municipality

Ćuprija is also located in the Pomoravlje district, along with Paraćin and Jagodina. The newest data show that the number of inhabitants is 20,585 in the city, and 33,540 in the municipality.

Fig. 2 Paraćin - the second largest municipality in the future conurbation, still keeping the communist type of buildings. The photo was taken by the author a.Valjarević

Unlike Jagodina and Paraćin, Ćuprija was built on the right bank of Great Morava. The Ravanica river flows through the city. Geographical coordinates 43° 56’ N and 21° 23′ E show excellent position for the traffic and the central spot of the country. Ćuprija is one of the oldest settlements in the Great Morava valley as well as in Serbia. Prelude to the city were Roman city (*Horreum*) and Medieval city (*Ravno*), namely the wheat-belt of Morava. In the past, Ćuprija was the biggest city of Upper Moesia(Moesia Superior). In 1183 in Ravno, nowadays Ćuprija Friedrich Barbarossa was met on the third crusade. The Turks used the infrastructure of the ancient city and built a big fortress upon it, in the Middle Ages. An important medieval road Via *Militaris*, later known as Carigradski drum”, was passing through Ćuprija. In the nineteenth century, the city became administrational headquarters. The industrialization of the city started by the opening of Sugar plant in 1912. In spite of its ideal geographical and traffic position, Ćuprija still hasn’t developed completely, both as agricultural and industrial zone. The main characteristic of the city is its meridian position, 2 km long. In 1846, the city had 1477 inhabitants, in 1866 2439, in 1885 3408, in 1910 5356, and a sudden rise in 1948 to 9609 inhabitants. According to the 1953 census, the number rose to 11,967 whereas in 1971 it was 17,600. The ancient city on the Great Morava developes slowly, but it’s becoming a big settlement. Numerous communications, mineral resources, the vicinity of the mines Resavica and Senj, forests, agricultural land may present an important part of the future development. The main advantage of Ćuprija is the distance from Paraćin and Jagodina less than 7 km. The other advantage is the passing of European and railway corridor 10. Urban plans by 1966 didn’t include the merge of the three cities into conurbation, however, the need for the creation of the same has constantly been growing for the past 54 years. According to the last data, the number of employees in Ćuprija is 6706 (Fig. 3; Table 1).

Materials and Methods

The future conurbation is located on a fertile alluvial plain. Alluvial terraces are placed at the elevation of 160 m. The terraces which are on the lower elevation are covered with sand, gravel and clay. The Jagodina-Paraćin basin is surrounded by mountains Juhor (705 m) and Crni Vrh (775 m). These mountains are the part of the Rhodope mountain range. In the East, the basin is surrounded by higher mountains -Beljanica (1336 m) and Kučajske (1284 m). These mountains are the part of the Carpatho-Balkan mountains. The zone of conurbation has moderate-continental climate with cold winters and hot summers (see Table 2). According to the Köppen climate classification, the zone of conurbation has Dfa climate with prominent local characteristics (Kottek et al. 2006) (Fig. 4).

The first GIS (Geographical Information System) analysis used for the purpose of this research, was conducted to describe the characteristics of the relief. Satellite data with the resolution of 10 m were downloaded from the platforms LandSat 8 and USGS (United States Geological Survey). These satellite data were in the extension AsterDem, and being such, they are suitable for manipulations and analyses, since raster is cleaned and georeferenced. On completing this operation, the process of vectorization is conducted. The borders of the future conurbation, made of three municipalities were vectorized and converted into shp file. GIS techniques and analyses

Fig. 3 Ćuprija - the third municipality, with central position in conurbation. The photo was taken by the author a.Valjarević

are used in the majority of spatial sciences (Pettit and Pullar, 2009; Brabyn and Mark, 2011; Uuemaa et al. 2013; Olafsson and Skov-Petersen 2014; Saeed et al. 2019; Klatko et al. 2016). Geographical Information System and modelling of geospatial data is a very important and powerful tool in calculating and analyzing quantitative and qualitative data (Valjarević et al. 2018; Germino et al. 2001). For the analysis of satellite and spatial data, two softwares of open code QGIS 3.12.0 (Quantum GIS) and SAGA 2.3.2 (System for Automated Geoscientific Analyses) were used (Hendriks et al. 2019; Bíl et al. 2012; Frechtling 1999; Wu and Chen 2016). Softwares are used for mapping and the analysis of future potential conurbation”Morava”. For better analysis of the region of conurbation, buffer spatial analysis was used, which marked the belts of traffic connectivity and nodal attraction within the area (Petterson and Hoalst-Pullen, 2011; Xiang 1996; Thomson and Hardin 2000; Al-kheder et al. 2009; Bugs et al. 2010; Xiang 2001). For the analysis of gravitational attraction of all the settlements within conurbation, we used modified criging and semi-kriging. The data on all the settlements in the region were taken from the last available census for the three municipalities from

Table 1 Strategic document and model of urban areas in the republic of Serbia for 2020

Main urban area	With connection to the main urban area	Number of citizens in the City	Number of citizens in connection	% in comparison with Serbia	Area in km^2	Area in % in comparison with Serbia
Beograd	Stara Pazova, Opovo, Pećinci, Pančevo,Inđija, Ruma	1,576,124	1,882,687	25.4	5758	7,4
Čačak	Lučani	117,072	141,686	1.9	1096	1.4
Jagodina	Ćuprija, Paraćin	72,543	**164,384**	1.4	751	1.0
Kikinda	Novi Bečej, Nova Crnja	67,002	86,818	1.4	1664	2.2
Kragujevac	Knić, Betočina, Rača	175,802	217,129	2.9	1603	2.1
Kraljevo	Vrnjaška Banja	121,707	148,199	2.0	1758	2.3
Kruševac	Ćićevac, Aleksandrovac	131,368	171,512	2.3	1363	1.8
Leskovac	Lebane, Vlasotince, Bojnik	156,252	227,600	3.0	1829	2.4
Loznica	Mali Zvornik, Krupanj	86,413	120,681	1.6	1140	1.5
Niš	Doljevac, Merošina, Gadzin Han, Žitoradja	250,518	327,943	4.4	1964	2.5
Novi Pazar	Raška, Tutin	85,996	143,031	1.9	2168	2.8
Novi Sad	Sremski Karlovci, Temerin, Beočin, Žabalj, Bački Petrovac, Irig, Indjija, Vrbas,Srbobran, Bačka Palanka,Titel	299,294	513,304	7.0	3086	4.0
Pančevo	Kovin, Kovačica, Opovo, Alibunar	127,162	220,316	3.8	2525	3.3
Pirot	Dimitrovgrad	63,791	75.539	1.0	1712	2.2
Požarevac	Malo Crnić, Žabari	74,902	101,789	1.4	1017	1.3
Šabac	Vladimirci, Bogetić	122,893	176,256	2.4	1509	2.0
Smederevo	Velika Plana	109,809	154,279	2.1	711	0.9
Sombor	Apatin	97,263	130,076	1.7	1593	2.1
S.Mitrovica	Šid	85,902	124,875	1.7	1444	1.9

2011. Modified kriging was used for the distance between settlements whereas magnitude of attraction was given through the number of inhabitants per territory, according to the equation (Eq.1)

Table 2 Main relief and climatological characteristics of the future conurbation

Municipality	Area (km^2)	Altitude (m)	Average temperature for periods of 1967–2017 (C°)	Average precipitation for periods of 1967–2017 (mm)
Jagodina	470	116	11.2–11.7	619
Ćuprija	287	116	10.8	654.8
Paraćin	541.7	130	11.2–11.7	631.9
Conurbation Total/Average	1298.7	120.6	11.2	635.23

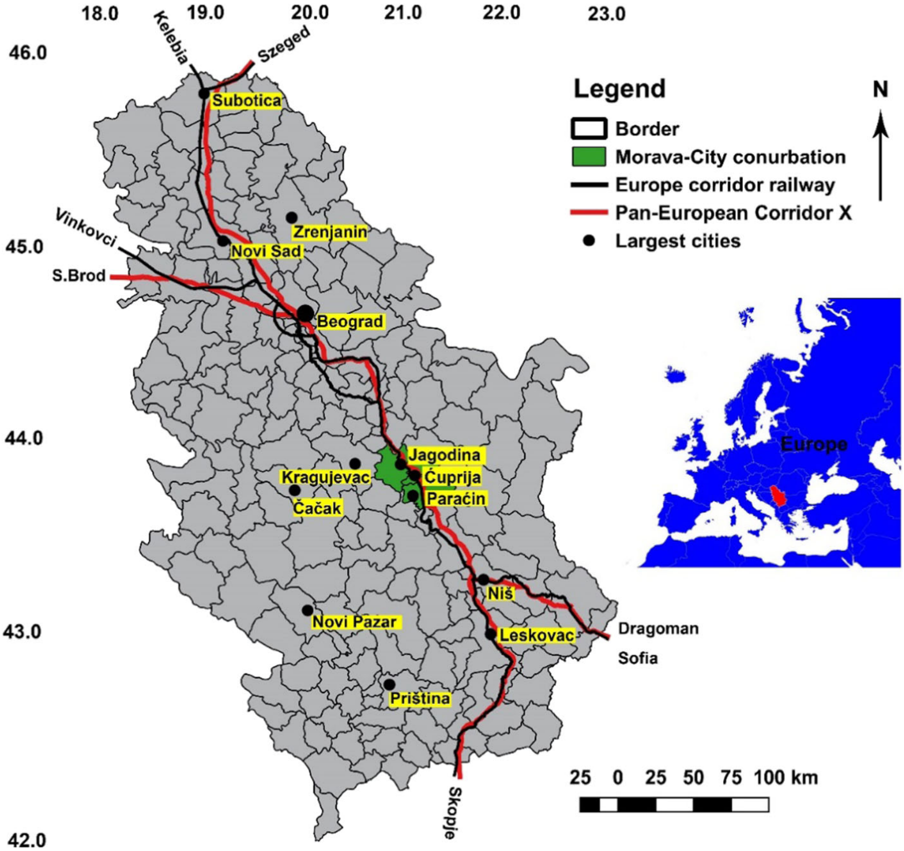

Fig. 4 Position of the first possible Serbian conurbation in the territory of Serbia. The figure made by the author a.Valjarević

$$I_{ab} = k\frac{P_a P_b}{d^2} \tag{1}$$

where I_{ab}- represents spatial interaction of two spots in space. P – shows the overall population, K- is a constant determined within the software, depending on kriging applied as well as on the spatial model. The equation can also be presented

$$I_{ab} = \sum_{i,j} k\frac{V_i W_j}{c_{i,j}^b} \tag{2}$$

where V_i- is a capability of spatial interaction, W_j- availability of the destination, J- is the attraction of the spatial interactions and C_{ij} a generalized power of interaction, which serves as an inverse measure of accessibility. The constant b - which can vary according to the context, must be estimated from the observed data (Howard et al. 1997; Ports et al. 2006). Modified kriging used in SAGA software, distributed the attraction belts of the biggest settlements of Jagodina, Ćuprija and Paraćin through rings. Modified kriging as a way of interpolation or Gaussian process regression uses certain boundary values. Modifed-kriging method and nugget values between −0.7 and + 1.2 on Z axis and between 0.4 and − 0.8 on X axis were used. In addition, modified Gaussian regression and Kolmogorov prediction were used as well. Furthermore, average nearest neighbor Euclidean distance was utilized. Lag size was 0.5°. For classical kriging method these values are between 0.7 and + 1.0 on Z axis and between 0.3 and − 1.0 on X axis and lag size was 0.3 °. These kriging methods are good because they include standard variance and estimation error is very low <2% (Kienast et al. 1996). There are many techniques which could be used for the nodal analysis of roads and road network. Spatial interpolation within GIS platform provides satisfactory results. Thus, the analysis of, roads, their capacity and connectivity is conducted. (Klatko et al. 2017; Hilton et al., 2011; Kawamura et al., 2014). When analyzing the hexagonal network, a special tool within QGIS 3.12.0, called MMGIS was used. Such analysis provides valuable insight into the distribution of spatial data (Ritsema van Eck and Jong 1999). All types of grid display are within this algorithm. Finally, all the procedures and all the algorithms used for the purpose of this research were presented in the flow chart, which was modified in a way to point out the algorithm of spatial analysis of communications and settlements. (Klatko et al. 2017). (Fig. 5).

Results and Discussion

After gravitational analysis of urban belts by means of GIS, the urban zone of future conurbation was presented (Fig. 6). Jagodina is presented as the central zone (see Fig.6). This belt within the municipality of Jagodina was marked by red colour with the radius of 4.7 km covering the area of 66 km^2. At the same time, this belt presents the densest part of conurbation. The average number of inhabitants within this belt is 743 per km^2, the overall number being 49,101. Accordingly, the central zone of conurbation was determined. The following belt is at 400 m distance away from the central zone, heading to all directions. This belt was marked by yellow colour. The number of inhabitants is 1473 with the average density of 123 inhabitants per km^2. The following zone, marked by green, has the radius of 1.5 km with 2193 inhabitants and the average density of 101 inhabitant per km^2. The last belt, marked by blue colour, represents the zone of the last urban belt. This belt has the radius of 1 km with 3331 inhabitants and the average density of 233 inhabitants per km^2. The radius of all belts is 8 km, covering the area of 88 km^2. The number of inhabitants is 56,078 with the average density of 298 inhabitants per km^2 (see Fig. 6). Light blue and white zone represent the rural belt.

The city of Paraćin, as well as the whole municipality of Paraćin, have following spatial characteristics: the radius of the first urban belt, marked by red, is 2.3 km, covering the area of 21. 5 km^2. The number of inhabitants within this central urban belt is 25,104 with the average density of 1168 inhabitants. The radius of the second belt, marked by yellow, is 1 km, covering the area of 9 km^2. The number of inhabitants is 3146 with the average density of 89 inhabitants per km^2. The radius of the third belt is 2,3 km, covering the area of 5.6 km^2. The belt is marked by green and it has 544 inhabitants with the average density of 23 inhabitants per km^2. The fourth belt, marked by blue, has 426 inhabitants with the average density of 45 inhabitants per km^2. The radius of this belt is 1.1 km, covering the area of 6.8 km^2. The total number of

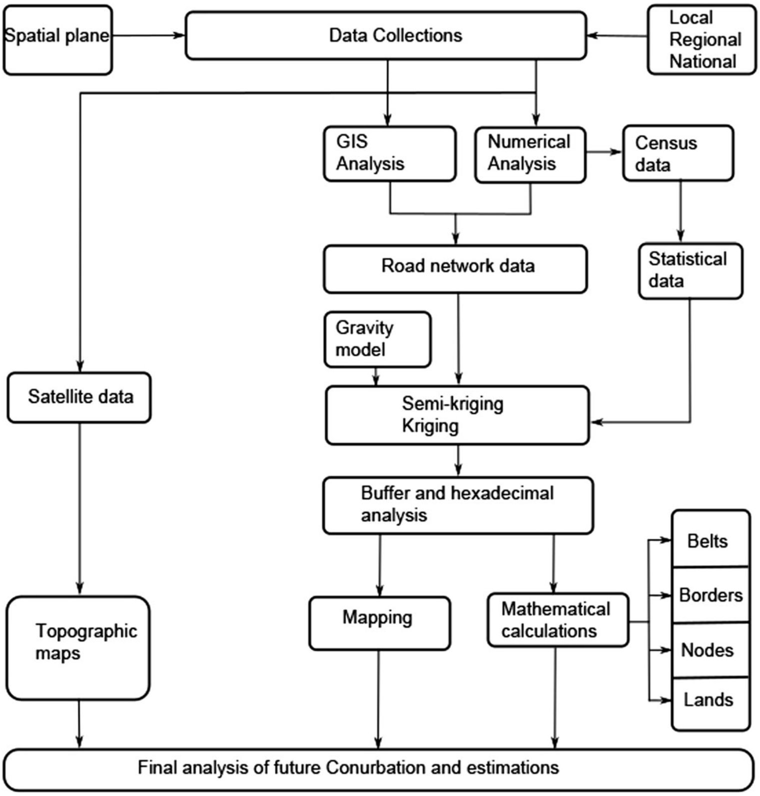

Fig. 5 Algorithms and procedures of the conurbation research

inhabitants within all urban belts is 29,920 with the average density of 293 inhabitants per km$^{2.}$ What is interesting is that the red urban belt crosses the border of the municipality of Ćuprija.

The radius of this zone is 3.3 km, covering the area of 2.5 km^2. Light blue and white colour represent the rural belt. Unlike Paraćin and Jagodina, which have 5 belts, Ćuprija has 3 belts. In that way, it is shown that Ćuprija doesn't have prominent urban characteristics, since it doesn't have gravitational contraction force. The first belt, marked by yellow, has the radius of 4.1 km, covering the area of 67 km^2. The total number of inhabitants within this belt is 19,471 inhabitants with the average density of 295 inhabitants per km^2. Within the following, green belt, the radius is 1.5 km, with 3006 inhabitants and the average density of 89 inhabitants per km^2. Within the blue belt, the radius is 800 m with 1373 inhabitants and the average density of 66 inhabitants per km^2. The total number of inhabitants within the urban belts of the municipality of Ćuprija is 24,120 with the average density of 7 inhabitants per km^2 and the area of 160 km^2. The area of all the belts within conurbation, i.e. the area of all three municipalities is 442 km^2, with 110,118 inhabitants in total and the average density of 249 inhabitants per 1 km^2. After georeferencing the whole geospace and the vectorization of all the units within the future conurbation, we obtained the display of natural resources of the conurbation. Detailed GIS analysis was performed after the processing of satellite data. Apart from GIS techniques and the methods of detailed

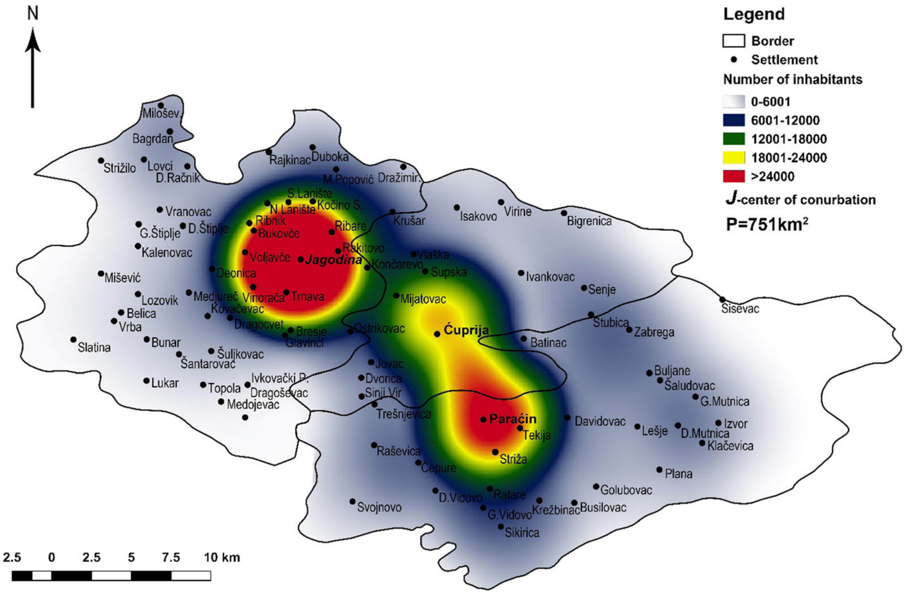

Fig. 6 The analysis of future Morava conurbation with GIS methods, red belt-presents the city urban area; yellow-urbanized; green-future urbanized zone II; blue- border of future conurbation; white-blue rural areas. This figure made by the author a.Valjarević

analysis, we used topographic maps as well as spatial plans and pedological maps for each of the three municipalities. The types of soil within the conurbation are alluvium, podzol, clay, chernozem. The fertile valley of the Great Morava with the appropriate amount of precipitation, gives the possibility of growing most of crops. If the conurbation was viewed as a closed space, it would be self-sustainable according to the amount of food producing. The sustainability presents the base for the formation i.e. the expansion of urban zones (Lufafa et al. 2003). Vegetables and fruit grown within geospace enable the sustainability of management and development. The fruit which would be the most suitable for growing within the area of conurbation are plums, apples, nuts, apricots, peach, strawberry and cherries. Vegetables, whose growth would be the most successful are carrots, potato, beans, peas, string beans, cabbage, tomato

Table 3 Areas of agricultural lands in the conurbation after GIS analysis in (ha)

Municipality	Used agricultural land	Gardens and arable land	Orchards	Vineyards	Meadows and Pastures
Jagodina	19,746	15,594	940	310	2596
Paraćin	17,425	14,673	298	238	1993
Ćuprija	12,817	10,643	230	79	1655
Conurbation	49,988	40,910	1468	627	6244

and cucumber. Apart from satisfying the needs of the conurbation, it would also be possible to export 45% of the products (Table 3).

After the analysis of the newest satellite data, as well as the analysis of spatial plans, the area of forests would satisfy the need for green corridors within the conurbation. Prevailing type of forests are deciduous and mixed. On the edges of conurbation, in smaller communities, there are also the areas of coniferous trees. The most widespread types of trees are beech, linden, poplar, willow, white beech, oak, white pine, fir (Table 4).

The basic characteristics of the relief point to the advantages of new road directions, due to slight inclinations. The elevation of conurbation is between 100 m and 400 m. 70% of conurbation is placed in the alluvial plain of the Great Morava (see Fig. 7).

Newly formed urban zone of the conurbation would have North-east and South-West direction. The central point of Jagodina is at 111 m elevation. With the azimuth of 127° 05′ 37.9″ the slope is 0.06°, the maximum slope being 1.11°. The central point of Ćuprija is at 116 m of elevation and geographical azimuth is 131° 29′ 24.9″, slope is 0.25°, maximum slope is 1.71°. Potential implementation of tram and trolley lines according to the urban plan from 1966 would make sense due to slight inclination and vast plain. This line would have the frequency of 30 min and good connectivity with railway and road European corridor 10.

Urban settlement's Concept from the Geospatial Perspective

Post-socialist concept of construction brought about big problems because of unplanned parts of the city. Illegal construction has been growing rapidly since 2000 in majority of the cities in Serbia.

Vasilevska et al. (2014). The remaining qualitative and quantitative analyses implicated the appearance of one-way and blind streets within the cities (Vranić, 2012). Similar situation exists within the potential zone of conurbation of all three cities. Frequent changes of green areas, new urban zones for construction and the change of parking places influence the occurence of poorly connected streets. Spatial analysis of centrality and urban zones was conducted with the help of open-source software Gephi 0.92 (see Fig. 8).

After detailed spatial analysis, the characteristics of all spatial nodes were obtained. Jagodina as the most dominant city of the future conurbation has following characteristics-114.5 nodes per 1 km^2. Ćuprija has centrality index 30, whereas Paraćin has 70. The biggest number of traffic is in Jagodina-1456, Paraćin-890 and Ćuprija- 447. The total length of all communication within conurbation is 6234.6 km. The maximum number of traffic connections is in Jagodina 75%, Paraćin 15% and Ćuprija only 10% (see Fig. 8).

After condtucted buffer analysis along with the analysis of nodes and main communications the results showed the best connectivity of streets within the radius of 1 km (Fig. 9).

Socio-Demographic Characteristic of the Future Conurbation

Socio-demographic characteristics determine the future of the cities as much as the conurbations. According to the newest demographic forecast, in 2020, Jagodina will

Table 4 Forested areas in the cities

Town	Forested area in the municipalities in ha				Area of forest in (ha^2)	Average tree volume			
	Into the Forest		Outside of Forest			Total in m^3		Technical trunks %	
	deciduous	coniferous	deciduous	coniferous		deciduous	coniferous	deciduous	coniferous
Jagodina	–	–	–	–	16,864.19	11,517	535	15	61
Paraćin	–	7.52	1.22	0.9	22,636.07	27,315	2881	14	13
Ćuprija	28.51	–	2.1	1.2	8862.07	4602	1591	2	87
Conurbation/Total	28.51	7.52	3.31	2.1	48,362.33	43,434	5007	31	161

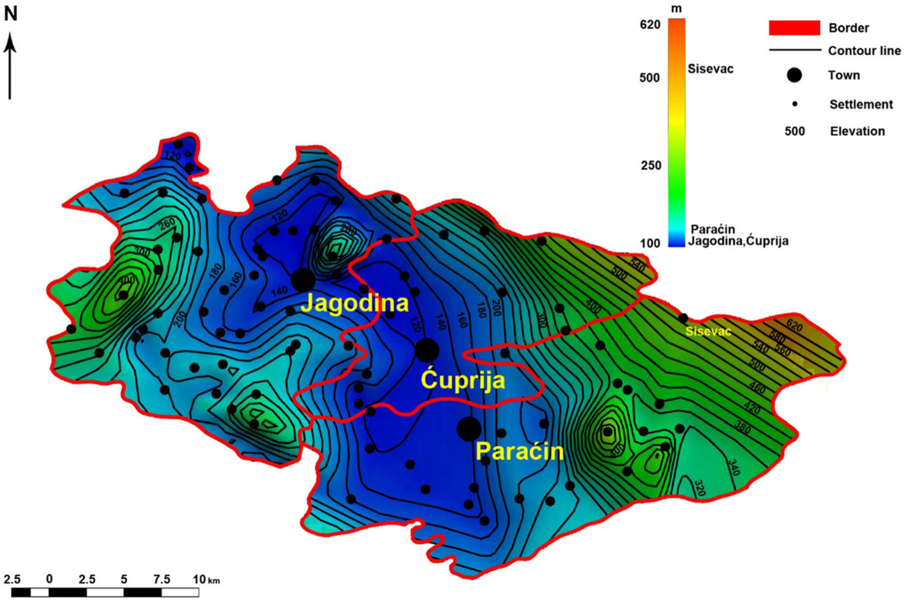

Fig. 7 The relief properties of the conurbation with elevation. This figure made by the author a.Valjarević

have 47,058 inhabitants, which is 1679 higher number than the one from the census data from 2002. If the conurbation was set today, in the urban parts there would be 50.8% of population, whereas 49.2% would be living in the rural areas (Grčić and Sluka, 2006). The municipality of Jagodina has 53 rural settlements, but three of them-Majur, Ribare, Trnava have more than 2000 inhabitants, while Topola, being an urban settlement has only 20 inhabitants. GIS analysis has shown that many rural settlements would enter the urban belt. According to these parameters, Jagodina would be the center of conurbation. Within less than 16 years, the number of inhabitants increased by 4.000. If we were to compare the period from the last census in 2002, and today's data, the number increased by 2925. What makes the difference is that, when studying the

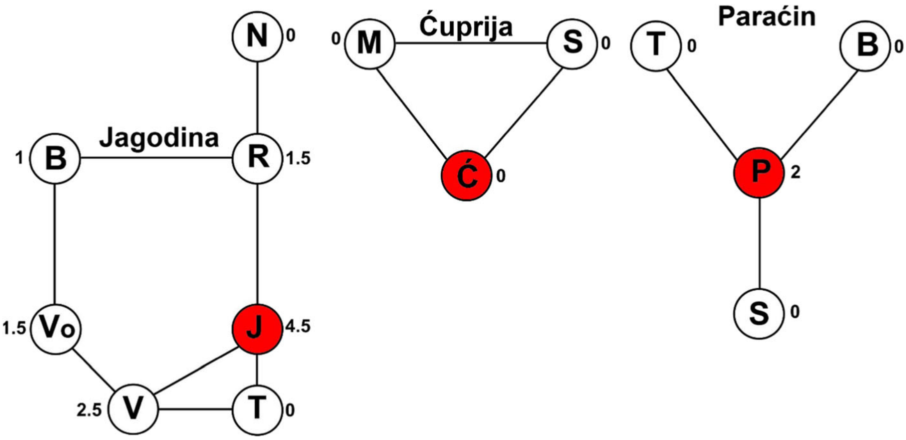

Fig. 8 Generalized centrality of the network for three municipalities into conurbation shows influence of communist built concept. This figure made by the author a.Valjarević

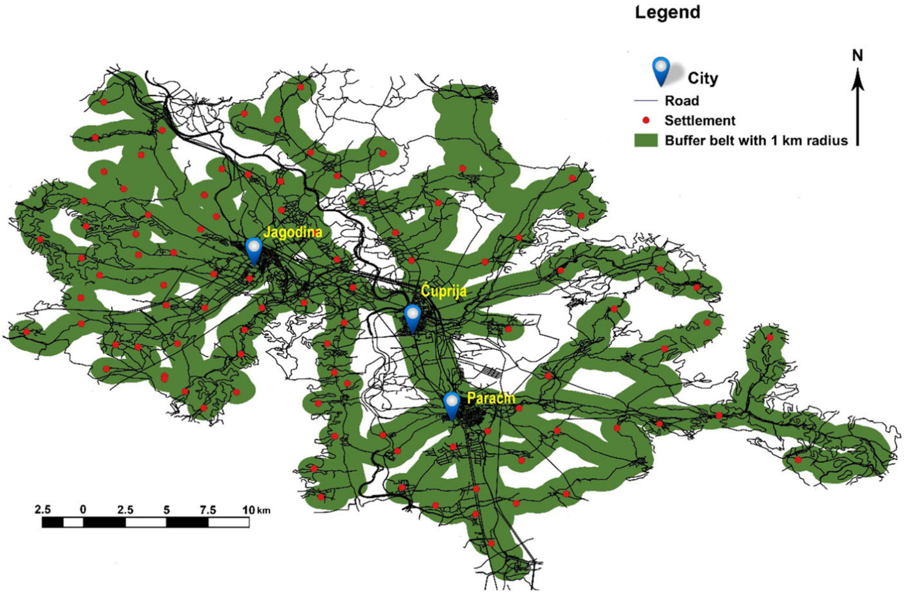

Fig. 9 Morava conurbation with road network dispersion and position of all nodes (settlements) with performed buffer analysis in radius of 1 km. This figure made by the author a.Valjarević

whole municipality, there is a decrease in population, by 8.8%, especially in the rural parts. In urban parts, the poulation rate increased by 8.2%. In 2002, there were 25,292 inhabitants in the city and 33,009 living in the rural parts of Paraćin. The population rate of municipality has been in constant decrease by 12.3%. Annually, the percentage is 0.7%. Within 18 years, rural parts were left by 3971 inhabitants, and 208 inhabitants left the urban parts of Paraćin. According to the estimate, Paraćin has 25,303 inhabitants today. The municipality of Ćuprija had 20,585 inhabitants in 2002, whereas today there are 19,371 inhabitants. By today Ćuprija reduced the number of inhabitants by 1214 i.e. 5.7%. After the demographic analysis, Jagodina has marked an increase by 9% on the whole territory of the municipality. On completing hexagonal grid analyis on the area of 2 km^2, we obtained the results for the distribution of density on the territory of the future conurbation. The map showed that the central territories possess strong potential for the creation of future conurbation, particularly inside Jagodina. Jagodina has 6 hexagons with the values between 2700 and 3000 inhabitants. In Ćuprija there are 5 hexagons with the values being the same as the ones in Paraćin, the total number of hexagons with the biggest number of inhabitants is 16. It implies that in the future conurbation 32 km^2 would have high population density. 46 hexagons, i.e. 92 km^2 have between 1 and 300 inhabitants per hexagon. Settlements above the elevation of 500 m have very low density, while the setllements between 200 m and 400 m of elevation have higher density. The lowest density is in the west and in the east of conurbation. (see Fig. 10).

The densest parts of conurbation would be in the central and south-east parts of conurbation. This distribution of population density would follow European road and railway corridor 10.

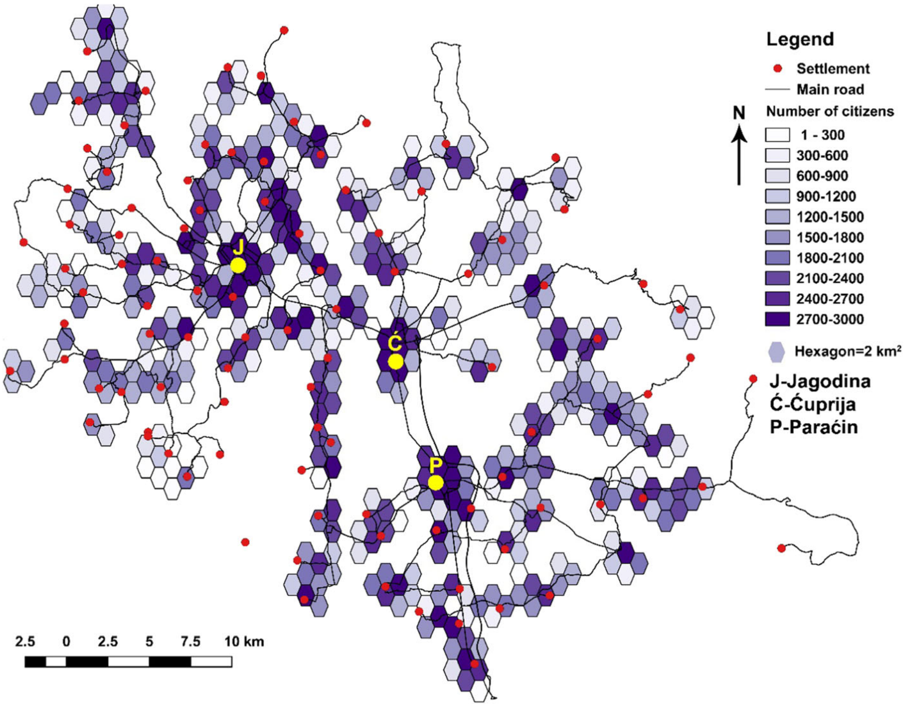

Fig. 10 Hexagonal map of population density in the future conurbation. This figure made by the author a.Valjarević

Conclusion

Serbia as most of the Balkan countries has the problem of low birthrate and high emigration rate. According to the UN data, by 2050, Serbia will lose 20% of population. The process of urbanization in Serbia started late, not until the beginning of the nineteenth century. After the Second World War, there was a continuing process of urbanization, which included ambitious construction projects. A reverse process was taking place in the rural areas, since the population was emigrating. The process of emigrating to other countries was continuous. Industrialization in Serbia today is at a much lower level than after the Second World War. Another big problem is depopulation of rural areas. There will be 70% inhabitants less in these areas by 2050. Each of the three studied municipalities has marked the decrease in the number of inhabitants and social activities. If these three municipalities were merged into the first Serbian conurbation called “Morava “, the potential for their development would be much greater. Some of the benefits would be 50,000 employees; 150,000 inhabitants living in the area; the conurbation would have the central position on European corridor 10, thus becoming a subject to possible foreign investments, due to excellent traffic position. The effects of deagrarization, due to the depopulation of rural areas, would be reduced. It would also stop the process of deforestation, since the majority of green areas would become a part of urban belts, with a specific status. Traffic connectivity would be improved, starting with the implementation of a transport line among the three cities. Administrative rationalization would implicate the existence of one central bus and railway station, one central hospital and many other objects of utmost significance for the population. Accordingly, it would lead to the reduction of the budget expenditure. Despite the fact that the project of conurbation was made in 1966, during the Communist regime, its significance is not diminished. By means of this systematic research, the long forgotten project was brought to life again. The importance of the future conurbation was revised by means of GIS methods, satellite detection, numerical analysis and sociological researches. The majority of studied parametres showed the facts in favor of the creation of the first Serbian conurbation "Morava". The conurbation itself has proven the sustainability, upon studying the natural and social characteristics. This research could instigate the detailed analysis at the national level, for the purpose of forming the first Serbian conurbation. Such an example could be followed by other municipalities in Serbia, which are facing with the problem of depopulation.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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