12th INTERNATIONAL SCIENTIFIC CONFERENCE ON DEFENSIVE TECHNOLOGIES
OTEH 2026
Serbia, Tara, 21 - 24 October 2026

GEOSPATIAL ASSESSMENT OF THE DEVELOPMENT LEVEL OF LOCAL GOVERNMENT UNITS IN THE REPUBLIC OF SERBIA

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Abstract: *Assessing the level of development of local government units (LGUs) represents one of the key instruments for understanding spatial disparities and supporting evidence-based regional policy. The methodological framework of this study integrates statistical and geospatial analyses to assess the level of development of LGUs in the Republic of Serbia. The analysis uses relevant socio-economic indicators. The Development Index of LGUs was calculated based on the following indicators: unemployment rate, income per capita, own revenue per capita, educational attainment, and population growth or decline rate. The highest development index was detected in Stara Pazova with 182.04 index points (i.p.), which means that the development of this LGU is 82.04 % above the republic average. Belgrade, as the largest city, is in the second place with 158.92 i.p., followed by Novi Sad (154.6 i.p.). Niš, as the third largest city in the Republic of Serbia, with 98.62 i.p. belongs to the second development group. In the fourth, the lowest development group, three LGUs detected development index lower than 50 % of the republic average – Rekovac (47.49 i.p.), Bojnik (49.19 i.p.), and Sjenica (49.62 i.p.). These findings highlight the need to reform the methodological framework, as well as the necessity of introducing new indicators that would more adequately reflect contemporary social, economic, and demographic challenges.*

Keywords: *Geospatial analysis, GIS, Local Government Units, development index, Republic of Serbia.*

1. INTRODUCTION

Assessing the level of development of local government units (LGUs) represents one of the key instruments for understanding spatial disparities and supporting evidence-based regional policy. Such assessments enable the identification of developed and underdeveloped areas, the allocation of development funds, and the implementation of measures aimed at achieving balanced regional growth.

The concept of territorial development is relatively recent and has evolved from earlier notions of regional and local development, as well as top-down and bottom-up approaches. Although these terms are often used interchangeably in practice, each represents a theoretical advancement over its predecessors. Local development, while frequently positioned within broader regional policy, remains insufficiently defined, yet is closely linked to key pillars such as capital and infrastructure policies, migration, and growth center strategies [1].

Development strategies have traditionally been framed through two contrasting approaches: top-down models based on industrialization and centralized planning, which often exacerbate inequalities, and bottom-up approaches that emphasize local resources, small-scale initiatives, and community participation [2].

More recently, the concept of territorial development has emerged as an integrative framework that encompasses local and regional development while incorporating notions such as place, clusters, and ecosystems [3]. Contemporary perspectives further highlight the role of both production processes and governance structures as

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DOI: 10.5937/OTEH26098K

key drivers of territorial development, alongside broader forms of innovation, including social and institutional change, often shaped through both cooperation and conflict [4].

Regional disparities in Serbia remain a significant development challenge [5]. Although a legal and institutional framework exists, anchored in the Constitution and the Law on Regional Development [6], its implementation is constrained by outdated strategic documents and limited policy updates. The classification and measurement of LGU development levels represent a key instrument of regional policy [7], yet no revised regulatory framework has been adopted in recent years. This underscores the need for updated methodologies and policies to support more balanced and sustainable territorial development.

In Serbia, as in many other countries of Central and Eastern Europe, significant regional inequalities persist, both in terms of economic potential and quality of life [8]. The use of geospatial analysis in this context enables a more detailed examination of spatial patterns of development, revealing the spatial concentration of more or less developed municipalities. By applying GIS tools and statistical methods, it becomes possible to visualize the spatial distribution of indicators of socio-economic development and to detect LGUs that share similar development characteristics. This approach contributes not only to a better understanding of spatial disparities, but also to the formulation of more targeted and efficient development policies.

The methodological framework of this study is based on the integration of statistical and geospatial analyses aimed at assessing the level of development of LGUs in the Republic of Serbia. The analysis includes the use of relevant socio-economic indicators that reflect the demographic, economic, and infrastructural characteristics of municipalities and cities.

2. METHODOLOGY

The study area encompasses the entire territory of the Republic of Serbia, including its LGUs. According to the data of the Statistical Office of the Republic of Serbia (SORS), there are 197 municipalities, city municipalities, and cities that constitute the LGUs [9], [10], [11]. Out of the total number of LGUs, 29 are located in the region of Kosovo and Metohija, for which statistical data are not available in the official databases of SORS. Consequently, these LGUs were excluded from this research.

Spatial data used in this analysis were obtained from the open data platform of the Republic Geodetic Authority (RGA) [12]. As the results of this study are presented at the level of cities and municipalities, it was necessary to adjust the available RGA datasets accordingly. Figure 1 presents an overview of the research workflow applied in this study.

In this process, the city municipalities of Belgrade, Niš, Vranje, Požarevac, and Užice were merged into single city polygons, thereby forming 145 LGUs analysed in total across the Republic of Serbia. The spatial processing and aggregation were conducted in ArcGIS Pro 3.0. During the research, Microsoft Excel was used for the initial processing and cleaning of open datasets obtained from SORS. This step included the identification, extraction, and preparation of relevant data to be used for further analysis. According to the Official Gazette [13], the Development Index of LGUs is calculated based on the following indicators:

– Unemployment rate, calculated as the ratio between the number of unemployed persons and the sum of employed and unemployed persons within an LGU;
– Income per capita, representing the ratio of the total taxable income earned in a given calendar year (by the place of residence of the income recipient) and the total population of the LGU;
– Own revenue per capita, calculated as the ratio between the total realized own revenues of an LGU and its total population;
– Educational attainment, expressed as the share of the working-age population with completed secondary, post-secondary, or higher education in the total working-age population (according to the most recent census); and
– Population growth or decline rate, calculated as the ratio between the population size in the observed year and that recorded in the 2002 census at the LGU level.

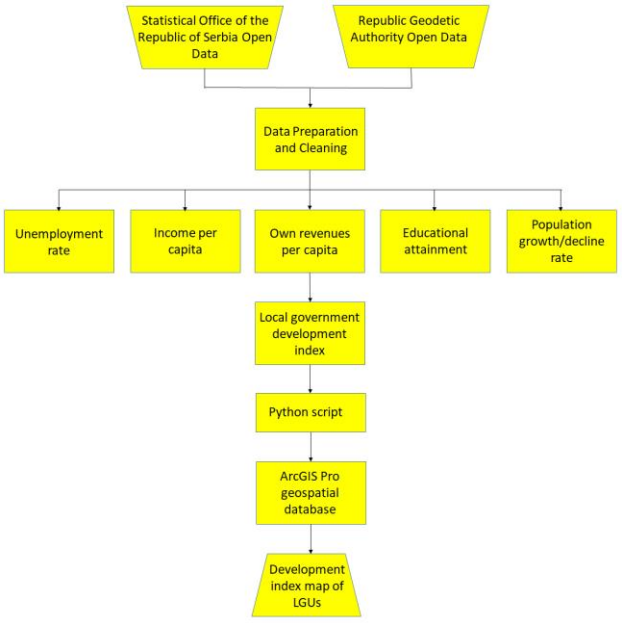


Figure 1. Schematic process of the research.

After calculating all indicators that reflect the level of development of a given territory or region, they were used to prepare an updated Unified Development List of LGUs in Serbia. According to the Official Gazette [13], each indicator is assigned a specific weight coefficient within the composite Development Index:

– Unemployment rate – 30%,
– Income per capita – 25%,
– Own revenue per capita – 10%,

– Educational attainment – 15%,

– Population growth or decline rate – 20%.

For the calculation of unemployment, income, and own revenue per capita, data for the three years preceding the year of calculation were used. In this study, that period covered 2022-2024. Additionally, a correction factor of -10 points was applied for LGUs in the fourth development group, whose working-age population density is lower than 30 persons per square kilometre. The calculation of the unemployment rate indicator was performed using the following equation:

$$I_{j,i} = \frac{R_i}{P_{j,i}} \times 100 \quad (1)$$

where I is the relative index (the national average equals 100), j represents the LGU, i the indicator, R the national average, and P the value of the indicator for the given LGU. For other indicators, the inverse proportion was applied, as higher values indicate better performance. According to these proportions, for the unemployment rate, values greater than 100 indicate results above the national average, while values below 100 indicate below-average performance. For all other indicators, higher values denote better results relative to the national average.

A review of the STAT database of the SORS and the publications Municipalities and Regions in the Republic of Serbia ([9], [10], [11]) revealed that data on income per capita at the municipal level are not available. Following direct communication with the Communication and Information Department of the SORS via email, it was confirmed that the SORS does not possess such data, but only data on the average wages of employees by municipality of residence and on household income at the regional level. The use of regional-level income data was considered inappropriate, as disaggregation to the level of LGUs would likely result in significant inaccuracies. Therefore, this study employs data on the average wages of employees by municipality and the number of employees as indicators of the economic status of the population, enabling an approximate estimation of income per capita. The Tax Administration of the Republic of Serbia undoubtedly collects such data, as clearly outlined in its Tax Guide [14], which specifies the categories of taxable income, including wages, taxable income from self-employment, copyright and related rights and industrial property rights, real estate, the rental of movable property, from the provision of hospitality services, taxable income of athletes and sports professionals, seafarers, and other taxable income [14].

In this context, foreign income refers to income earned and taxed in another country by taxpayers who are residents of the Republic of Serbia. Therefore, average wages represent only one of nine income categories that would be relevant for calculating the income per capita indicator. Consequently, this indicator, when estimated solely on the basis of average wages at the level of LGUs, does not fully reflect the actual socio-economic conditions of the population within a given territory or region. However, due to the lack of publicly available data, it is not possible to calculate income per capita in a precise and comprehensive manner. Data for the next indicator, own-source revenue per capita, were used on current revenues data from the SORS. The reason is the same as for the previous indicator – official publications of the SORS do not provide data on own-source revenues of LGUs, but only on current revenues.

The level of education, as the following indicator of territorial or regional development is defined as the ratio between the working-age population with completed secondary, post-secondary, or higher education and the total working-age population. During the analysis of this indicator certain inconsistencies were identified. Specifically, if the working-age population is assumed to comprise individuals aged 15 to 64, and the number of individuals with the aforementioned levels of education is aggregated based on the 2022 census data [15], the resulting share of the education level exceeds 100% in some LGUs. This clearly represents an unrealistic depiction of the actual educational structure of the population. It is established that the publications of the SORS do not present the number of working-age population by educational structure, but rather only data for the population aged 15 and over. For this reason, the total population aged 15 and above was used for the purposes of this research, in order to ensure that differences in educational structure remain positive and suitable for further analysis.

Based on the SORS data on 2002 census [15] and the projection of the population number at the end of 2024 [11], the population growth or decline rate by LGU is calculated. After applying the assigned weights, the final Development Index (N) for each LGU (j) was calculated using the following equation:

$$N_j = \omega_1 I_{j1} + \omega_2 I_{j2} + \omega_3 I_{j3} + \omega_4 I_{j4} + \omega_5 I_{j5} \quad (2)$$

The correction factor mentioned above was then applied to the final index values for the fourth development group. As data on Kosovo and Metohija region for some indicators were not available, therefore the development index for this region couldn't be calculated.

As a link between the data and the obtained results in MS Excel, a script written in the Python programming language was used. The open-source software PyCharm, a popular Integrated Development Environment (IDE) for Python, served as the main development platform. Today, Python offers a large number of libraries applicable to various fields. In this research, in addition to the core libraries, two additional libraries were used: openpyxl and arcpy.

The openpyxl library is used for working with Excel files in the .xlsx format. It enables reading, creating, editing, and saving Excel files without requiring MS Excel itself. Its key functionalities include reading and writing data to cells, formatting (colours, fonts, styles), working with multiple sheets, creating formulas, charts, and tables, as well as manipulating rows and columns [16].

The second library, arcpy, was developed by Esri for use with ArcGIS Pro (and formerly ArcMap). It allows for the

automation of GIS workflows – including spatial analysis, geospatial data processing, management of raster and vector data, and the administration of geodatabases. The key advantage of this library lies in its ability to automate spatial analyses [17]. Arcpy serves as the foundation for the integration of ArcGIS Pro within the Python environment and provides a vital link between various data sources and geospatial databases.

3. RESULTS AND DISCUSSION

According to the Official Gazette [13], out of the five regions that constitute the second level of the Nomenclature of Statistical Territorial Units (NUTS 2) of the Republic of Serbia, two (Belgrade and Vojvodina regions) are classified as developed, while the remaining three, located in the southern part of the country (Šumadija and Western Serbia, Southern and Eastern Serbia, and Kosovo and Metohija regions), are considered underdeveloped. It is evident that the northern part of the Republic is more developed than the southern part. Of the total territory of the Republic of Serbia, 28% is classified as developed, whereas the remaining 72% is underdeveloped. Thus, the developed area accounts for less than one-third of the country's total territory. The geographical distribution of development clearly reflects the inequality in the territorial development of the Republic of Serbia.

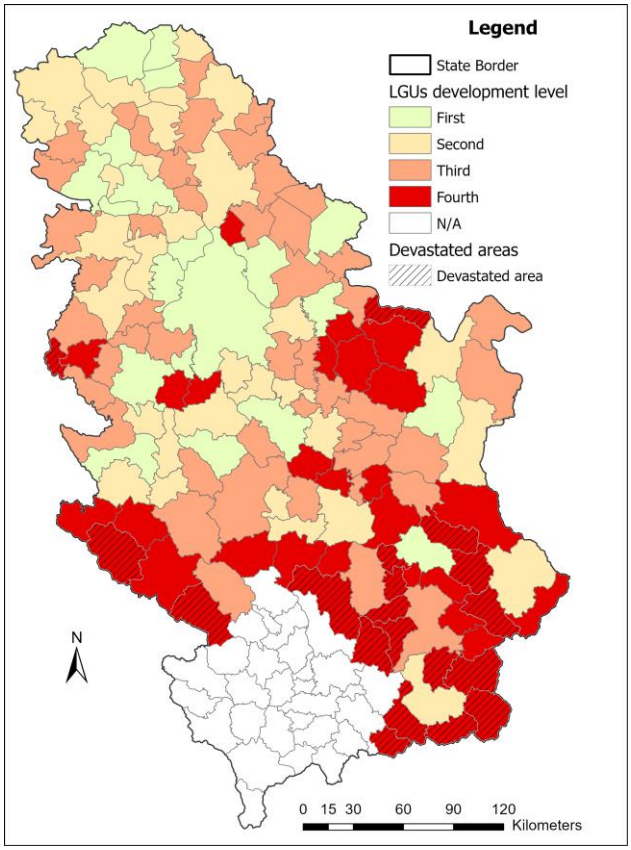


Figure 2. Spatial LGUs development according the Unified List of Development Levels of Regions and LGUs for 2014 [13].

Spatial distribution of the development of cities and municipalities within the territory of the Republic of Serbia is compiled according to the Regulation on the Determination of a Unified List of Development Levels of Regions and LGUs for 2014 (Figure 2). According to this overview, out of a total of 145 cities and municipalities, 20 belong to the first, most developed group, 34 to the second, 47 to the third, and 44 to the least developed, fourth group. Of these 44 LGUs from the least developed group, 19 are classified as devastated areas. Only 13.78% of LGUs have a development level above the national average, while nearly one-third (30.35%) have a development level below 60% of the national average. Devastated areas account for 13.1% of the total number of LGUs in the Republic of Serbia. It is evident that the least developed LGUs and the most devastated areas are located in the southern part of the Republic of Serbia, indicating significant regional disparities in territorial development.

As the first indicator of the development index, the unemployment rate shows a clear spatial disparity in the unemployment rate across the territory of the Republic of Serbia can be observed, with the highest levels recorded in the southwestern and southeastern parts of the country. The highest unemployment rates, exceeding 50%, were registered in Tutin (64.39%) and Novi Pazar (53.05%), while the lowest rates were observed in Stara Pazova (4.18%), Žagubica (6.53%), and Bački Petrovac (6.9%). Belgrade, as the capital city, follows closely with an unemployment rate of 7.01%.

The second indicator, Income per capita, calculated according to the method described above, also clearly highlights the higher level of development in major urban centres such as Belgrade and Novi Sad. An exception is observed in Bor, where the highest income per capita was recorded. In contrast, LGUs in the south-western and southern parts of Serbia, including Novi Pazar, Sjenica, Tutin, Preševo, and Bujanovac, exhibit the lowest levels of this indicator.

Due to the use of the aforementioned data, the results are somewhat overestimated for the third indicator – own revenue per capita, as the current revenues exceed own-source revenues. This indicator clearly reveals differences in relation to LGUs with smaller populations, where the highest own-source revenues per capita were recorded, such as in Čajetina (194.37 thousand RSD), Crna Trava (169.38 thousand RSD), Trgovište (148.12 thousand RSD), and Bor (142.5 thousand RSD), which thus represent the LGUs with the highest values of this indicator.

In contrast, LGUs with larger populations exhibit lower own-source revenues per capita, as observed in Bujanovac (27.14 thousand RSD), Preševo (28.15 thousand RSD), and Tutin (30.58 thousand RSD). As illustrated on the map, the majority of LGUs fall within the lowest category of own-source revenues (70 LGUs), followed by 56 LGUs in the second group and 19 LGUs in the third group, which includes the City of Belgrade as the largest urban center in the Republic of Serbia.

The aforementioned inconsistencies in the calculation of the following indicator of the development index – educational attainment, can be illustrated by the example

of the capital city, Belgrade. The SORS 2022 census data of the population between 15-64 years old for this city is 1,086,113. When the number of the population older than 15 years with completed secondary, post-secondary, or higher education is added, the result is 1,235,175 population. This is negative difference and this calculation is impossible to use. The uneven development of LGUs is clearly visible, with more populous cities generally exhibiting higher educational attainment, such as Novi Sad (86.68 %), Belgrade (86.55 %) and Niš (84.80 %). Unlike these, cities in Braničevo District have the lowest educational attainment – Malo Crniće (38.55 %), Žabari (43.38 %), and Petrovac na Mlavi (44.7 %).

The last indicator – population growth shows that population growth was detected in only four LGUs – Novi Pazar (126.75 %), Novi Sad (124.59 %), Tutin (111.13 %), and Belgrade (106.72 %). Unlike these, in the remaining 97% of LGUs population decline was detected, with the highest percentage detected in Crna Trava, with only 37.22 % of the population from 2002.

After all indicators calculated, the development index is calculated according earlier mentioned methodology. The geospatial distribution of LGUs according to the calculated Development Index is shown in Figure 3. It is clear the development progress of the LGUs, as in the lowest group are 13 LGUs, in the second, most number of the LGUs was detected – 62, in the third 42 and in the first group, in which development is above republic average, are 29 LGUs. Also, uneven territorial development of the Republic of Serbia is visible.

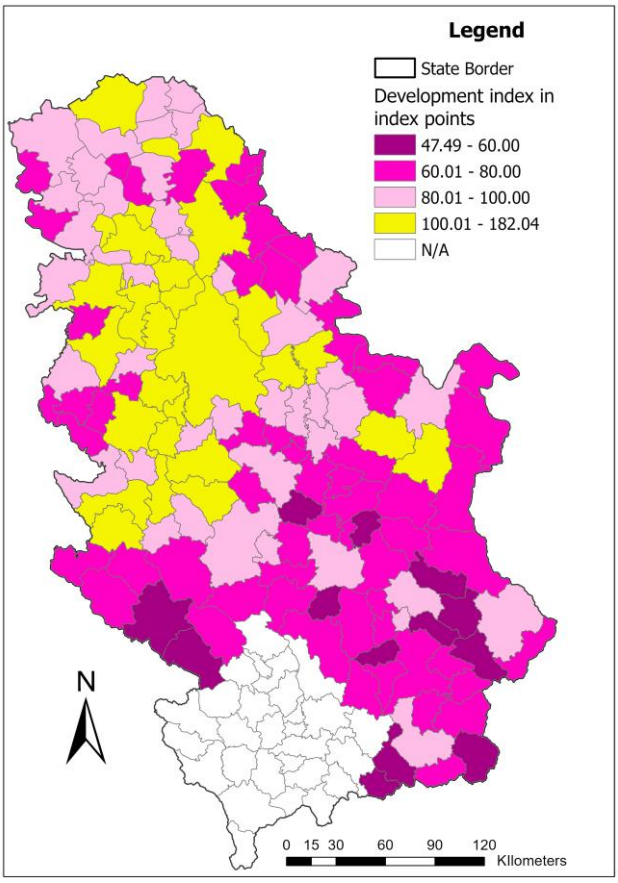


Figure 3. Development index for 2024 year according to publicly available SORS data.

The highest development index was detected in Stara Pazova with 182.04 index points (i.p.), which means that the development of this LGU is 82.04 % above republic average. Belgrade, as the largest city is in the second place with 158.92 i.p. followed by Novi Sad (154.6 i.p.). Niš, as the third largest city in the Republic of Serbia, with 98.62 i.p. belongs to the second development group. In the fourth, the lowest development group, three LGUs detected development index lower then 50 % of the republic average – Rekovac (47.49 i.p.), Bojnik (49.19 i.p.), and Sjenica (49.62 i.p.).

If these results are visually compared with the new methodologies proposed in [7], in which the authors identified two variants that, in terms of all structural performance indicators, provide the most realistic representation of the level of development of municipalities in the Republic of Serbia [7], it can be concluded that they yield broadly similar results with regard to the territorial distribution of the development index, although individual outcomes differ significantly. This is particularly evident in the case of Žagubica, which, according to this study, belongs to the first group of developed LGUs (108.77 i.p.), whereas in [7] it is classified within the fourth group, comprising devastated areas. Other LGUs do not exhibit such pronounced differences in the development index between this study and the results presented in [7].

In the context of the Republic of Serbia, the analysis indicates significant regional disparities. Although a well-developed legal and institutional framework for monitoring the level of development of LGUs exists [6], and [13], the continued application of a unified classification list from 2014 points to issues related to insufficient updating and the limitations of existing mechanisms, as also discussed in [7]. The results of this study, based on the most recent statistical data, confirm pronounced inequalities, particularly between the northern and southern parts of the country, furthermore that more than one-third of LGUs fall into the category of underdeveloped or devastated areas.

The assessment of local self-government development in Serbia, based on the official development methodology and the most recent statistical indicators, provides valuable insights into the spatial distribution of demographic, economic, infrastructural, and public service capacities across municipalities. The results of this research can significantly support the identification and prioritization of safe helicopter landing zones within the Project in the Military Geographical Institute “The use of geospatial data within a multicriteria analysis for the identification of safe helicopter landing zones in the territory of the Republic of Serbia”, as these development indicators may provide useful contextual information for future multicriteria analyses of transport accessibility, healthcare infrastructure, emergency response capacity, and public-space availability. Integrating development indicators with geospatial criteria may therefore contribute to a more efficient and equitable planning of helicopter landing networks, particularly in areas requiring rapid access to emergency medical and disaster response services.

Furthermore, these findings highlight the need to reform the methodological framework, as well as the necessity of introducing new indicators that would more adequately reflect contemporary social, economic, and demographic challenges. Furthermore, strengthening the role of local communities in the formulation of development policies is essential, in order to enable the inclusion of specific local resources and potentials.

4. CONCLUSION

The comparative analysis of the development index has shown that Serbia is still characterized by a high degree of inequality in the level of regional and LGU development, which significantly limits the possibilities for balanced and sustainable development. Although the existing institutional and legal mechanisms are well established in theory, in practice they are not sufficiently updated or adequately implemented, as reflected in the continued use of the 2014 Regulation. The data obtained in this study indicate the need to develop a new, up-to-date unified classification of LGU development levels, which would provide a more realistic representation of the current situation and serve as a basis for more effective regional policy planning.

In the future, it is necessary to design a model that would align the interests of local communities with national development strategies and introduce modern indicators that reflect the complexity of territorial development, as also proposed in the Study of the Republic of Serbia and its collaborators. Only through the integration of economic, social, and demographic dimensions, together with the active participation of all stakeholders, can a more equitable distribution of resources and a more balanced territorial development of the Republic of Serbia be achieved.

Acknowledgement

This study was supported by the project of the Ministry of Defence of the Republic of Serbia and the Serbian Armed Forces (Project No. 1.18-2026). Also, this study was supported by the Program of Cooperation with the Serbian Scientific Diaspora- Joint Research Projects – DIASPORA 2023, under the project LAMINATION (Project No: 17807). Furthermore, this study was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Grant No 451-03-33/2026-03/200125 & 451-03-34/2026-03/200125 and 451-03-33/2026-03/200091).

References

[1] W. J. Coffey and M. Polèse, “Local development: Conceptual bases and policy implications,” Regional Studies , vol. 19, no. 2, p. 85–93, 1985.

[2] W. Stöhr and D. R. F. Taylor, “Development from above or below? The dialectics of regional planning in developing countries,” WU Vienna University of Economics and Business, Vienna, vol. 2: Regional Development Alternatives: International Perspectives, pp. 9-27, 1981.

[3] A. Torre, “Territorial development: towards a dynamic and innovative understanding,” Regional Studies, vol. 59, no. 1, 2025.

[4] A. Torre, “Contribution to the theory of territorial development: a territorial innovations approach,” Regional Studies, vol. 59, no. 1, 2025.

[5] Petrović J, Radukić S, Radović M. Multicriteria analysis of the level of demographic development of regions in Serbia. Poslovna ekonomija. 2017;12(2). Serbian.

[6] Official Gazette of the Republic of Serbia. Law on Regional Development. Official Gazette of the Republic of Serbia. 2009;51/2009.

[7] Šećerov V, Filipović D, Čokorilo N, Tontić S, Šantić D, Bjelobrk G, Vračarević B, Jeftić M, Duškov Lj, Protić B. New model for measuring the level of development of local self-government units in the Republic of Serbia. Belgrade: Republic of Serbia, Cabinet of the Minister for Balanced Regional Development; University of Belgrade, Faculty of Geography; 2023. Serbian.

[8] Heyns B. Emerging inequalities in Central and Eastern Europe. Annu Rev Sociol. 2005;31:163-197. doi:10.1146/annurev.soc.30.012703.110637

[9] Statistical Office of the Republic of Serbia. Municipalities and regions in the Republic of Serbia. Belgrade: Statistical Office of the Republic of Serbia; 2022.

[10] Statistical Office of the Republic of Serbia. Municipalities and regions in the Republic of Serbia. Belgrade: Statistical Office of the Republic of Serbia; 2023.

[11] Statistical Office of the Republic of Serbia. Municipalities and regions in the Republic of Serbia. Belgrade: Statistical Office of the Republic of Serbia; 2024.

[12] Republic Geodetic Authority. GeoSerbia e-Services: Data download [Internet]. Available from: https://download.geosrbija.rs/download/login [cited 2025 Aug 8].

[13] Official Gazette of the Republic of Serbia. Decree on establishing the unified list of development levels of regions and local self-government units for 2014. Belgrade: Official Gazette of the Republic of Serbia; 2015.

[14] Republic of Serbia, Ministry of Finance, Tax Administration. Tax Informer: Annual personal income tax [Internet]. April 2025. Available from: https://purs.gov.rs/upload/media/2025/4/11/759560/Godisnji_porez_na_dohodak_gradjana.pdf [cited 2025 Sep].

[15] Statistical Office of the Republic of Serbia. 2022 Census of Population, Households and Dwellings: Data by municipalities and cities. Belgrade: Statistical Office of the Republic of Serbia; 2023.

[16] OpenPyXL Documentation, “OpenPyXL documentation. Read the Docs,” [Online]. Available: https://openpyxl.readthedocs.io/. [Accessed 2025].

[17] Esri, “What is ArcPy? In ArcGIS Pro documentation,” Esri, [Online]. Available: https://pro.arcgis.com/en/pro-app/arcpy/get-started/what-is-arcpy-.htm. [Accessed 2025].