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Urban vitality reflects the intensity and diversity of everyday urban activities and their spatial distribution, serving as a key indicator for planning and managing cities. In medium-sized, post-socialist cities, spatial disparities in vitality often remain underexplored due to limited data integration and analytical tools. This study examines urban vitality in Niš, one of Serbia's few medium-sized regional centres, using a spatial multi-criteria assessment that integrates socioeconomic, infrastructural, and spatial indicators. An entropy-TOPSIS multi-criteria model integrated with GIS was applied to determine the relative importance of indicators and derive a composite urban vitality index across sixty-nine settlements. The analysis

reveals pronounced intra-urban differences, highlighting areas of concentrated vitality as well as zones of relative functional and social weakness. Beyond mapping vitality, the study identifies key indicators that most strongly influence urban vitality and provides insights into monitoring and enhancing vitality in similar urban contexts. The findings provide a transparent, spatially explicit framework to support evidence-based planning, targeted regeneration, and follow-up qualitative or participatory assessments in medium-sized cities.

Keywords: urban vitality, GIS, multi-criteria assessment, post-socialist urban development, Niš

1 Introduction

Urban vitality refers to the intensity and diversity of human activities in urban spaces, reflecting interactions between spatial structure, functional mix, and socioeconomic dynamics. In urban planning and urban studies, vitality is closely associated with walkability, land-use diversity, accessibility, and the presence of active public spaces (Cardoso & Meijers, 2016; Istrate et al., 2020). Recent scholarship further conceptualizes urban vitality as an emergent, dynamic phenomenon shaped by temporal activity patterns, social interaction, and community engagement (Garau & Annunziata, 2022; Osunkoya & Partanen, 2024).

Urban vitality has been studied more in large metropolitan regions, whereas medium-sized and second-tier cities have been insufficiently explored despite their crucial role in regional development and territorial cohesion (Cardoso, 2016). Unlike large cities around the world, medium-sized cities often experience depopulation (Parkinson & Meegan, 2013). They also undergo functional mono-structuring following industrial restructuring (Berroir et al., 2019) and gradual centre devitalization (Chouraqui, 2021). These transformations often call for context-specific analytical approaches able to capture intra-urban disparities rather than relying solely on aggregate city-level indicators.

European research highlights several spatial dimensions of vitality. Functional density and mixed land use have been shown to strengthen everyday urban activity (Istrate et al., 2020). Socioeconomic diversity and connectivity contribute to resilient local economies (Gao et al., 2024). Moreover, cultural initiatives (Kara et al., 2025) and culture-led regeneration programs (Tzatzadaki, 2024) are useful tools for enhancing urban identity and social cohesion, particularly in second-tier cities (Błaszczuk & Krysiński, 2023).

In post-socialist cities, institutional transformation and economic restructuring have shaped urban spatial dynamics (Cvetinović et al., 2016). Fragmented planning systems and uneven development patterns have contributed to disparities between central and peripheral areas (Stojić & Timotijević, 2024). Urban planning in Serbia often fails to address structural inequalities (Petrović, 2009), remaining detached from the specific needs of peripheral and sub-municipal zones (Vujošević et al., 2012). Research on major cities such as Belgrade, Novi Sad, and Niš identifies demographic change, migration, and infrastructural inequality as important drivers of spatial differentiation (Antonić, 2024; Šantić & Đorđević, 2023). Integrating cultural initiatives, participatory governance (Nedučin & Krklješ, 2022), and infrastructure quality (Đorđević et al.,

2023) is increasingly highlighted as a pathway to maintain vibrant and inclusive urban spaces (Protić et al., 2020). Nevertheless, systematic, fine-grained spatial assessments of urban vitality at the sub-municipal level remain limited.

Methodologically, European studies increasingly combine spatial statistics (Gao et al., 2024), GIS modelling, big data (Osunkoya & Partanen, 2024), and spatial analysis (Galaktionova & Istrate, 2025) to capture both static and temporal dimensions of urban vitality. On the other hand, although multicriteria decision-making (MCDM) methods, due to their robustness, are increasingly employed to integrate heterogeneous indicator datasets (Ali et al., 2023; Ginting et al., 2017), they are less present in this domain. Such approaches can allow the identification of intra-urban variability and provide transparent support for evidence-based planning. However, they are rarely applied in medium-sized post-socialist cities, particularly in Serbia.

This study focuses on Niš, Serbia, a representative second-tier city with a compact urban core, a mixed urban–rural administrative structure, and pronounced spatial disparities. Using entropy-based weighting and the TOPSIS method coupled with GIS, the research develops a composite vitality index for a fine-grained understanding of intra-urban differences. The study offers a spatially explicit and transferable MCDM model tailored to medium-sized cities and, by identifying the indicators with the greatest differentiating capacity at the urban level, it supports evidence-based planning beyond municipal aggregates. It addresses the following research question: How can a hybrid GIS–MCDM model be effectively applied to evaluate urban vitality by assessing various levels of urban vitality at the sub-municipal level using data from publicly managed infrastructure assets, environmental resources, and social facilities?

To address this primary question, the study explores the following sub-questions: 1) To what extent can this GIS-based entropy–TOPSIS model serve as a replicable tool for evidence-based planning in other regional centres with limited data integration? 2) How is the vitality disparity spatially manifested? and 3) Which indicators carry the highest weights that can strongly impact vitality index results?

2 Literature review

Urban researchers have highlighted the spatial dimension as a main factor determining urban vitality. For instance, Cardoso and Meijers (2016) reported that urban areas experience greater daily activity when accessibility and land-use diversity, together with density, reach optimal levels. Findings from

multiple European cities show that pedestrian traffic and socioeconomic connections increase when cities have functional density combined with mixed-use development (Istrate et al., 2020). On the other hand, Gao et al. (2024) employed GIS-based spatial metrics to show that medium-sized urban areas experience higher vitality levels when their land uses show more diversity and their street networks provide better access to different areas. Furthermore, Liu et al. (2023) demonstrated that, in medium-sized contexts, fine-grained analysis of spatial environmental data is essential to uncover the “sub-municipal” realities of urban vitality. Osunkoya and Partanen (2024) combined spatial data with activity patterns by analysing mobile phone data and reported that vitality levels depend on mobility patterns and access to services. A study by Garau and Annunziata (2022) demonstrated that compact urban areas with proximity to public amenities foster both tangible and perceived vitality among their inhabitants. These findings indicate that a single infrastructure indicator cannot adequately capture vitality; instead, a multidimensional evaluation is necessary.

Considering medium-sized and second-tier cities, European spatial policy discussions have started to recognize their rising significance in their development plans. Cardoso (2016) argued that such cities play a stabilizing role in regional systems, despite lacking the global competitiveness of metropolitan centres. However, several important factors affect their vitality. Parkinson and Meegan (2013) identified demographic decline as a common trend in post-industrial second-tier cities. Berroir et al. (2019) showed how functional mono-structuring as a consequence of the industrial restructuring of cities reduces urban diversity and weakens local resilience. Chouraqui (2021) demonstrated that suburbanization, with its limited service node development, is the root cause of the decline in central areas. Studies have also reported that culture-led regeneration initiatives have potential as a community revitalization method. Kara et al. (2025) examined the impact of European Capital of Culture initiatives on urban identity and local economic dynamics. Tzatzadaki (2024) found that cultural programming can stimulate social cohesion when embedded in long-term governance frameworks. However, Błaszczyk and Krysiński (2023) warned that the outcomes from such projects depend on their specific environment, resulting in different effects across different areas. There is an evident incline in research toward larger cities; thus, there is a limited understanding of vitality in a wider spectrum of European cities.

Research on post-socialist cities recognizes three main factors that affect their urban vitality: institutional changes, privatization, and alterations to governing systems. Cvetinović et al. (2016) argued that deregulation and fragmented planning practices largely influenced uneven urban development patterns in Serbia. Stojić and Timotijević (2024) showed that

peripheral settlements often experience infrastructural deficits compared to central zones. Serbian scholarship provides additional context. For instance, Antonić et al. (2024) reported that demographic changes in major Serbian cities mainly result from migration and aging. On the other hand, Šantić and Đorđević (2023) showed that infrastructure distribution creates persistent uneven development patterns between different areas. Protić et al. (2020) and Nedučin & Krklješ (2022) argued that improved accessibility to public areas positively affects their use, which leads to increased urban activities. The research conducted in Serbia primarily focuses on single aspects of urban sustainability and vibrancy, and lacks attempts at integrated vitality analysis. Due to the regional differences in post-socialist urban transformations, mapping urban vitality in Serbian cities requires a context-sensitive framework.

Urban vitality is examined using various methodologies. For instance, Osunkoya and Partanen (2024) combined traditional metrics with mobile phone data through GIS analysis to understand how urban diversity and socioeconomic features correlate with vitality. Gao et al. (2024) employed data such as nighttime light, housing prices, social media, points of interest (POIs), and NDVI data to measure various aspects of urban vibrancy using the Geodetector and geographically weighted regression models. Galaktionova and Istrate (2025) assessed street vitality by using functional density as a proxy, which was derived from OpenStreetMap (OSM) data and analysed through a spatial lag regression model. Lopes and Camanho (2013) used data envelopment analysis to understand how public green spaces contribute to urban vitality. Garau and Annunziata (2022) combined space syntax and GIS to understand how urban form components impact vitality potential.

Despite the different methodological approaches, challenges related to data alignment and resolution discrepancies persist. There is also variability in data availability, applied technology, and level of analysis. Some studies focus on a fine-grained local scale, and others consider a broader, metropolitan scale. Furthermore, the use of aggregated data sources (such as mobile phone data or POI datasets) may oversimplify contextual information.

Several significant challenges are identified in the literature reviewed, such as the multidimensional nature of urban vitality, which challenges “one size fits all” urban theories and supports context-specific frameworks for urban vitality analysis, the distinct structural challenges affecting urban vitality in medium-sized and post-socialist cities, and the dearth of studies using MCDM in this setting.

As a result, this study contributes by operationalizing a spatial MCDM-GIS model tailored to a medium-sized post-social-

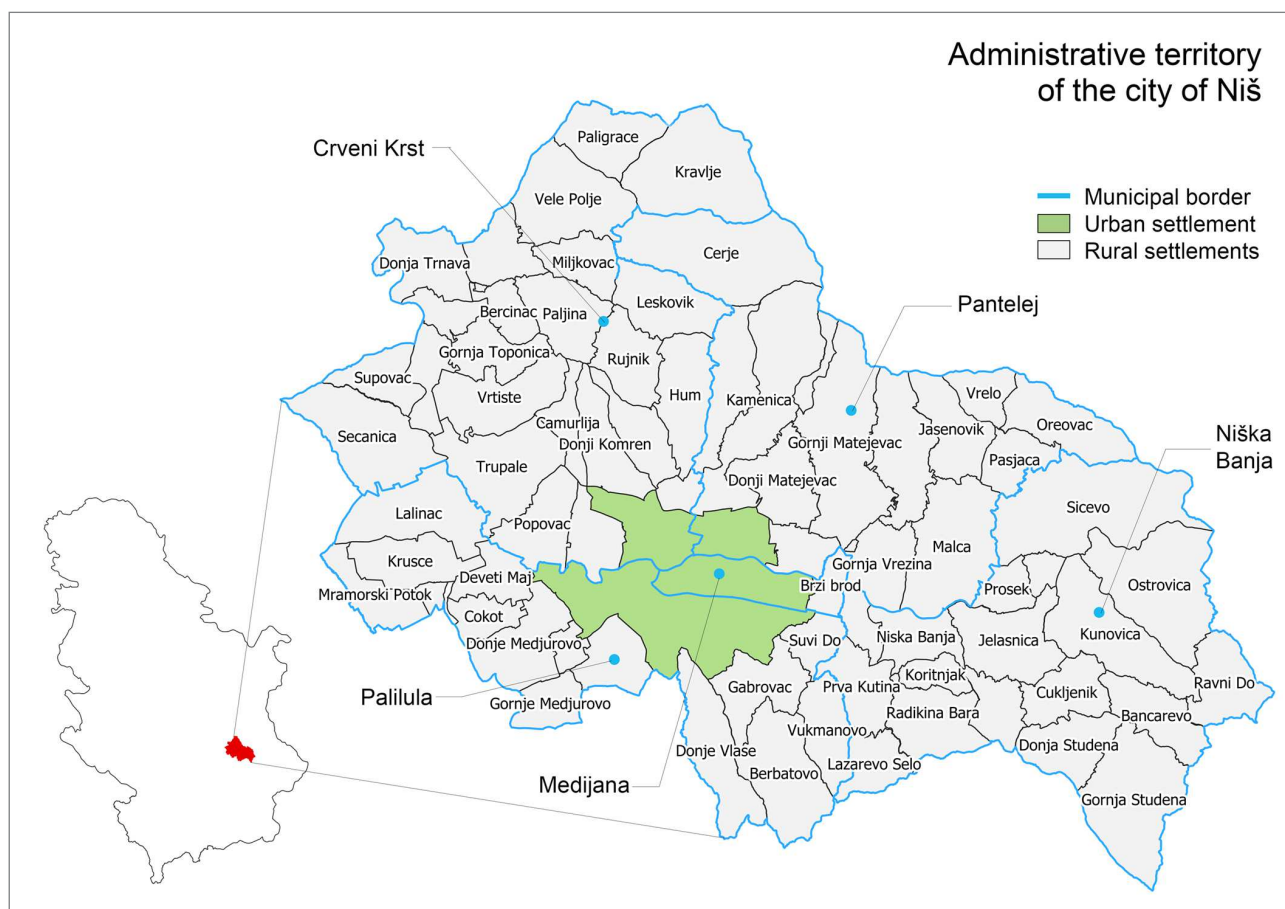


Figure 1: Study area.

ist city and by providing a transparent ranking of settlements based on publicly governed infrastructural, environmental, and social assets, expanding the scope of commonly used determinants of urban vitality (such as spatial diversity, mixed land uses, urban density, and so on).

3 Methodology

3.1 Study area

Niš was chosen as an illustrative case of a medium-sized Serbian city facing spatial disparities and functional challenges. As one of the few urban centres outside the capital region with a strong regional role, Niš serves as an administrative, economic, and educational hub for southern Serbia while showing marked differences in accessibility, land use, and socioeconomic activity between central and peripheral areas (Figure 1). Its compact urban structure, combined with areas of both decline and emerging development, makes Niš suitable for examining how different characteristics influence vitality. Since 2004, Niš has been administratively divided into five municipalities. These municipalities have diverse spatial, demographic, and

functional characteristics. For instance, the municipality of Medijana, although the smallest (16 km²), is the most densely populated, with 82,360 residents. In contrast, Niška Banja, the largest in area, is predominantly rural and features the lowest population density. Differences in urban development levels, infrastructure provision, and access to services combined with the coexistence of urban and rural lifestyles generate divergent quality-of-life outcomes. Demographic disparities further reinforce this fragmentation: some settlements have an average age as low as thirty-eight, and others as high as sixty-nine. These spatial and demographic differences necessitate detailed sub-municipal analysis. The presence of sixty-nine rural settlements within the five city municipalities emphasizes the limitations of using the municipal scale as the primary unit of urban analysis. Therefore, these settlements are considered as study units because they lack sufficient data and are frequently excluded from conventional planning processes.

3.2 Indicators

The indicators used for this study primarily focus on physical resources and important infrastructure under the municipal government. Although privately owned facilities, such as gro-

cery stores or banks, contribute to daily life and urban vitality, their presence is market-dependent and reflects commercial decisions rather than public-sector support, and so they are not included on the indicator list. The final list of indicators was developed in accordance with relevant literature and following an extensive field investigation, which included an inventory of all infrastructure elements (e.g., roads, schools, and sport facilities) and resources (e.g., watercourses, forests, and caves). The indicators are classified according to five criteria briefly outlined below.

1. Geographical location, natural potential, and environmental protection

- Proximity to the city centre indicates accessibility to diverse economic opportunities, public services, cultural amenities, and transportation infrastructure. According to Jacobs (1961), the quality of urban life depends on dense mixed-use urban environments that provide better closeness and social networks, and where everyday activities are close together. Montgomery (1998) supported this, stating that urban vitality diminishes with distance from the urban core.
- Proximity to watercourses offers ecosystem services such as provisions for agriculture, natural flood regulation, and recreational values, which MEA (2005) recognized as essential for long-term local development.
- Proximity to forests reflects potential for eco-tourism, sustainable resource use, recreation, improved microclimate, and overall well-being (Tzoulas et al., 2007).
- Protected natural areas function as part of a green infrastructure network linking environmental conservation with community well-being and supporting local livelihoods through regulated low-impact activities such as eco-tourism, speleology, or collecting herbs, allowing an economy in line with long-term ecological preservation (MEA, 2005).
- Geological resources include features such as caves, thermal springs, and spas, which support tourism, small business development, sports, and recreation (Farsani et al., 2011).

2. Infrastructure and communications

- Types of access roads from the city centre, roads within the settlement, and accessibility to public transportation are indicators of physical connectivity, economic potential, emergency response, and community integration (Litman, 2021).
- Frequency of organized public transport.
- Presence of petrol stations refers to the spatial proximity of these to agricultural and residential clusters, cutting transport costs, and ensuring farmers have the fuel they need close by. This can support infrastructure integration,

economic vitality, and support for tourism and logistics.

- Presence of a post office indicates developed communication infrastructure, access to financial and logistical services, and information dissemination, which is especially important in rural areas (Castells, 2010). It is an important physical gateway for e-commerce, providing the “last mile” logistical link needed for community integration in rural or remote areas.
- Mobile network coverage serves as the fundamental digital system allowing suburban areas to develop into connected economic centres through the provision of final data transmission and communication services while also supporting the social and cultural activities that drive suburban community life.

3. Healthcare

Niš's suburban settlements are already experiencing demographic decline. Most of these settlements lack access to healthcare facilities. Thus, the following two indicators can contribute to local vitality:

- Access to primary healthcare facilities.
- Access to pharmacies.

4. Education

- Access to educational institutions: a lack of primary schools causes families to migrate toward the city. Thus, a primary school in a settlement reflects a capacity to retain residents.

5. Social development

- Number of public outdoor sports fields and recreational facilities, and sports clubs: such facilities are “bonding” spaces (Putnam, 2000), essential for creating trust and cooperation. Sports fields and sport clubs are a proxy for healthy and multigenerational demographics, and a base for social interaction and community well-being.
- Number of cultural institutions and local events refers to cultural festivals and creative hubs, mainly in the urban core of Niš, that draw the younger generation out from metropolitan edges. This creates stagnant areas of peripheral community, dull and without the social vibrancy and institutional “glue” that Florida (2002) proposed as a requirement for maintaining a productive long-term multi-generational population.
- Number of religious buildings reflects the potential for social cohesion, community inclusion, and opportunities for volunteerism and civic participation. A diversity of religious institutions may also suggest cultural tolerance and pluralism (Putnam & Campbell, 2010).

3.3 Scoring method and data sources

Class boundaries were established by considering both accepted norms and empirical evidence. We utilized the walkability thresholds established by UN-Habitat (2018) to determine distance-based measures. For indicators with established classifications, such as mobile network coverage and road categories, the corresponding institutional categories were utilized. For the remaining indicators, the complete dataset was analysed and classes that accurately reflected the distribution of values were established. For instance, if the inventory showed that the maximum number of geological resources within the settlement boundary is more than three, we assigned three classes to this indicator (see Table 1); if the maximum number of schools in all settlements is 1, we assigned binary classes. The scoring system was thus both evidence-based and aligned with current planning and regulatory frameworks. Consequently, the scoring system may accurately represent actual differences and respond to minor variations within communities while adhering to a four-point or binary rating framework. The settlement boundaries (SB) were taken into account when evaluating indicators.

The values of the four-point scale are 3 = significant potential for local development, 2 = moderate potential, 1 = weak potential, 0 = absent. Scoring is based on data collected from publicly available sources, institutional records, field visits, and planning documentation, ensuring a comprehensive and reliable data foundation (Vranić et al., 2026a).

3.4 Prioritization methodology

The objective of applying the multi-criteria method was to rank local communities according to predetermined criteria to assess their vitality. Shannon's entropy method was used to calculate the weight values of the criteria and determine the weight coefficients. The term *entropy* denotes disorder and uniformity in a data set (Shannon, 1948). The relationship between the entropy value and weight coefficient is inverse (Zakeri et al., 2025): criteria with a higher entropy value have low coefficients and vice versa (Ali et al., 2023). Criteria with a minimum difference between their values have a higher entropy value because the data are uniformly distributed and provide limited information. In contrast, criteria with a greater difference between individual values provide a variety

Table 1: Indicator values and rationale.

Indicator	Data source, method	Rating
1. Geographical location, natural potential and environmental protection		
Proximity to the city centre	Calculation of isochrones with QGIS TravelTime plugin using centre of settlement as origin point, city centre as destination point	3: < 10 min drive to city centre 2: 10–20 min 1: 20–30 min
Proximity to watercourse	Calculation of Euclidean distance from centre of settlement to closest watercourse/forest using buffer tool in QGIS	3: 5 min walk 2: 10 min
Proximity to forests		1: 15 min
Protected natural areas	Environment Protection Institute of Serbia data applying spatial overlay	1: Protected area present within SB 0: Does not exist
Geological resources	OSM data	3: three or more geological sites are present within SB 2: two 1: one 0: none
2. Infrastructure and communication		
Types of access roads from the city centre	Public utility Co. "Directorate for Construction of the City of Niš" and OSM data, applying zonal statistics in QGIS. Due to data limitations on road quality, analysis focused only on road hierarchy.	3: The settlement is accessible via primary roads 2: via secondary roads 1: via tertiary roads
Types of roads within settlement		3: road network of mostly primary roads 2: secondary roads 1: tertiary roads

Accessibility to public transportation	Analysis of "Directorate for Public Transport of Niš and Serbian Railways data applying zonal statistics in QGIS	2: more than one type of transport available 1: one 0: none
Frequency of organized public transport*		3: high 2: medium 1: low
Presence of petrol stations	OSM and Google Earth data	1: present within SB 0: none
Presence of a post office	Post of Serbia, Google Earth, and field study data	1: present 0: none
Mobile network coverage**	GIS analysis of regulatory authority for Electronic Communications and Postal Services (RATEL) data	3: mostly good/excellent coverage 2: satisfactory to good/excellent 1: satisfactory for $\geq 80\%$
3. Healthcare		
Access to primary healthcare facilities	Voronoi diagram in QGIS based on health centre data	3: health centre present within SB 2: shared with one settlement 1: serves several settlements
Access to pharmacies	Voronoi diagram in QGIS based on Google Earth data and online data	3: pharmacy present within SB 2: shared with one settlement 1: serves several settlements
4. Education		
Access to educational institutions	School administration, Google Earth, and field study data	1: primary school present within SB 0: none
5. Social development		
Number of public outdoor sports fields and recreational facilities,	OSM, Google Earth, and field study data	2: two or more facilities within SB 1: one 0: none
Number of cultural institutions		1: institution present 0: none
Number of religious buildings	Google Earth, Diocese of Niš, and field study data	1: religious building is present within SB 0: none
Number of local events	Local tourist organization data	2: more than one event annually 1: one 0: none
Number of registered sports clubs	Local sports federation data	2: more than one club 1: one 0: none

*Based on the number of departures to each municipality per workday. The final number was standardized to a range of 0–1 using the min–max approach, with 0 being the least frequency and 1 the most. For uniformity of evaluation, the normalized range was divided into three frequency groups.

**The signal area for the three national operators was compared to the total area of the settlement using the Regulatory Authority for Electronic Communications and Postal Services (RATEL) classification levels: excellent (expected very good connection), good (expected good connection), and satisfactory (expected acceptable connection with interruptions). The final grade was determined by averaging the scores of all three operators based on signal dominance: 3 = combined territory of excellent/good signal exceeds satisfactory signal area, 2 = satisfactory signal area exceeds combined excellent/good signal coverage, 1 = satisfactory signal level covers more than 80% of the territory.

of information for ranking, the degree of entropy is lower, and their weight value is greater (Chen, 2020). Criteria with lower entropy can contribute to the observation of differences among local communities because they imply variability in the data and facilitate ranking. Applying this method seeks to avoid subjectivity in the ranking process. The TOPSIS method then combined the weighted indicators into a composite urban vitality index, ranking settlements by how close they are to an “ideal” high-vitality scenario and how far from the “least desirable” scenario. More information about each method can be found in the Vranić et al., (2026b).

4 Results

4.1 Indicators

The spatial distribution of indicators is presented in Figure 2. For proximity to the city centre, isochrone maps were generated to estimate travel times to the city center of Niš under optimal driving conditions by car (excluding rush hour), measured from the settlement center. Fifty per cent of settlements lie within the third zone (20–30 minutes), 47.1% in the second zone (10–20 minutes), and only two within ten minutes. Several settlements fall on isochrone boundaries. Sixty per cent are in the second zone, indicating most residents drive eighteen to twenty minutes to the city centre (Figure 2a). Residents generally walk five to fifteen minutes (400–1,200 m) to the nearest watercourse (51.4% are within 400 m, 18.6% within 400–800 m, 15.7% within 800–1,200 m, and 14.3% beyond 1,200 m; Figure 2b). Proximity to forest area considered the distance between the centre of the settlement and the closest forest; 58.6% of residents live near forests: 19% within five to ten minutes walking, 14% within fifteen minutes (800–1,200 m), and 8% within five minutes. The remaining 41.4% are over 1,200 meters away (Figure 2c). Protected areas cover 10.4% of the study area, mainly in the east. Thirteen of sixty-nine settlements are partially or fully within nature parks and reserves such as the Sicevo Gorge and Mount Suva (Figure 2d). Only seven settlements (10.1%) have geological resources within their boundaries. Some even have thermal springs and caves with national or international significance, such as Cerje and Pešturina caves (Figure 2e). Regarding types of access roads from the city centre and roads within the settlement, 10% of settlements are accessible from the city centre only via tertiary roads, 29% via secondary roads, and 61% via primary roads. Within settlements, 31% rely on tertiary roads, 33% on secondary roads, and 6% on primary roads (Figure 2f).

Approximately 80% of settlements have organized public transport, mostly buses; 11.4% also have rail service. If accessible neighbouring areas are included, rail access rises to 35.7%. Four percent of settlements lack organized transport entirely (Figure 2a). In terms of frequency of public transport, 12.9% have the highest frequency (0.69–1.0), 12.9% medium (0.31–0.53), and 74.2% low (up to 0.30), decreasing with distance from the city centre (Figure 2b). The spatial distribution of petrol stations corresponds to the expected directions of the main highways and access roads. Along these, petrol stations are present in 14.2% of settlements. Including neighbouring settlements that can be driven to in ten minutes or less, an additional 41.4% of settlements are direct users of this resource. The number of post offices decreases with distance from the centre of Niš, but coverage remains good, at 49% overall. Including settlements bordering those with post offices, the coverage increases to 95.7% of the population. There is great spatial variation in mobile network signal quality for local communities: 19.4% of settlements have very good to excellent signal coverage (≥ 2.7), with acceptable mobile access for digital services, online communication, and smart infrastructure. However, 23.6% of settlements are in the poor to very poor range (≤ 1.3), meaning that direct, good mobile signal coverage exists only 19.4% of the local settlements.

Primary schools are present in half of the settlements; 28.5% are branch schools. The remainder lack primary schools, requiring residents to attend school in nearby settlements. Voronoi diagrams showed half the settlements share a health centre with two or more others, 37.6% share with three or more, 14.3% share with only one other, and 35.7% have their own. Pharmacy coverage is slightly lower than that of healthcare facilities and diminishes with distance from the centre of Niš: 87.1% of settlements share a pharmacy with two or more others, and 64.3% with four or more settlements. Only 12.9% of settlements have their own pharmacy, and 4.3% share with one other. Regarding sports and recreational facilities, 11.4% of settlements lack facilities, 51.4% have at least one, and 37.2% have two or more. Cultural institutions are absent in 88.6% of settlements, and 11.4% have at least one. Among religious buildings and cultural institutions, Orthodox monasteries and churches dominate, although activity data are limited. Half the settlements lack religious buildings, 40% have one, and 10% have multiple. Most communities (85.7%) do not host cultural, sports, or traditional events, 5.8% hold one or two, and 8.6% host more than two. Regarding sports clubs, 35.7% of settlements lack these, 57.1% have one, and 5.7% have two or more.

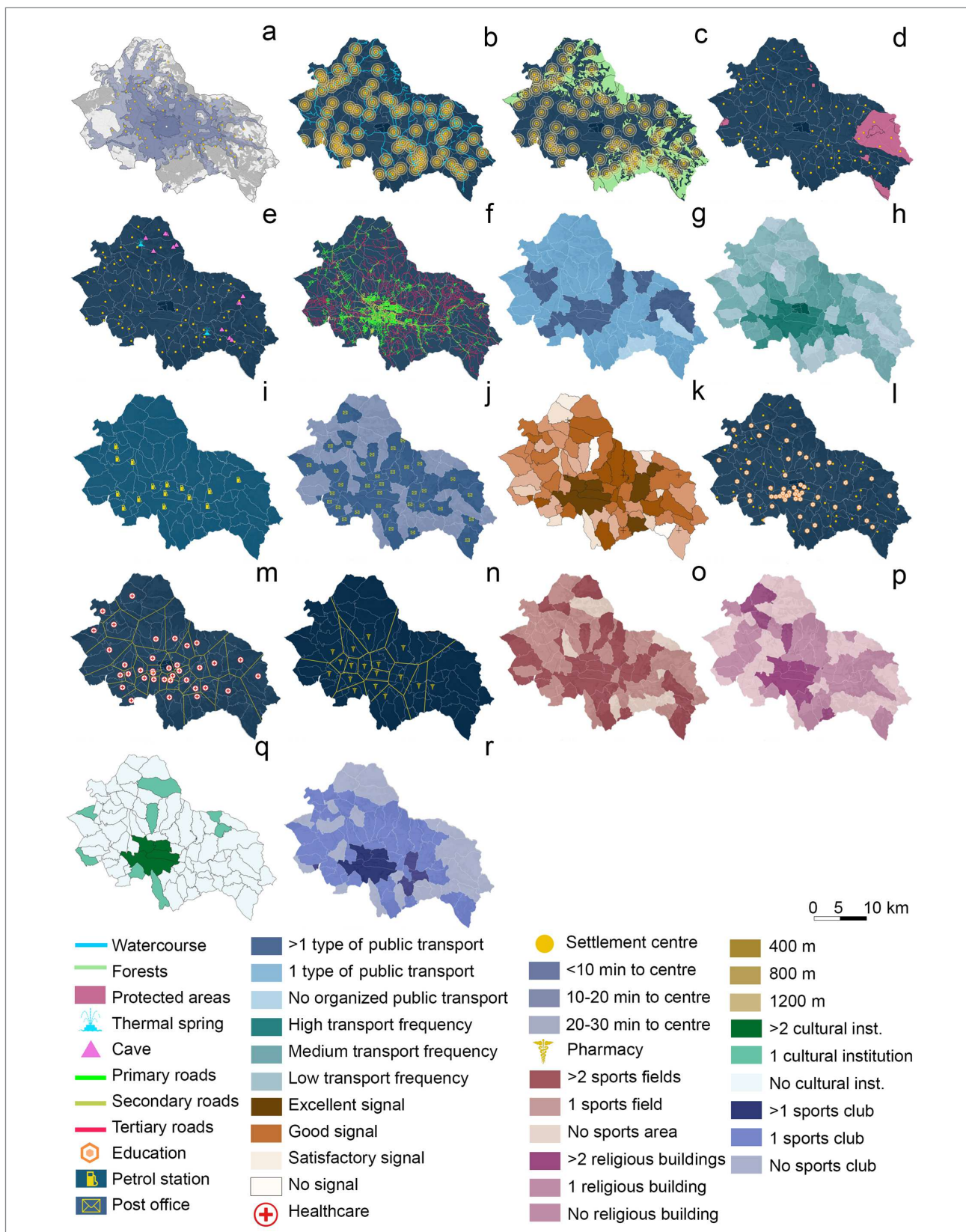


Figure 2: a) proximity to the city centre, b) proximity to watercourses, c) proximity to forests, d) protected natural areas, e) geological resources, f) types of roads within the settlement and types of roads leading there, g) accessibility to public transportation, h) frequency of organized public transport, i) presence of petrol stations, j) presence of a post office, k) mobile network coverage, l) access to educational institutions, m) primary healthcare facilities, n) access to pharmacies, o) number of public outdoor sports fields and recreational facilities, p) number of religious buildings, q) number of cultural institutions, and r) number of sports clubs.

Table 2: Objective weight coefficients by Shannon's entropy method.

Criteria	Indicator	Weight coefficient
Geographical location, natural potential and environmental protection	Proximity to the city centre	0.004
	Proximity to watercourse	0.012
	Proximity to forests	0.035
	Protected natural areas	0.096
	Geological resources	0.136
Infrastructure and communication	Types of access roads from the city centre	0.002
	Types of roads within the settlement	0.006
	Accessibility to public transportation	0.006
	Frequency of organized public transport	0.020
	Presence of petrol stations	0.111
	Presence of post office	0.048
	Mobile network coverage	0.006
Healthcare	Access to primary healthcare facilities	0.006
	Access to pharmacies	0.101
Education	Access to educational institutions	0.040
Social development	Number of public outdoor sports fields and recreational facilities	0.010
	Number of cultural institutions	0.124
	Number of religious buildings	0.042
	Number of local events	0.139
	Number of registered sports clubs	0.054

4.2 Weights and ranks

The applied entropy method highlights the indicators' relative importance through weight coefficients (Table 2). A higher weight coefficient means that the observed indicator has a high impact on the vitality index ranking, and a low weight coefficient mean that that the indicator has limited impact. The highest-weighted indicators are the number of events (0.139), geological resources (0.136), and cultural institutions (0.124). Along with indicators such as pharmacies (0.101) and petrol stations (0.111), these have the highest influence on the vitality ranking. Their determined entropy is lower, and the data make it possible to differentiate settlements, which is important for developing the vitality index. On the other hand, the indicators with the lowest weight, such as road hierarchy (0.002), proximity to the city centre (0.004), and primary healthcare access (0.006), were not very influential for differentiation. Their entropy is higher because the criteria values are homogenous

and do not distinguish settlements. This does not imply that these indicators are irrelevant; rather, their relatively uniform distribution or limited variability across settlements reduces their ability to shape overall vitality ranking. These outcomes indicate that, although basic infrastructure is important, Niš is mainly defined in terms of culture, ecology, and community-based assets.

The TOPSIS ranking results in Table 3 show discrepancy among the settlements: Malča ($C_i = 0.690$) and Nikola Tesla ($C_i = 0.622$) lead, whereas Berčinac, Rujnik, and Manastir stand at the bottom because they differ only minimally from the most negative solution. Based on natural breaks and considering the complete vitality ratings (from 0.690 to 0.017), three vitality categories can be recognized: 1) the high-vitality tier, with only 7% of settlements that attain a score over 0.400;

Table 3: TOPSIS prioritization list.

Name	S_i^+	S_i^-	C_i	Rank
Bancarevo	0.019	0.006	0.233	31
Berbatovo	0.019	0.010	0.345	13
Berčinac	0.019	0.000	0.017	70
Brenica	0.019	0.004	0.187	39
Brzi Brod	0.017	0.009	0.358	12
Bubanj	0.019	0.001	0.052	63
Čamurlija	0.018	0.002	0.109	54
Cerje	0.017	0.003	0.142	47
Čokot	0.019	0.009	0.315	18
Čukljenik	0.020	0.006	0.232	33
Deveti Maj	0.017	0.004	0.179	43
Donja Studena	0.019	0.011	0.365	9
Donja Toponica	0.019	0.010	0.345	14
Donja Trnava	0.012	0.005	0.299	22
Donja Vrežina	0.018	0.003	0.146	46
Donje Medjurovo	0.018	0.005	0.217	36
Donje Vlase	0.018	0.011	0.374	8
Donji Komren	0.014	0.010	0.405	6
Donji Matejevac	0.019	0.001	0.028	67
Gabrovac	0.018	0.008	0.315	19
Gornja Studena	0.018	0.010	0.340	16
Gornja Toponica	0.016	0.001	0.049	65
Gornja Trnava	0.019	0.001	0.059	61
Gornja Vrežina	0.019	0.001	0.057	62
Gornje Medjurovo	0.019	0.007	0.271	26
Gornji Komren	0.020	0.001	0.051	64
Gornji Matejevac	0.018	0.002	0.098	55
Hum	0.015	0.011	0.415	5
Jasenovik	0.019	0.007	0.275	24
Jelašnica	0.019	0.007	0.287	23
Kamenica	0.019	0.003	0.140	48
Knez Selo	0.019	0.008	0.302	21
Koritnjak	0.019	0.007	0.270	27
Kravlje	0.019	0.007	0.262	28
Krušce	0.020	0.004	0.184	41
Kunovica	0.020	0.004	0.184	42
Lalinac	0.019	0.003	0.139	49
Lazarevo Selo	0.018	0.005	0.230	34
Leskovik	0.014	0.003	0.191	38
Malča	0.007	0.015	0.690	1
Manastir	0.019	0.000	0.023	68
Medoševac	0.014	0.008	0.363	10
Mezgraja	0.018	0.002	0.083	57
Miljkovac	0.019	0.005	0.219	35

Name	S_i^+	S_i^-	C_i	Rank
Mramor	0.019	0.001	0.042	66
Mramorski Potok	0.017	0.002	0.118	51
Nikola Tesla	0.010	0.017	0.622	2
Niška Banja	0.009	0.006	0.384	7
Oreovac	0.016	0.002	0.112	53
Ostrovica	0.019	0.002	0.083	58
Paligrace	0.016	0.008	0.344	15
Paljina	0.019	0.002	0.093	56
Pasi Poljana	0.016	0.007	0.314	20
Pasjača	0.017	0.009	0.360	11
Popovac	0.018	0.003	0.130	50
Prosek	0.019	0.007	0.274	25
Prva Kutina	0.019	0.005	0.202	37
Radikina Bara	0.019	0.002	0.080	60
Rautovo	0.019	0.004	0.186	40
Ravni Do	0.015	0.012	0.436	4
Rujnik	0.019	0.000	0.022	69
Sečanica	0.016	0.008	0.324	17
Sičevo	0.017	0.004	0.175	44
Supovac	0.017	0.002	0.116	52
Suvi Do	0.020	0.006	0.233	30
Trupale	0.013	0.011	0.449	3
Vele Polje	0.019	0.006	0.243	29
Vrelo	0.017	0.003	0.147	45
Vrtište	0.018	0.002	0.081	59
Vukmanovo	0.019	0.006	0.233	32

2) the predominant middle tier, with 68% of settlements with values between 0.100 and 0.399; and 3) the low-vitality tier, with 25% of settlements with vitality ratings below 0.100. Niška Banja and Donje Vlase are as the closest to advancing to higher vitality status, and Čamurlija and Oreovac are the closest to dropping to lower vitality status. In the higher vitality group, Komren is at risk of becoming a member of the medium vitality group if conditions change. The spatial distribution of vitality rankings in Figure 3 reveals significant variances within the administrative boundaries of Niš, without a distinct centrality pattern, indicating that proximity to the city centre is not directly related to improved vitality.

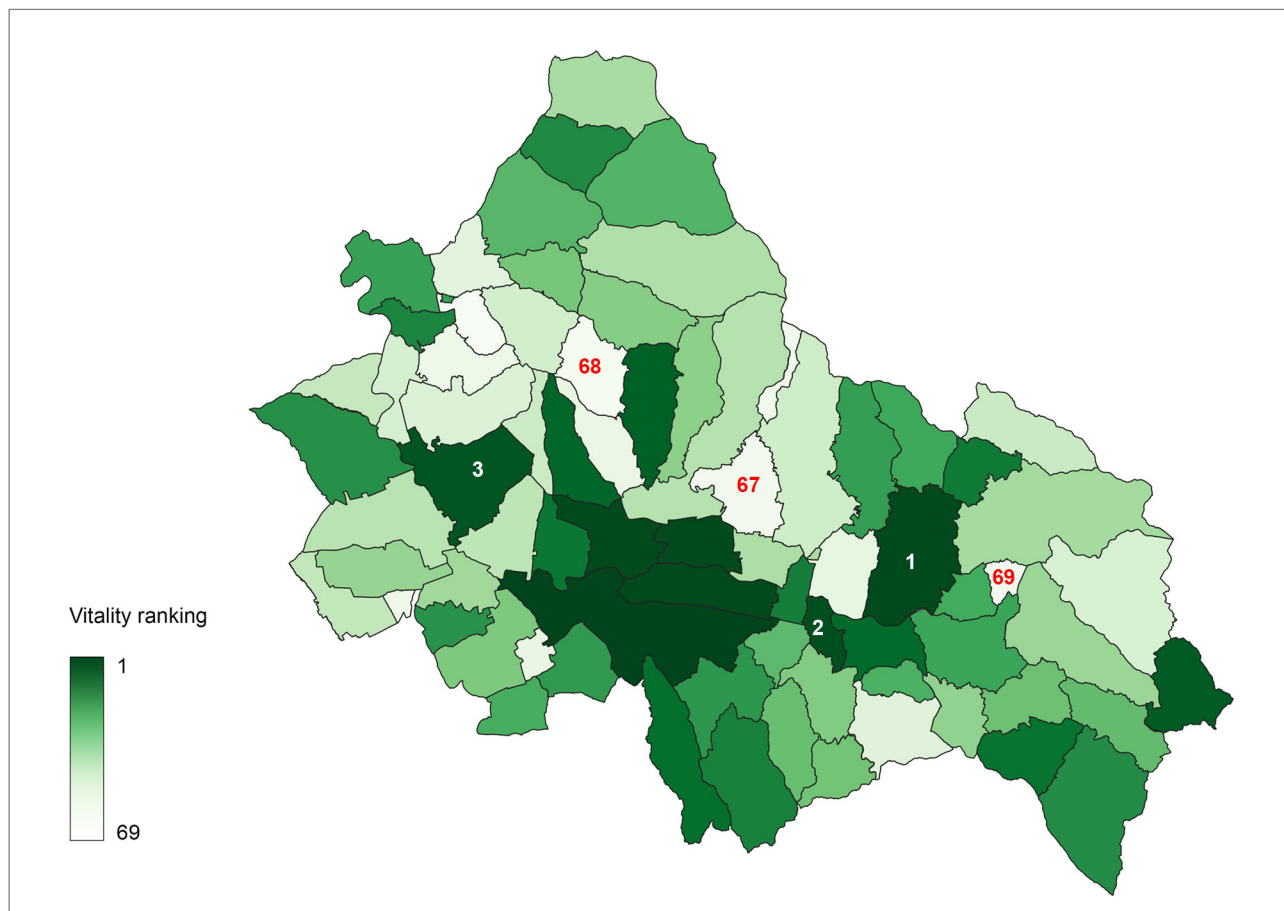


Figure 3: Visual representation of the vitality index (source: authors).

5 Discussion

5.1 Interpretation of findings

This research has developed a spatially explicit hybrid MCDM model to assess urban vitality at the sub-municipal level. It was initially tested and validated in Niš, Serbia. In line with the first research sub-question, by merging entropy-based weighting with TOPSIS methodology, a composite vitality index sought to capture disparities among five key dimensions: geography and natural assets, infrastructure and communications, health-care, education, and social development. The model can serve as a highly replicable tool by using public indicators that can be easily mapped in any urban area. It is suitable for identification of spatial disparity with use of basic data requirements while creating a clear evidence-based foundation for planning in data-scarce post-socialist regions.

The findings demonstrate a significant gap in settlements' capacity to foster vitality, primarily in terms of accessible physical infrastructure and resources. In spatial terms, and in line with the second research sub-question, the analysis showed no

connection between proximity to the city centre and vitality. Instead of a monotonic outflow from the urban centre, the lowest vitality rankings (67–69) are found in the intermediate zone between the urban core and the northern and northeastern peripheries, indicating pockets of low vitality in this zone rather than a single-channel peripheral decline. This shows that the potential vitality of the settlement is influenced more by the mix of its assets than by its distance from the urban core.

The study also shows a prominent digital and cultural gap. Although most settlements have easy access to resources and infrastructure, mobile phone signal coverage remains an issue, with around 25% of settlements having poor connections. This can limit their residents' digital integration – that is, access to associated options such as online jobs, online education, and e-commerce, which contributes not only to overall vitality but also to emergency-response options. Furthermore, nearly 90% of settlements lack cultural institutions, which are critical to the development of local social life and identity.

In addition, based on the distribution of vitality, the findings imply that planning interventions should focus on the settlements that belong to the predominant middle vitality tier, which comprise most of the research area.

5.2 Relation to previous studies

The results strengthen the multidimensionality of vitality, meaning that it must include both material and intangible services that constitute cultural and ecological resources. The disparities identified are not reflected in Niš's planning documents, which employ municipal-level statistics, masking sub-municipal reality. In this respect, the vitality index meets the need for fine-grained spatially indexed approaches to embody intra-urban heterogeneity (Liu et al., 2023). By revealing inequalities between different settlements, this index provides a clear guide for making local decisions that are more responsive to each settlement's specific needs.

In line with the third research sub-question, the results also confirm a key role of social development for vitality. Receiving relatively high weightings through the entropy method, social development indicators (such as number of events and cultural institutions) demonstrate that even modest variations can strongly influence vitality rankings. This resonates with Jacobs's (1961) and Putnam's (2000) emphasis on social cohesion and civic life as vital components of urban sustainability, and with Osunkoya and Partanen (2024), who reported that socioeconomic variables significantly correlate and influence the vitality value. Furthermore, the TOPSIS ranking points to deviation from the centrality pattern, frequently noted in post-socialist cities, which generally entails the marginalization of peripheral areas because investment increasingly focuses on urban cores, as discussed by Vujošević et al. (2012) and Petrović (2009). Therefore, the spatial arrangement observed appears to highlight the importance of relational rather than positional aspects of urban vitality.

The landscape of vitality indicators is diverse and well covered in the literature. For instance, Lopes and Camanho (2013) focused on the use of public green spaces as a measurable indicator of urban vitality. Galaktionova and Istrate (2025) suggested using "functional density" as a proxy to assess street-level vitality. Osunkoya and Partanen (2024) proposed integration of traditional metrics with big data, such as mobile phone records. Garau and Annunziata (2022) applied built-up and population density, various centrality indexes, density of POIs, and environmental quality indicators. Putnam (2000) and Putnam and Campbell (2010) highlighted social capital indicators such as civic engagement, religious participation, and community networks as a "social" side of vitality. Many of these indicators were included directly or indirectly in this study, such as proximity to geological resources as a proxy for Garau and Annunziata's environmental quality, the presence of religious buildings as a proxy for Putnam's religious participation, and mobile network coverage as a proxy for Olukoya and Partanen's phone records. However, the purpose of this

study was to address a set of indicators that cover the segment of infrastructure and resources under public authority (i.e., municipal governance) and focus on rural settlements within the administrative boundaries of the city, relying on an extensive field inventory that provided an initial set of indicators for existing assets. As a result, many of the literature's proposed indicators, which are largely concerned with urban centres, were not directly applicable. Although the selected set of indicators meets the contextual analysis requirements, it also limits the scope of a more extensive investigation.

5.3 Limitations

Because this research was intentionally framed to emphasize the essential physical assets that can support vitality, one limitation is the absence of indicators that map human activity in the settlements analysed. A second limitation is the use of categorical metrics (e.g., the presence of cultural institutions or healthcare facilities), which might oversimplify the complexities of service quality, accessibility, and usage. A selected set of indicators also mapped the current state of the settlements, but they lacked a temporal component that may reflect seasonal or daily patterns of vitality. Finally, by examining the indicators that represent municipal responsibility, the researchers have purposely neglected market-driven and community-led activities that clearly contribute equally to local vibrancy.

Recognizing that a "one size fits all" framework is not attainable, the primary objective of this research was to provide a fundamental spatial baseline with field-validated indicators, offering a clear actionable map for municipal planners.

5.4 Future research

In line with the limitations identified, future research should explore more fine-grained data, such as facility capacity, quality of provision, or user satisfaction, to better capture community-level differences. Second, and in line with what Osunkoya and Partanen (2024) proposed, the results should be overlaid with big data (such as social media analysis, GPS, and location-based services, integrating real-time data on business/service openings and closures). Third, the analysis reflects a single temporal snapshot of vitality. Incorporating temporal dimensions would allow for a more comprehensive understanding of vitality rhythms. Fourth, although the entropy-TOPSIS methodology reduced subjectivity in weighting, it may inadvertently undervalue indicators with low variability but high conceptual importance (e.g., education and healthcare). A potential avenue is the use of hybrid approaches that combine objective statistical variation with expert choices. By integrating these dynamic measurements, future research can

move toward a predictive analytic framework that can show how adding a particular physical asset can affect settlement vitality.

6 Conclusion

This study presented the vitality index, a flexible tool for identifying inequities and developing spatial strategies at the sub-municipal level. However, it is important to acknowledge that the observed weightings are context specific, reflecting the data structure and variability of the local sample. This emphasizes the need to tailor vitality evaluations to unique local conditions and demonstrates that the approach may be adjusted to detect substantial variations across urban areas.

In practice, the findings and methods in this study can help enhance evidence-based decision making by contributing to the asset-based strategy in the local planning process, which takes into account the unique characteristics of each settlement. It also provides a platform for further improvements with dynamic and demographic indicators for greater insights into urban vitality.

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Data availability statement

The data used in this article can be accessed from Zenodo at <https://zenodo.org/records/18670892> (Vranić et al., 2026); this article must be cited if these data are used in other publications.

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Vitalnost srednje velikih mest: izsledki večkriterijske prostorske analize

Vitalnost mest se nanaša na intenzivnost in raznovrstnost vsakdanjih dejavnosti v mestu in njihovo prostorsko porazdelitev ter je eden ključnih kazalnikov za prostorsko urejanje in upravljanje mest. Zaradi slabe povezanosti podatkov in pomanjkanja analitičnih orodij so v srednje velikih postsocialističnih mestih prostorske razlike v vitalnosti pogosto slabo raziskane. V članku je na podlagi večkriterijske prostorske analize, ki združuje družbeno-gospodarske, infrastrukturne in prostorske kazalnike, proučena vitalnost Niša, enega redkih srednje velikih srbskih regionalnih središč. Avtorji so z modelom večkriterijskega odločanja, ki združuje metodi entropije in TOPSIS ter je podprt z geografskim informacijskim sistemom, določili relativni pomen kazalnikov in oblikovali sestavljeni indeks vitalnosti 69 naselij. Analiza je pokazala izrazite

prostorske razlike znotraj mesta, pri čemer so na eni strani izstopala območja zgoščene vitalnosti, na drugi pa funkcionalno in socialno razmeroma šibka območja. Avtorji so vitalnost mestnih območij kartirali, opredelili so ključne kazalnike, ki nanjo najmočnejše vplivajo, in predstavili, kako vitalnost spremljajo in krepijo v primerljivih mestih. Izsledki zagotavljajo pregleden in jasen prostorski okvir za znanstveno utemeljeno načrtovanje, ciljno usmerjeno urbano prenovo in naknadne kvalitativne ali participativne analize v srednje velikih mestih.

Ključne besede: vitalnost mest, geografski informacijski sistem, večkriterijska analiza, razvoj postsocialističnih mest, Niš

1 Uvod

Vitalnost mest se nanaša na intenzivnost in raznovrstnost človekovih dejavnosti v mestnih prostorih, hkrati pa se v njej kažejo medsebojni vplivi prostorske strukture, mešane rabe prostora in družbenogospodarske dinamike. V urbanizmu in urbanih študijah je vitalnost tesno povezana s hodljivostjo, raznovrstno rabo zemljišč, dostopnostjo in prisotnostjo aktivnih javnih prostorov (Cardoso in Meijers, 2016; Istrate idr., 2020). V novejših znanstvenih razpravah se poleg tega vitalnost mest pojmuje kot nastajajoč, dinamičen pojav, na katerega vplivajo časovni vzorci aktivnosti, družbeni stiki in skupnostno vključevanje (Garau in Annunziata, 2022; Osunkoya in Partanen, 2024).

Raziskave vitalnosti mest se osredotočajo zlasti na velika metropolitanska območja, srednje velika mesta in mesta drugega reda pa so kljub svoji ključni vlogi v regionalnem razvoju in teritorialni koheziji razmeroma slabo raziskana (Cardoso, 2016). V nasprotju z velikimi mesti po svetu prebivalstvo v srednje velikih mestih pogosto upada (Parkinson in Meegan, 2013). Poleg tega ta po industrijskem prestrukturiranju pogosto postanejo monofunkcionalna (Berroir idr., 2019), njihova središča pa začnejo postopno izgubljati vitalnost (Chouraqui, 2021). Zaradi tovrstnih preobrazb so pogosto potrebni analitični pristopi, ki so prilagojeni posameznemu okolju in lahko zajamejo razlike med mestnimi območji, namesto da bi temeljili zgolj na skupnih kazalnikih na ravni celotnega mesta.

Evropske raziskave izpostavljajo več prostorskih razsežnosti vitalnosti. Gostota funkcij in mešana raba zemljišč dokazano krepita vsakdanje dejavnosti v mestih (Istrate idr., 2020). Družbenogospodarska raznovrstnost in povezanost prispevata k odpornim lokalnim gospodarstvom (Gao idr., 2024). Kulturne pobude (Kara idr., 2025) in programi prenove, ki se osredotočajo na kulturo (Tzatzadaki, 2024), so uporabna orodja za krepitev mestne identitete in socialne kohezije, zlasti v mestih drugega reda (Błaszczuk in Krysiński, 2023).

Prostorska dinamika postsocialističnih mest se je preoblikovala zaradi institucionalnih sprememb in gospodarskega prestrukturiranja (Cvetinović idr., 2016). Razdrobljeni načrtovalski sistemi in neenakomeren razvoj so prispevali k razlikam med središčnimi in obrobniimi območji (Stojić in Timotijević, 2024). V okviru urbanističnega načrtovanja v Srbiji se pogosto ne rešujejo strukturne neenakosti (Petrović, 2009) ter se ne upoštevajo specifične potrebe obrobni in podobčinskih območij (Vujošević idr., 2012). V raziskavah večjih mest, kot so Beograd, Novi Sad in Niš, so bili kot pomembni dejavniki prostorskih razlik opredeljene demografske spremembe, mi-

gracije in infrastrukturne neenakosti (Antonić, 2024; Šantić in Đorđević, 2023). Vse pogostejše se poudarja tudi pomen vključevanja kulturnih pobud, participativnega upravljanja (Nedučin in Krklješ, 2022) in kakovostne infrastrukture (Đorđević idr., 2023) pri ohranjanju živahnih in vključujočih mestnih prostorov (Protić idr., 2020). Kljub temu so sistematične in podrobne prostorske presoje vitalnosti mest na podobčinski ravni še vedno redke.

Z metodološkega vidika evropske raziskave čedalje pogostejše združujejo prostorsko statistiko (Gao idr., 2024), modeliranje z geografskim informacijskim sistemom (GIS), velepodatke (Osunkoya in Partanen, 2024) in prostorske analize (Galaktionova in Istrate, 2025), ki omogočajo zajem tako statičnih kot časovnih razsežnosti vitalnosti mest. Po drugi strani so metode večkriterijskega odločanja kljub svoji robustnosti in vse pogostejši uporabi pri združevanju heterogenih naborov kazalnikov (Ali idr., 2023; Ginting idr., 2017) na tem področju še vedno razmeroma redke. Navedeni pristopi omogočajo prepoznavanje razlik znotraj mest in podpirajo na dokazih temelječe načrtovanje. Kljub vsemu se tovrstni analitični okvirji v srednje velikih postsocialističnih mestih, zlasti v Srbiji, le redko uporabljajo.

Članek se osredotoča na Niš, značilno mesto drugega reda s strnjanim jedrom, mešano urbano-podeželsko upravno zgradbo in izrazitimi prostorskimi razlikami. Z določanjem uteži na podlagi entropije ter uporabo metode TOPSIS in geografskega informacijskega sistema so avtorji oblikovali sestavljeni indeks vitalnosti, ki omogoča natančnejše razumevanje razlik v mestu. Raziskava zagotavlja prostorsko jasen in prenosljiv okvir večkriterijskega odločanja, prilagojen srednje velikim mestom, z opredelitvijo kazalnikov, ki lahko pokažejo največje razlike med posameznimi mestnimi območji, pa podpira na dokazih temelječe načrtovanje, ki presega skupne kazalnike na občinski ravni. Avtorji so se osredotočili na naslednje raziskovalno vprašanje: Kako je mogoče hibridni model, ki združuje geografski informacijski sistem in večkriterijsko odločanje, učinkovito uporabiti za proučevanje vitalnosti mest z analizo ravni vitalnosti na podobčinski ravni na podlagi podatkov, ki se nanašajo na javno upravljano infrastrukturo, okoljske vire in socialno infrastrukturo?

Pri tem so proučili naslednja podvprašanja: 1. Koliko je model, ki združuje metodi entropije in TOPSIS ter je podprt z geografskim informacijskim sistemom, uporaben kot orodje za na dokazih temelječe načrtovanje, ki se lahko prenese tudi v druga regionalna središča, v katerih primanjkuje ustreznih, med seboj povezanih podatkov? 2. Kako se razlike v vitalnosti kažejo v prostoru? 3. Kateri kazalniki imajo najvišje uteži in tako najmočneje vplivajo na vrednosti indeksa vitalnosti?

2 Pregled literature

Raziskovalci poudarjajo prostorsko razsežnost kot enega glavnih dejavnikov, ki določajo vitalnost mest. Cardoso in Meijers (2016) na primer ugotavljata, da je na mestnih območjih z optimalno dostopnostjo, raznolikostjo rabe zemljišč in gostoto funkcij na dnevni ravni aktivnost večja. Ugotovitve iz več evropskih mest kažejo, da se pretok pešcev in družbenogospodarske povezave okrepijo v mestih z veliko gostoto funkcij in mešano rabo prostora (Istrate idr., 2020). Gao idr. (2024) so s prostorskimi meritvami na podlagi GIS pokazali, da srednje velika mestna območja dosegajo večjo vitalnost, če imajo bolj raznovrstno rabo zemljišč in njihova ulična omrežja zagotavljajo boljši dostop do območij. Liu idr. (2023) navajajo, da je v srednje velikih mestih za boljše razumevanje vitalnosti na podobčinski ravni nujna podrobna analiza prostorskih okoljskih podatkov. Osunkoya in Partanen (2024) sta z združitvijo prostorskih podatkov in vzorcev aktivnosti na podlagi analize podatkov mobilne telefonije ugotovili, da je vitalnost odvisna od vzorcev mobilnosti in dostopa do storitev. Garau in Annunziata (2022) sta ugotovila, da strnjena mestna območja z dobro dostopno javno infrastrukturo krepijo tako dejansko kot zaznano vitalnost med prebivalci. Navedeni izsledki kažejo, da vitalnosti ni mogoče ustrezno meriti s samo enim infrastrukturnim kazalnikom, temveč je potrebna večdimenzionalna analiza.

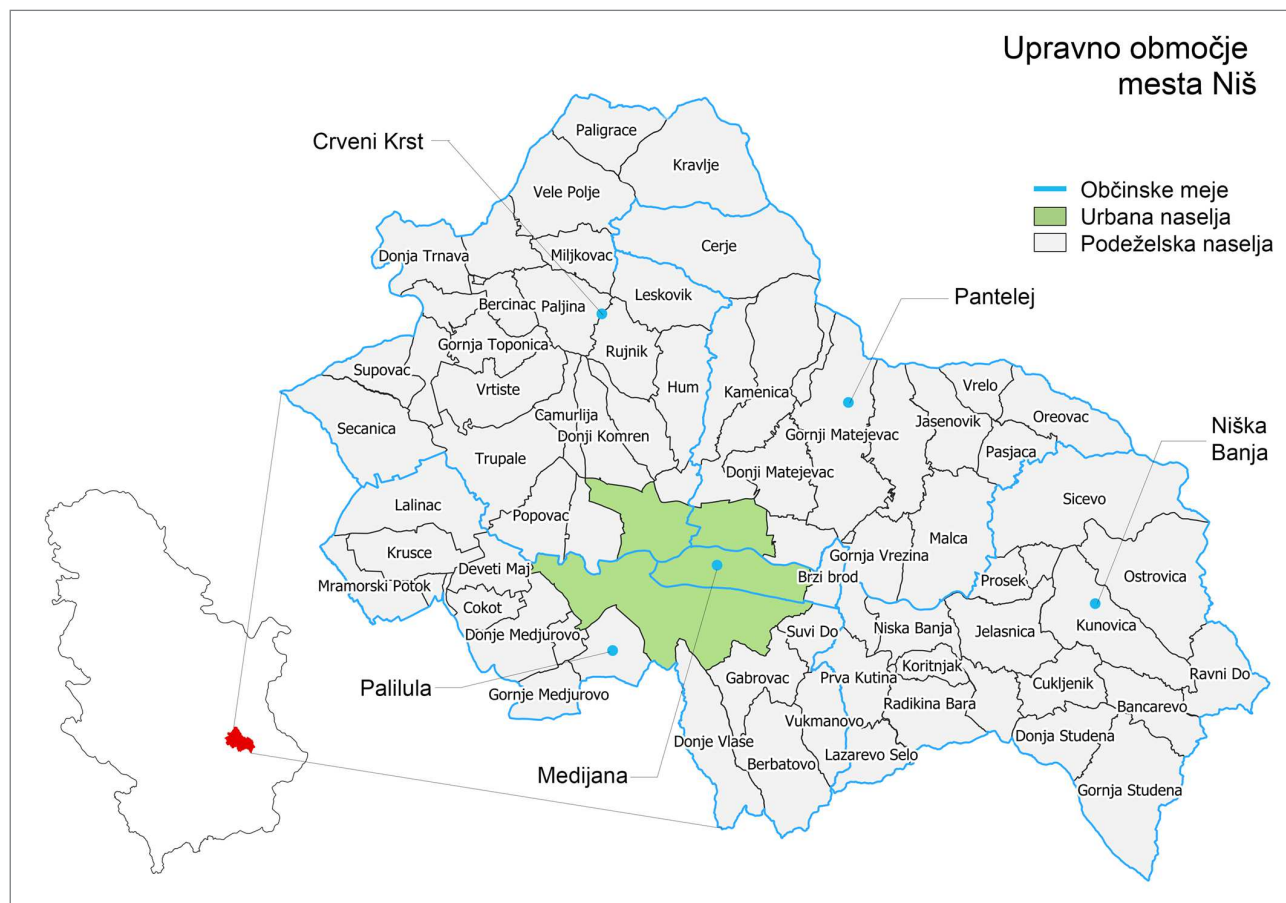
V evropskih razpravah s področja prostorske politike se prepoznavna čedalje večji pomen srednje velikih mest in mest drugega reda v razvojnih načrtih. Cardoso (2016) navaja, da imajo zadnjenavedena mesta stabilizacijsko vlogo v regionalnih sistemih, čeprav na globalni ravni niso tako konkurenčna kot metropolitanska središča. Na njihovo vitalnost vpliva več pomembnih dejavnikov. Kot ugotavljata Parkinson in Meegan (2013), je za postsocialistična in postindustrijska mesta drugega reda pogosto značilen trend upadanja prebivalstva. Po navedbah Berroir idr. (2019) monofunkcionalnost kot posledica industrijskega prestrukturiranja zmanjšuje raznovrstnost mestnih območij in slabi lokalno odpornost. Chouraqui (2021) je kot enega ključnih vzrokov za izgubo vitalnosti mestnih središč izpostavil suburbanizacijo in z njo povezan omejen razvoj storitvenih vozlišč. Raziskave so pokazale še, da so lahko pobude za prenovo, osredotočene na kulturo, koristne za revitalizacijo skupnosti. Kara idr. (2025) so proučevali vpliv pobud v okviru evropske prestolnice kulture na mestno identiteto in lokalno gospodarsko dinamiko. Tzatzadaki (2024) ugotavlja, da lahko kulturni programi spodbujajo socialno kohezijo, če so vključeni v dolgoročne upravljavske okvire. Błaszczyk in Krysiński (2023) pa opozarjata, da so učinki tovrstnih projektov močno odvisni od okolja, v katerem se izvajajo, zato se po območjih

razlikujejo. Očitno je, da se raziskave osredotočajo na večja mesta, kar omejuje razumevanje vitalnosti v širšem obsegu evropskih mest.

Raziskave postsocialističnih mest kažejo, da na vitalnost mest v glavnem vplivajo naslednji trije dejavniki: institucionalne spremembe, privatizacija in spremembe upravljavskih sistemov. Cvetinović idr. (2016) navajajo, da so deregulacija in razdrobljene načrtovalske prakse pomembno vplivale na neenakomeren razvoj mestnih območij v Srbiji. Stojić in Timotijević (2024) ugotavljata, da v obrobni naseljih v primerjavi s središčnimi območji pogosto ni ustrezne infrastrukture. V srbski znanstveni literaturi so obravnavani dodatni vpogledi v obravnavano problematiko. Antonić idr. (2024) na primer navajajo, da so demografske spremembe v večjih srbskih mestih posledica zlasti migracij in staranja prebivalstva. Šantić in Đorđević (2023) ugotavljata, da neenakomerna razporeditev infrastrukture vpliva na razlike v razvoju posameznih območij. Protić idr. (2020) in Nedučin in Krklješ (2022) navajajo, da boljša dostopnost javnih prostorov pozitivno vpliva na njihovo rabo, kar pomeni več aktivnosti v mestu. Raziskave v Srbiji se večinoma osredotočajo na posamezne vidike trajnosti in živahnosti mest ter redko vključujejo celovite analize vitalnosti. Zaradi regionalnih razlik v preobrazbi postsocialističnih mest je za kartiranje njihove vitalnosti v Srbiji potreben analitični okvir, prilagojen posameznemu mestu.

Vitalnost mest se proučuje z več metodami. Osunkoya in Partanen (2024) sta na primer analizirali tradicionalne kazalnike in podatke mobilne telefonije v okolju GIS, da bi ugotovili, kako so prostorska raznovrstnost in družbenogospodarske značilnosti povezane z vitalnostjo. Gao idr. (2024) so na podlagi podatkov o nočni osvetljenosti, cen nepremičnin, objav na družbenih omrežjih, mestnih zanimivostih in vegetacijskega indeksa NDVI ter modelov Geodetector in geografsko utežene regresije merili vidike vitalnosti mestnih območij. Galaktionova in Istrate (2025) sta vitalnost ulic proučevali na podlagi gostote funkcij kot merila, ki sta ga izpeljali iz podatkov orodja OpenStreetMap (OSM) in analizirali z modelom regresije s prostorskim zamikom. Lopes in Camanho (2013) sta z analizo ovojnice podatkov proučevala, kako javne zelene površine prispevajo k vitalnosti mest, Garau in Annunziata (2022) pa sta s kombinacijo metode prostorske sintakse in GIS analizirala vpliv prvin grajenega okolja na vitalnost mestnih območij.

Kljub raznovrstnim metodološkim pristopom se pri raziskavah še vedno pojavljajo izzivi, povezani z usklajevanjem podatkov in razlikami v prostorski ločljivosti. Zaznati je mogoče tudi razlike v razpoložljivosti podatkov, uporabljenih tehnologijah in ravneh analize. Nekatere raziskave se osredotočajo na lokalno raven, druge pa na širšo, metropolitansko raven. Poleg tega



Slika 1: Proučevano območje

se lahko z uporabo združenih podatkovnih virov (npr. podatkov mobilne telefonije ali podatkov o mestnih zanimivostih) informacije o posameznem območju pretirano poenostavimo.

Iz pregleda literature je razvidnih več pomembnih izzivov, kot so večdimenzionalna narava vitalnosti mest, ki presega univerzalne urbane teorije in zahteva analitične okvire, prilagojene posameznemu mestnemu okolju, specifični strukturni izzivi, ki vplivajo na vitalnost srednje velikih in postsocialističnih mest, in pomanjkanje raziskav v teh mestih, ki bi vključevale metode večkriterijskega odločanja.

V tem okviru članek prispeva k razvoju proučevanega področja z operacionalizacijo prostorskega modela, ki združuje večkriterijsko odločanje in GIS ter je prilagojen srednje velikim postsocialističnim mestom, in s preglednim razvrščanjem naselij na podlagi javno upravljanih infrastrukturnih, okoljskih in družbenih virov. S tem razširja nabor kazalnikov, s katerimi se običajno meri vitalnost mest (npr. prostorska raznovrstnost, mešana raba zemljišč in gostota poselitve).

3 Metodologija

3.1 Proučevano območje

Avtorji so za proučevanje vitalnosti izbrali Niš, ker je značilen primer srednje velikega srbskega mesta, ki se spopada s prostorskimi razlikami in funkcionalnimi izzivi. Kot eno redkih urbanih središč zunaj območja prestolnice z izrazito regionalno vlogo je Niš upravno, gospodarsko in izobraževalno središče južne Srbije, za katero so hkrati značilne izrazite razlike med osrednjimi in obrobni območji, ki se kažejo v prostorski dostopnosti, rabi zemljišč in družbenogospodarski aktivnosti (slika 1). Zaradi strnjene urbane gradnje s propadajočimi območji na eni strani in območji novogradenj na drugi je mesto primerno za proučevanje vpliva značilnosti na vitalnost mestnih območij. Od leta 2004 je upravno razdeljeno na pet mestnih občin, ki se med seboj razlikujejo po prostorskih, demografskih in funkcionalnih značilnostih. Občina Medijana je na primer najmanjša (16 km²) in z 82.360 prebivalci najgostejše poseljena, Niška Banja pa je po površini največja, pretežno ruralna in najredkeje naseljena. Razlike v stopnji urbanističnega razvoja,

opremljenosti z infrastrukturo in dostopnosti storitev, skupaj s soobstojem mestnega in podeželskega življenjskega sloga, vplivajo tudi na razlike v kakovosti življenja prebivalcev. Demografske razlike še dodatno povečujejo to neenakost: v nekaterih naseljih je povprečna starost prebivalcev le 38 let, v drugih pa 69 let. Zaradi navedenih prostorskih in demografskih razlik je potrebna podrobna analiza na podobčinski ravni. Neprimerenost uporabe občinske ravni kot osnovne enote prostorske analize utemeljuje tudi dejstvo, da je v petih mestnih občinah kar 69 podeželskih naselij. Avtorji so jih vključili v raziskavo, saj zanje primanjkuje ustreznih podatkov, hkrati pa so pogosto izključena iz običajnih načrtovalskih procesov.

3.2 Kazalniki

Kazalniki, uporabljeni v tej raziskavi, se nanašajo zlasti na fizične vire in pomembno infrastrukturo, ki jih upravljajo občinske oblasti. Čeprav zasebni objekti, kot so trgovine z živili ali banke, pomembno prispevajo k vsakdanjemu življenju v mestih in njihovi vitalnosti, je njihova prisotnost odvisna od tržnih razmer in poslovnih odločitev, ne pa od podpore javnega sektorja, zato v nabor kazalnikov niso bili vključeni. Končni seznam kazalnikov je bil oblikovan na podlagi relevantne literature in obsežne terenske raziskave, ki je vključevala popis vse infrastrukture (npr. cest, šol in športnih objektov) in naravnih virov (npr. vodotokov, gozdov in jam). Kazalniki so bili razvrščeni glede na pet kriterijev, ki so na kratko predstavljeni v nadaljevanju.

1. Geografska lega, naravni viri in varstvo okolja

- Oddaljenost od mestnega središča: vpliva na stopnjo dostopnosti raznovrstnih gospodarskih priložnosti, javnih storitev, kulturnih objektov in prometne infrastrukture. Kot je poudarila že Jane Jacobs (1961), je kakovost življenja v mestu odvisna od goste poseljenosti sosesk z mešano rabo prostora, v katerih vsakdanje aktivnosti potekajo blizu druga druge in so socialne mreže bolje razvite. Navedeno potrjujejo tudi izsledki Johna Montgomeryja (1998), ki je ugotovil, da se vitalnost območij zmanjšuje z oddaljenostjo od mestnega jedra.
- Bližina vodotokov: zagotavlja ekosistemske storitve, kot so kmetijska pridelava, naravno uravnavanje poplav in rekreacija, ki so bile v okviru mednarodne raziskave MEA (2005) prepoznane kot ključne za dolgoročni lokalni razvoj.
- Bližina gozdov: kazalnik se nanaša na možnosti za ekoturizem, trajnostno rabo virov, rekreacijo, izboljšanje mikroklimе in splošno dobro počutje prebivalcev (Tzoulas idr., 2007).
- Zavarovana naravna območja: so del omrežja zelene infrastrukture, ki povezuje varstvo okolja in dobro počutje skupnosti ter podpira lokalno gospodarstvo z regulira-

nimi dejavnostmi z majhnim vplivom na okolje, kot so ekoturizem, jamarstvo in zeliščarstvo, skladno s cilji dolgoročnega ohranjanja okolja (MEA, 2005).

- Geološki viri: prvine, kot so jame, termalni izviri in zdravilišča, podpirajo razvoj turizma, malih podjetij, športa in rekreacije (Farsani idr., 2011).

2. Infrastruktura in komunikacije

- Vrsta povezovalnih cest iz mestnega središča, kakovost cest v naseljih in dostopnost javnega prevoza: to so kazalniki prostorske povezanosti, gospodarskega potenciala, odzivnosti v izrednih razmerah in vključenosti v skupnost (Litman, 2021).
- Pogostost linij organiziranega javnega prevoza.
- Prisotnost bencinskih servisov: kazalnik se nanaša na majhno oddaljenost teh objektov od kmetijskih in stanovanjskih območij, kar zmanjšuje prevozne stroške in kmetom zagotavlja hiter dostop do goriva. Navedeno prispeva k infrastrukturni povezanosti, gospodarski vitalnosti ter razvoju turizma in logistike.
- Prisotnost pošte: to kaže na razvito komunikacijsko infrastrukturo ter zagotavlja dostop do finančnih in logističnih storitev ter širjenje informacij, kar je še zlasti pomembno na podeželskih območjih (Castells, 2010). Hkrati zagotavlja pomembno fizično točko za e-trgovino, saj je zadnji člen v logistični verigi, potreben za vključevanje v skupnost na podeželskih ali odmaknjenih območjih.
- Pokritost z mobilnim omrežjem: zagotavlja temeljni digitalni sistem, ki primestnim območjem omogoča, da se s prenosom končnih podatkov in komunikacijskimi storitvami razvijejo v povezana gospodarska središča, hkrati pa podpira tudi družabne in kulturne dejavnosti, ki so gonilo skupnostnega življenja v predmestjih.

3. Zdravstvena oskrba

Primestna naselja v Nišu se že spopadajo z odseljevanjem prebivalcev in večina jih nima ustreznega dostopa do zdravstvenih storitev. K vitalnosti lokalnega okolja lahko pomembno prispevata ta kazalnika:

- dostop do primarnega zdravstvenega varstva,
- dostop do lekarn.

4. Izobraževanje

- Dostop do izobraževalnih ustanov: zaradi pomanjkanja osnovnih šol se družine preseljujejo bližje mestnemu središču. Če ima naselje osnovno šolo, je torej sposobno zadržati prebivalce.

5. Družbeni razvoj

- Število zunanjih javnih športnih igrišč, rekreacijskih objektov in športnih klubov: tovrstni prostori delujejo kot prostori povezovanja (Putnam, 2000), ki so ključni za

vzpostavljanje zaupanja in sodelovanja. Športna igrišča in klubi so poleg tega znak zdravega prebivalstva različne starosti ter temelj za družabne stike in dobro počutje skupnosti.

- Število kulturnih ustanov in lokalnih prireditev: to se nanaša na festivale in ustvarjalna središča, zlasti v urbanem jedru Niša, ki privabljajo mlajše generacije z obrobni območij. Navedeno povzroča stagnacijo skupnosti na mestnem obrobju, ki so zato puste ter brez živahnega družabnega življenja in institucionalnega »lepila«, ki jo Florida (2002) prepozna kot pogoj za dolgoročno produktivno prebivalstvo, sestavljeno iz več generacij.
- Število verskih objektov: kazalnik se nanaša na zmožnost okolja, da spodbuja socialno kohezijo in vključevanje skupnosti, ter priložnosti za prostovoljstvo in državljansko udejstvovanje. Raznovrstnost verskih ustanov lahko odraža tudi kulturno strpnost in pluralizem (Putnam in Campbell, 2010).

3.3 Metoda ocenjevanja in podatkovni viri

Meje razredov so bile določene na podlagi kombinacije uveljavljenih normativov in empiričnih izsledkov. Pri kazalnikih, ki temeljijo na razdalji, so bili uporabljeni pragovi hodljivosti,

ki jih določa Program ZN za naselja (UN-Habitat, 2018). Pri kazalnikih z že uveljavljenimi klasifikacijami, kot sta pokritost z mobilnim omrežjem in kategorije cest, so bile uporabljene ustrezne institucionalne kategorije. Pri preostalih kazalnikih je bil analiziran celoten nabor podatkov, nato pa so bili oblikovani razredi, ki pravilno odražajo porazdelitev vrednosti. Če se je na primer izkazalo, da je največje število geoloških virov znotraj meja posameznega naselja večje kot tri, so bili za ta kazalnik določeni trije razredi (glej preglednico 1), če pa je bilo največje število šol v vseh naseljih ena, je bila uporabljena binarna klasifikacija. Sistem točkovanja je tako temeljil na empiričnih podatkih, hkrati pa je bil usklajen z veljavnimi načrtovalskimi in regulativnimi okviri. S tovrstnim sistemom se lahko pravilno prikažejo dejanske razlike in zaznajo manjša odstopanja v skupnostih, pri čemer se uporabi štiristopenjski ali binarni ocenjevalni okvir. Pri ocenjevanju kazalnikov so bile upoštevane meje posameznih naselij (MN).

Uporabljene so bile naslednje vrednosti na štiristopenjski lestvici: 3 = pomemben potencial za lokalni razvoj, 2 = zmeren potencial, 1 = šibek potencial, 0 = brez potenciala. Točkovanje je temeljilo na podatkih iz javno dostopnih virov, institucionalnih evidenc, terenskih raziskav in prostorskih aktov, s čimer so avtorji zagotovili celovito in zanesljivo podatkovno osnovo (Vranić idr., 2026).

Preglednica 1: Vrednosti kazalnikov in razlaga metode ocenjevanja

Kazalnik	Podatkovni vir, metoda	Točkovanje
1. Geografska lega, naravni viri in varstvo okolja		
Oddaljenost od mestnega središča	Izohrone in vtičnik QGIS TravelTime, pri čemer je bilo kot izhodišče potovanja uporabljeno središče naselja, kot končna destinacija pa je bilo uporabljeno mestno središče.	3: < 10 min vožnje do središča 2: 10–20 min 1: 20–30 min
Bližina vodotokov	Evklidska oddaljenost središča naselja od najbližjega vodotoka/gozda, izračunana z orodjem Buffer v okolju QGIS.	3: 5 min hoje 2: 10 min 1: 15 min
Bližina gozdov		
Zavarovana naravna območja	Podatki srbskega okoljevarstvenega inštituta in uporaba prostorskega prekrivanja.	1: zavarovano območje v MN 0: ni zavarovanega območja
Geološki viri	Podatki iz orodja OSM.	3: trije geološki pojavi ali več znotraj MN 2: dva 1: eden 0: nobeden
2. Infrastruktura in komunikacije		
Vrste povezovalnih cest iz mestnega središča	Podatki javnega komunalnega podjetja Direktorata za gradnjo mesta Niš in podatki iz orodja OSM, uporaba orodja Zonal Statistics v QGIS, podatki o kakovosti cest pa niso bili na voljo.	3: ceste 1. kategorije (avtoceste) 2: ceste 2. kategorije (regionalne ceste) 1: ceste 3. kategorije (lokalne ceste) 3: v naselju prevladujejo ceste 1. kategorije
Vrste cest v naselju		2: ceste 2. kategorije 1: ceste 3. kategorije

Kazalnik	Podatkovni vir, metoda	Točkovanje
Dostopnost javnega prevoza	Podatki o javnem prevozu Direktorata za javni prevoz mesta Niš in Srbskih železnic, uporaba orodja Zonal Statistics v QGIS.	2: znotraj MN na voljo več kot ena vrsta prevoza 1: ena 0: nobena 3: velika
Pogostost linij organiziranega javnega prevoza*		2: srednja 1: majhna
Prisotnost bencinskih servisov	Podatki iz orodij OSM in Google Earth.	1: so znotraj MN 0: jih ni
Prisotnost pošte	Podatki Pošte Srbije, orodja Google Earth in terenskih raziskav.	1: je znotraj MN 0: je ni
Pokritost z mobilnim omrežjem**	Analiza podatkov regulativnega organa za elektronske komunikacije in poštne storitve RATEL v programu GIS.	3: večinoma dobra/odlična pokritost 2: zadovoljiva do dobra/odlična pokritost 1: zadovoljiva pokritost v 80 odstotkih ali več
3. Zdravstvena oskrba		
Dostop do primarnega zdravstvenega varstva	Izdelava Voronojevega diagrama v QGIS na podlagi podatkov o zdravstvenih domovih.	3: zdravstveni dom je znotraj MN 2: zdravstveni dom pokriva dve naselji 1: zdravstveni dom pokriva več naselij
Dostop do lekarn	Izdelava Voronojevega diagrama v QGIS na podlagi podatkov orodja Google Earth in spletnih podatkov.	3: lekarna je znotraj MN 2: lekarna pokriva dve naselji 1: lekarna pokriva več naselij
4. Izobraževanje		
Dostop do izobraževalnih ustanov	Podatki mestne šolske uprave, orodja Google Earth in terenskih raziskav.	1: osnovna šola je znotraj MN 0: je ni
5. Družbeni razvoj		
Število zunanjih športnih igrišč in rekreacijskih objektov	Podatki orodij OSM in Google Earth ter terenskih raziskav.	2: dva ali več objektov znotraj MN 1: en objekt 0: ni objektov
Število kulturnih ustanov	Podatki orodja Google Earth, nadškofije Niš in terenskih raziskav.	1: ustanova je znotraj MN 0: je ni
Število verskih objektov		1: verski objekt je znotraj MN 0: ga ni
Število lokalnih prireditev	Podatki lokalne turistične organizacije.	2: več kot ena prireditev letno 1: ena prireditev 0: ni prireditev
Število registriranih športnih klubov	Podatki lokalne športne zveze.	2: več kot en klub 1: en klub 0: ni klubov

* Pogostost linij javnega prevoza temelji na številu odhodov v vsako občino na delovni dan. Končno število je bilo z metodo min-max pretvorjeno v razpon od 0 do 1, pri čemer 0 pomeni najmanjšo, 1 pa največjo pogostost. Zaradi enotnosti ocenjevanja je bil normalizirani razpon razdeljen v tri skupine pogostosti.

** Površina signala treh državnih operaterjev je bila primerjana s celotno površino posameznega naselja na podlagi naslednjih treh klasifikacijskih ravni organizacije RATEL: odličen signal (pričakovana zelo dobra povezava), dober signal (pričakovana dobra povezava) in zadovoljiv signal (pričakovana sprejemljiva povezava z občasnimi prekinitvami). Končna ocena je bila določena kot povprečje točk vseh treh operaterjev glede na prevladujočo raven signala: 3 = skupna površina z odličnim/dobrim signalom je večja od površine z zadovoljivim signalom, 2 = površina z zadovoljivim signalom je večja od skupne površine z odličnim/dobrim signalom, 1 = več kot 80 % površine naselja je pokrite z zadovoljivim signalom.

3.4 Metodologija razvrščanja naselij

Cilj uporabe metode večkriterijskega odločanja je bil razvrstiti lokalne skupnosti glede na vnaprej določene kriterije, da se oceni njihova vitalnost. Za izračun uteži kriterijev in določitev koeficientov uteži je bila uporabljena metoda Shannonove entropije. Izraz *entropija* pomeni neurejenost v nizu podatkov (Shannon, 1948). Razmerje med vrednostjo entropije in koeficientom uteži je obratno sorazmerno (Zakeri idr., 2025): kriteriji z višjo stopnjo entropije imajo nižje koeficiente in obratno (Ali idr., 2023). Kriteriji z minimalnimi razlikami med vrednostmi imajo večjo entropijo, saj so podatki enakomerno porazdeljeni in vsebujejo manj informacij. Nasprotno pa kriteriji z večjimi razlikami med posameznimi vrednostmi zagotavljajo več informacij za razvrščanje, stopnja entropije je v tem primeru nižja, vrednost uteži pa večja (Chen, 2020). Kriteriji z nižjo stopnjo entropije lahko prispevajo k zaznavanju razlik med lokalnimi skupnostmi, saj nakazujejo variabilnost podatkov in omogočajo učinkovitejšo razvrščanje. Uporaba te metode je namenjena zmanjševanju subjektivnosti v postopku razvrščanja. Z metodo TOPSIS so bili nato uteženi kazalniki združeni v sestavljeni indeks vitalnosti, pri čemer so bila naselja razvrščena glede na to, kako blizu so idealnemu scenariju visoke stopnje vitalnosti in kako daleč so od najmanj zelenega scenarija. Več informacij o posamezni metodi je na voljo v prilogi.

4 Rezultati

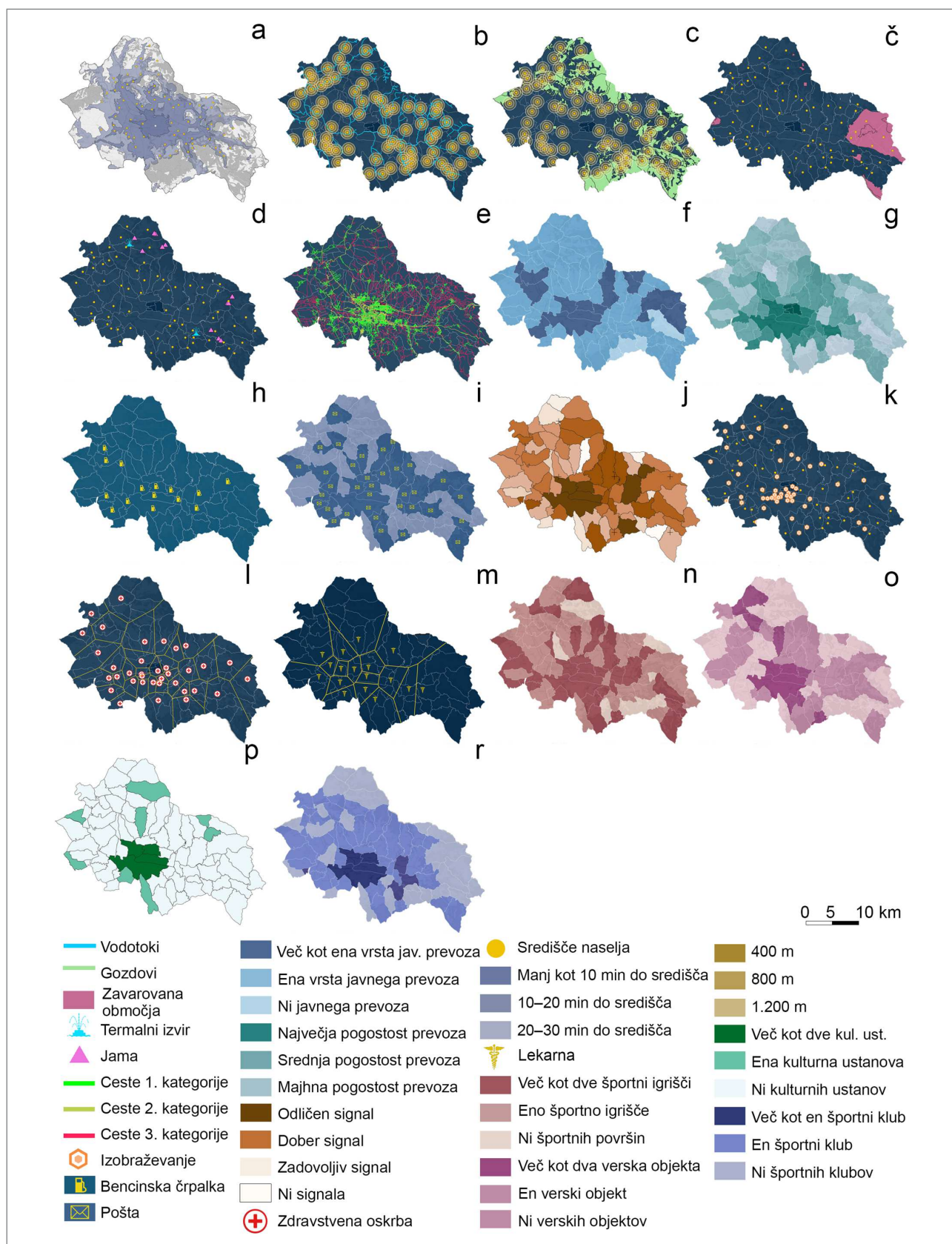
4.1 Kazalniki

Prostorska porazdelitev kazalnikov je prikazana na sliki 2. Za kazalnik oddaljenosti od mestnega središča so bile izdelane karte z izohronami, s katerimi so bili ocenjeni potovalni časi v optimalnih razmerah vožnje z avtomobilom (brez prometnih konic). Petdeset odstotkov naselij je v tretjem pasu (20–30 minut od središča), 47,1 % v drugem pasu (10–20 minut), le dve pa sta od središča oddaljeni manj kot 10 minut. Več naselij leži na meji dveh izohron. Šestdeset odstotkov jih spada v drugi pas, kar pomeni, da večina prebivalcev do mestnega središča potrebuje od 18 do 20 minut vožnje (slika 2a). Prebivalci praviloma potrebujejo od 5 do 15 minut hoje (400–1.200 m) do najbližje vodne površine. 51,4 % jih je od nje oddaljenih do 400 m, 18,6 % med 400 in 800 m, 15,7 % med 800 in 1.200 m, 14,3 % pa več kot 1.200 m (slika 2b). Bližina gozdnih površin je bila določena kot razdalja med središčem naselja in najbližjim gozdom. 58,6 % prebivalcev živi blizu gozdov: 19 % jih je 5 do 10 minut hoje stran, 14 % do 15 minut (800–1.200 m), 8 % pa do najbližjega gozda potrebuje 5 minut. Preostalih 41,4 % jih je od gozda oddaljenih več kot 1.200 m (slika 2c). Zavarovana območja pokrivajo 10,4 % proučevanega območja, večinoma v njegovem vzhodnem delu. 13 od 69 naselij delno ali v celoti

leži znotraj naravnih parkov in rezervatov, kot sta Sičevačka klisura in Suva planina (slika 2č). Geološke vire ima znotraj svojih meja le sedem naselij (10,1 %). Nekatera med njimi imajo celo termalne izvire in jame državnega ali mednarodnega pomena, kot sta Cerjanska pečina in Pešturina (slika 2d). Glede vrst povezovalnih cest iz mestnega središča in cest znotraj naselij je 10 % naselij dostopnih po lokalnih cestah (3. kategorije), 29 % po regionalnih cestah (2. kategorije) in 61 % po avtocestah (1. kategorije). V naseljih prevladujejo regionalne ceste (33 %), sledijo lokalne ceste (31 %), najmanj pa je avtocest in hitrih cest (6 %) (slika 2e).

Približno 80 % naselij ima organiziran javni prevoz, večinoma avtobusni, 11,4 % jih ima tudi železniško povezavo. Če upoštevamo še dostopna sosednja območja, se delež naselij z dostopom do železnice poveča na 35,7 %. Štirje odstotki naselij so brez kakršnega koli organiziranega javnega prevoza (slika 2a). Glede pogostosti linij javnega prevoza ima 12,9 % naselij največjo (0,69–1,0), 12,9 % srednjo (0,31–0,53) in 74,2 % majhno (do 0,30) pogostost, pri čemer se ta zmanjšuje z oddaljenostjo od mestnega središča (slika 2b). Prostorska porazdelitev bencinskih črpalk se ujema s smerjo glavnih avtocest in povezovalnih cest. Ob teh je bencinska črpalka v 14,2 % naselij. Če se upoštevajo še sosednja naselja, do katerih je mogoče priti z avtomobilom v 10 minutah ali manj, to storitev neposredno uporablja dodatnih 41,4 % naselij. Število poštних uradov se z oddaljenostjo od središča Niša zmanjšuje, vendar pokritost ostaja razmeroma dobra (49 %). Če se upoštevajo še naselja, ki mejijo na tista s poštним uradom, je s poštними storitvami pokritega 95,7 % prebivalstva. Kakovost signala mobilnega omrežja se med lokalnimi skupnostmi močno razlikuje: 19,4 % naselij ima zelo dober do odličen signal ($\geq 2,7$), kar omogoča zadovoljiv dostop do digitalnih storitev, spletne komunikacije in pametne infrastrukture. Nasprotno pa ima 23,6 % naselij slab do zelo slab signal ($\leq 1,3$), kar pomeni, da je neposreden, dober mobilni signal zagotovljen le v 19,4 % naselij.

Osnovna šola je v polovici proučevanih naselij, od teh je v 28,5 % naselij podružnična šola. V preostalih naseljih ni osnovne šole, zato jo morajo učenci obiskovati v bližnjih naseljih. Voronojevi diagrami so pokazali, da si polovica naselij deli zdravstveni dom z dvema ali več drugimi naselji, 37,6 % s tremi ali več, 14,3 % z enim, 35,7 % pa ima lasten zdravstveni dom. Pokritost z lekarnami je nekoliko manjša kot pokritost z zdravstvenimi storitvami in se zmanjšuje z oddaljenostjo od središča Niša: 87,1 % naselij si lekarno deli z dvema ali več drugimi naselji, 64,3 % pa s štirimi naselji ali več. Samo 12,9 % naselij ima lastno lekarno, 4,3 % pa si jo deli še z enim naseljem. Športnih in rekreacijskih površin v 11,4 % naselij ni, v 51,4 % naselij je vsaj ena, v 37,2 % naselij pa sta dve ali več. V 88,6 % naselij ni kulturnih ustanov, v 11,4 % naselij pa je



Slika 2: a) oddaljenost od mestnega središča, b) bližina vodotokov, c) bližina gozdov, č) zavarovana naravna območja, d) geološki viri, e) vrste povezovalnih cest iz mestnega središča in vrste cest, ki tja peljejo, f) dostopnost javnega prevoza, g) pogostost linij organiziranega javnega prevoza, h) prisotnost bencinskih servisov, i) prisotnost pošte, j) pokritost z mobilnim omrežjem, k) dostop do izobraževalnih ustanov, l) dostop do primarnega zdravstvenega varstva, m) dostop do lekarn, n) število zunanjih javnih športnih igrišč in rekreacijskih objektov, o) število verskih objektov, p) število kulturnih ustanov in r) število športnih klubov

Preglednica 2: Objektivni koeficienti uteži, izračunani s Shannonovo metodo entropije

Kriterij	Kazalnik	Koeficient uteži
Geografska lega, naravni viri in varstvo okolja	Oddaljenost od mestnega središča	0,004
	Bližina vodotokov	0,012
	Bližina gozdov	0,035
	Zavarovana naravna območja	0,096
	Geološki viri	0,136
Infrastruktura in komunikacije	Vrste povezovalnih cest iz mestnega središča	0,002
	Vrste cest v naselju	0,006
	Dostopnost javnega prevoza	0,006
	Pogostost linij organiziranega javnega prevoza	0,020
	Prisotnost bencinskih servisov	0,111
	Prisotnost pošte	0,048
	Pokritost z mobilnim omrežjem	0,006
Zdravstvena oskrba	Dostop do primarnega zdravstvenega varstva	0,006
	Dostop do lekarn	0,101
Izobraževanje	Dostop do izobraževalnih ustanov	0,040
Družbeni razvoj	Število zunanjih javnih športnih igrišč in rekreacijskih objektov	0,010
	Število kulturnih ustanov	0,124
	Število verskih objektov	0,042
	Število lokalnih prireditev	0,139
	Število športnih klubov	0,054

vsaj ena. Med verskimi objekti in kulturnimi ustanovami prevladujejo pravoslavni samostani in cerkve, vendar je podatkov o njihovi dejanski dejavnosti malo. V polovici naselij ni verskih objektov, v 40 % naselij je eden, v 10 % naselij pa jih je več. Večina skupnosti (85,7 %) ne organizira kulturnih, športnih ali tradicionalnih prireditev, 5,8 % jih organizira eno ali dve, 8,6 % pa več kot dve. V 35,7 % naselij ni športnih klubov, v 57,1 % naselij je eden, v 5,7 % naselij pa sta dva ali več.

4.2 Uteži in razvrstitev naselij

Z metodo entropije so avtorji določili relativno pomembnost posameznih kazalnikov na podlagi koeficientov uteži (preglednica 2). Višji koeficient pomeni, da ima kazalnik velik vpliv na razvrstitev naselij po vitalnosti, nižji koeficient pa pomeni manjši vpliv. Kazalniki z najvišjimi utežmi vključujejo število prireditev (0,139), geološke vire (0,136) in kulturne ustanove (0,124). Skupaj s kazalniki, kot sta lekarna (0,101) in bencinska črpalka (0,111), imajo ti največji vpliv na končno raz-

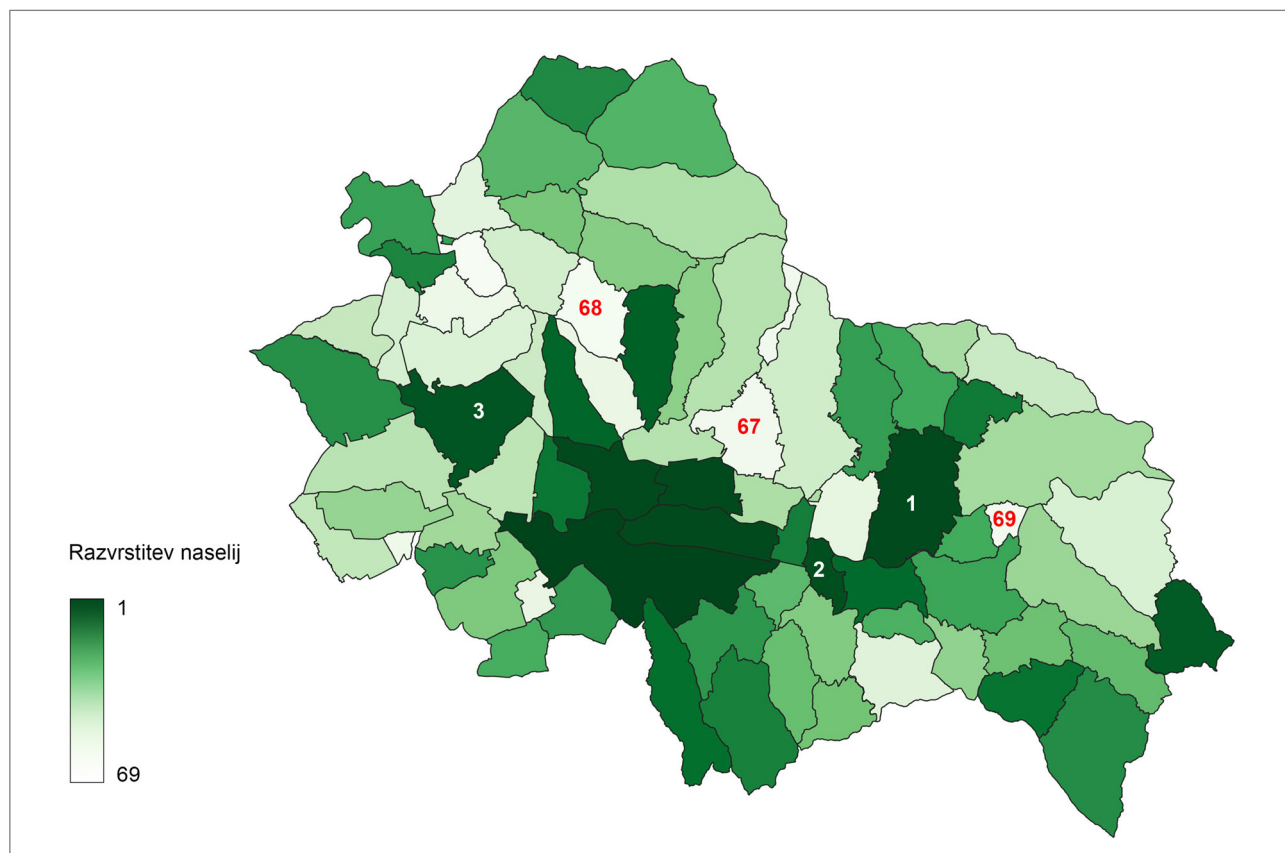
vrstitev po vitalnosti. Njihova izračunana entropija je nižja, podatki pa omogočajo razlikovanje med naselji, kar je ključno za oblikovanje indeksa vitalnosti. Nasprotno imajo kazalniki z najnižjo utežjo, kot so vrste cest (0,002), oddaljenost od mestnega središča (0,004) in dostop do primarnega zdravstvenega varstva (0,006), razmeroma majhen vpliv na razlikovanje med naselji. Njihova entropija je višja, ker so vrednosti kriterijev homogene in ne omogočajo razlikovanja med naselji. To ne pomeni, da ti kazalniki niso pomembni, gre bolj za to, da njihova razmeroma enakomerna porazdelitev ali omejena variabilnost med naselji zmanjšuje njihov vpliv na skupno razvrstitev naselij po vitalnosti. Navedeni rezultati kažejo, da čeprav je osnovna infrastruktura pomembna, vitalnost Niša večinoma določajo kulturni, okoljski in skupnostno usmerjeni dejavniki.

Preglednica 3: Razvrstitev naselij po metodi TOPSIS

Naselje	S_i^+	S_i^-	C_i	Rang
Bancarevo	0,019	0,006	0,233	31
Berbatovo	0,019	0,010	0,345	13
Berčinac	0,019	0,000	0,017	70
Brenica	0,019	0,004	0,187	39
Brzi Brod	0,017	0,009	0,358	12
Bubanj	0,019	0,001	0,052	63
Čamurlija	0,018	0,002	0,109	54
Cerje	0,017	0,003	0,142	47
Čokot	0,019	0,009	0,315	18
Čukljenik	0,020	0,006	0,232	33
Deveti Maj	0,017	0,004	0,179	43
Donja Studena	0,019	0,011	0,365	9
Donja Toponica	0,019	0,010	0,345	14
Donja Trnava	0,012	0,005	0,299	22
Donja Vrežina	0,018	0,003	0,146	46
Donje Medjurovo	0,018	0,005	0,217	36
Donje Vlake	0,018	0,011	0,374	8
Donji Komren	0,014	0,010	0,405	6
Donji Matejevac	0,019	0,001	0,028	67
Gabrovac	0,018	0,008	0,315	19
Gornja Studena	0,018	0,010	0,340	16
Gornja Toponica	0,016	0,001	0,049	65
Gornja Trnava	0,019	0,001	0,059	61
Gornja Vrežina	0,019	0,001	0,057	62
Gornje Medjurovo	0,019	0,007	0,271	26
Gornji Komren	0,020	0,001	0,051	64
Gornji Matejevac	0,018	0,002	0,098	55
Hum	0,015	0,011	0,415	5
Jasenovik	0,019	0,007	0,275	24
Jelašnica	0,019	0,007	0,287	23
Kamenica	0,019	0,003	0,140	48
Knez Selo	0,019	0,008	0,302	21
Koritnjak	0,019	0,007	0,270	27
Kravlje	0,019	0,007	0,262	28
Krušce	0,020	0,004	0,184	41
Kunovica	0,020	0,004	0,184	42
Lalinac	0,019	0,003	0,139	49
Lazarevo Selo	0,018	0,005	0,230	34
Leskovik	0,014	0,003	0,191	38
Malča	0,007	0,015	0,690	1
Manastir	0,019	0,000	0,023	68
Medoševac	0,014	0,008	0,363	10
Mezgraja	0,018	0,002	0,083	57
Miljkovac	0,019	0,005	0,219	35

Naselje	S_i^+	S_i^-	C_i	Rang
Mramor	0,019	0,001	0,042	66
Mramorski Potok	0,017	0,002	0,118	51
Nikola Tesla	0,010	0,017	0,622	2
Niška Banja	0,009	0,006	0,384	7
Oreovac	0,016	0,002	0,112	53
Ostrovica	0,019	0,002	0,083	58
Paligrace	0,016	0,008	0,344	15
Paljina	0,019	0,002	0,093	56
Pasi Poljana	0,016	0,007	0,314	20
Pasjača	0,017	0,009	0,360	11
Popovac	0,018	0,003	0,130	50
Prosek	0,019	0,007	0,274	25
Prva Kutina	0,019	0,005	0,202	37
Radikina Bara	0,019	0,002	0,080	60
Rautovo	0,019	0,004	0,186	40
Ravni Do	0,015	0,012	0,436	4
Rujnik	0,019	0,000	0,022	69
Sečanica	0,016	0,008	0,324	17
Sičevo	0,017	0,004	0,175	44
Supovac	0,017	0,002	0,116	52
Suvi Do	0,020	0,006	0,233	30
Trupale	0,013	0,011	0,449	3
Vele Polje	0,019	0,006	0,243	29
Vrelo	0,017	0,003	0,147	45
Vrtište	0,018	0,002	0,081	59
Vukmanovo	0,019	0,006	0,233	32

Rezultati razvrščanja po metodi TOPSIS v preglednici 3 kažejo izrazita neskladja med naselji: Malča ($C_i = 0,690$) in Nikola Tesla ($C_i = 0,622$) zasedata vodilni mesti, Berčinac, Rujnik in Manastir pa se uvrščajo na dno lestvice, saj se le minimalno razlikujejo od najbolj negativne rešitve. Na podlagi metode naravnih mej in ob upoštevanju celotnega razpona vrednosti indeksa vitalnosti (od 0,690 do 0,017) je mogoče opredeliti tri stopnje vitalnosti: visoko stopnjo z vrednostjo nad 0,400 (7 % naselij), prevladujočo srednjo stopnjo z vrednostmi med 0,100 in 0,399 (68 % naselij) in nizko stopnjo z vrednostjo pod 0,100 (25 % naselij). Niška Banja in Donje Vlake sta najbližje napredovanju v skupino naselij z višjo stopnjo vitalnosti, Čamurlija in Oreovac pa sta najbližje nazadovanju v nižjo skupino. V skupini z visoko stopnjo vitalnosti obstaja pri Komrenu tveganje, da bi ob spremembi razmer nazadoval na srednjo stopnjo vitalnosti. Iz prostorske porazdelitve vitalnosti na sliki 3 so razvidne izrazite razlike znotraj upravnih meja Niša, pri čemer bližina mestnega središča ni neposredno povezana z večjo vitalnostjo.



Slika 3: Prostorski prikaz indeksa vitalnosti (vir: avtorji)

5 Razprava

5.1 Razlaga izsledkov

Avtorji so oblikovali prostorsko eksplicitni hibridni model večkriterijskega odločanja za vrednotenje vitalnosti mest na podobčinski ravni, ki so ga najprej preizkusili in validirali na primeru Niša v Srbiji. V skladu s prvim raziskovalnim podvprašanjem so z združitvijo uteževanja na podlagi entropije in metode TOPSIS oblikovali sestavljeni indeks vitalnosti, da bi proučili razlike med petimi ključnimi vidiki: geografsko lego in naravnimi viri, infrastrukturo in komunikacijami, zdravstveno oskrbo, izobraževanjem in družbenim razvojem. Preizkušeni model se lahko zlahka prenese v druga okolja, saj temelji na javno dostopnih kazalnikih, ki jih je mogoče kartirati v katerem koli mestnem prostoru. Primeren je za prepoznavanje prostorskih neenakosti ob uporabi osnovnih podatkovnih virov ter za vzpostavitev jasne, znanstveno utemeljene podlage za urejanje prostora v postsocialističnih regijah, v katerih primanjkuje podatkov.

Izsledki so pokazali izrazite razlike v zmožnosti naselij, da spodbujajo vitalnost, zlasti z vidika dostopnosti infrastrukture in virov. V prostorskem smislu in skladno z drugim

raziskovalnim podvprašanjem je analiza pokazala, da bližina mestnega središča ni povezana s stopnjo vitalnosti. Namesto monotonega upadanja vitalnosti od mestnega središča navzven je bila najnižja stopnja vitalnosti (67.–69. mesto) ugotovljena v vmesnem pasu med mestnim središčem ter severnim in severovzhodnim obrobjem Niša. To kaže na žarišča nizke vitalnosti znotraj tega pasu, ne na enosmerno upadanje proti obrobju. Na vitalnost naselja torej bolj vpliva kombinacija njegovih virov kot pa oddaljenost od mestnega središča.

Raziskava je pokazala tudi izrazite digitalne in kulturne razlike. Čeprav ima večina naselij razmeroma dober dostop do virov in infrastrukture, ostaja pokritost z mobilnim omrežjem problematična – približno 25 % naselij ima slabo povezavo. To lahko omejuje digitalno vključenost prebivalcev, tj. dostop do možnosti, kot so delo na daljavo, spletno izobraževanje in e-trgovina, kar vpliva ne le na splošno vitalnost, temveč tudi na odzivnost v izrednih razmerah. Poleg tega v skoraj 90 % naselij ni kulturnih ustanov, ki so ključne za razvoj lokalnega družabnega življenja in identitete.

Glede na prostorsko porazdelitev vitalnosti bi se morali načrtovalski posegi osredotočati zlasti na naselja s srednjo stopnjo vitalnosti, ki obsegajo večino proučevanega območja.

5.2 Povezava s prejšnjimi raziskavami

Izsledki potrjujejo večdimenzionalnost vitalnosti mest, ki mora vključevati tako materialne kot nematerialne storitve in danosti, ki tvorijo kulturne in ekološke vire. Ugotovljene razlike niso razvidne iz prostorskih aktov mesta Niš, ki temeljijo na občinskih statističnih podatkih in tako zakrivajo podobčinske značilnosti. V tem smislu indeks vitalnosti zadovoljuje potrebo po podrobnih prostorsko indeksiranih pristopih, ki upoštevajo razlike v mestih (Liu idr., 2023). Z razkrivanjem neenakosti med naselji daje podlago za sprejemanje lokalnih odločitev, ki so bolj prilagojene potrebam vsakega naselja.

V skladu s tretjim raziskovalnim podvprašanjem izsledki potrjujejo tudi ključno vlogo družbenega razvoja pri zagotavljanju vitalnosti. Kazalniki družbenega razvoja (npr. število prireditelj in kulturnih ustanov) so zaradi razmeroma visokih uteži, določenih po metodi entropije, pokazali, da lahko že manjše razlike pomembno vplivajo na stopnjo vitalnosti. To se ujema z ugotovitvami Jane Jacobs (1961) in Roberta D. Putnama (2000), ki sta poudarila pomen socialne kohezije in državljankega udejstvovanja kot bistvenih sestavin trajnosti mest, ter z raziskavo, v kateri sta Osunkoya in Partanen (2024) ugotovili, da so družbenogospodarske spremenljivke pomembno povezane s stopnjo vitalnosti ali nanjo pomembno vplivajo. Razvrstitev naselij po metodi TOPSIS poleg tega kaže odstopanje od vzorca središčnosti, ki je pogost v postsocialističnih mestih in običajno pomeni marginalizacijo obrobni območij zaradi čedalje večje koncentracije naložb v mestnih središčih (gl. Vujošević idr., 2012; Petrović, 2009). Ugotovljena prostorska porazdelitev tako poudarja zlasti pomen medsebojnih razmerij med posameznimi kazalniki, ne pa njihovega rangiranja.

Nabor kazalnikov vitalnosti je v literaturi raznovrsten in dobro obravnavan. Lopes in Camanho (2013) sta se na primer osredotočila na uporabo javnih zelenih površin kot merljivega kazalnika vitalnosti mest. Galaktionova in Istrate (2025) sta predlagali uporabo funkcionalne gostote za vrednotenje vitalnosti ulic. Osunkoya in Partanen (2024) sta predlagali povezovanje tradicionalnih mer z velepodatki, kot so podatki mobilne telefonije. Garau in Annunziata (2022) sta proučevala gostoto pozidave in prebivalstva, razne indekse središčnosti, gostoto mestnih zanimivosti in kazalnike okoljske kakovosti. Putnam (2000) ter Putnam in Campbell (2010) so izpostavili kazalnike socialnega kapitala, kot so državljanstvo udejstvovanje, udeležba v verskih aktivnostih in skupnostna omrežja, kot družbeno razsežnost vitalnosti. Mnogi od teh kazalnikov so bili neposredno ali posredno vključeni v raziskavo, predstavljeno v tem članku – na primer bližina geoloških virov, ki je primerljiva s kazalnikom okoljske kakovosti v raziskavi, ki sta jo izvedla Garau in Annunziata (2022), prisotnost verskih objektov, primerljiva s kazalnikom udeležbe v verskih aktivno-

stih pri Putnamu (2000), ali pokritost z mobilnim omrežjem, primerljiva z mobilnimi podatki v raziskavi Osunkoye in Partanen (2024). Namen predstavljene raziskave je bil proučiti nabor kazalnikov, ki se nanašajo na infrastrukturo in vire pod javno oziroma občinsko upravo ter na podeželska naselja znotraj upravnih meja mesta, pri čemer so avtorji izvedli obsežen terenski popis infrastrukture in virov, s katerim so pridobili izhodiščni nabor kazalnikov. Posledično številni kazalniki, predlagani v literaturi, ki se večinoma osredotočajo na mestna središča, niso bili neposredno uporabni. Čeprav izbrani nabor kazalnikov ustreza zahtevam kontekstualne analize, hkrati omejuje izvedbo širše raziskave.

5.3 Omejitve

Ker je bila raziskava namenoma zasnovana tako, da poudari temeljne fizične dejavnike, ki lahko spodbujajo vitalnost, je ena od njenih omejitev odsotnost kazalnikov, ki se nanašajo na človeško aktivnost v analiziranih naseljih. Druga omejitev je uporaba kategoričnih mer (npr. prisotnosti kulturnih ustanov ali zdravstvenih storitev), ki lahko pretirano poenostavijo celovito naravo kakovosti, dostopnosti in rabe storitev. Izbrani nabor kazalnikov prikazuje trenutno stanje v naseljih, vendar ne vključuje časovne razsežnosti, ki bi lahko pokazala sezonske ali dnevne vzorce vitalnosti. Ne nazadnje so avtorji z osredotočanjem na kazalnike, ki se nanašajo na prvine v pristojnosti občin, tudi zavestno zanemarili tržno pogojene in skupnostno usmerjene aktivnosti, ki prav tako pomembno prispevajo k vitalnosti lokalnega okolja.

Avtorji so se zavedali, da ni mogoče ustvariti univerzalnega modela, ki bi bil primeren za vsa okolja, zato je bil njihov glavni cilj oblikovati temeljno prostorsko izhodišče s kazalniki, preverjenimi na terenu, in občinskim načrtovalcem ponuditi jasno operativno podlago za odločanje.

5.4 Prihodnje raziskave

V skladu z ugotovljenimi omejitvami bi morali biti v prihodnje raziskave vključeni podrobnejši podatki, na primer zmogljivost objektov, kakovost storitev ali zadovoljstvo uporabnikov, na podlagi katerih bi lahko bolje proučili razlike na ravni skupnosti. Drugič, skladno s predlogi Osunkoye in Partanen (2024) bi bilo smiselno rezultate nadgraditi z velepodatki (npr. podatki analize družbenih omrežij, podatki GPS in podatki o lokalnih storitvah, vključno s posodobljenimi podatki o ustanovitvi in zaprtju podjetij). Tretjič, v analizo bi bilo treba vključiti časovno razsežnost, kar bi omogočilo celovitejše razumevanje sprememb vitalnosti. Četrto, čeprav se s pristopom, ki združuje entropijo in metodo TOPSIS, zmanjša subjektivnost pri določanju uteži, se lahko nenamerno prenizko ovrednotijo ka-

zalniki z majhno spremenljivostjo, a velikim konceptualnim pomenom (npr. izobraževanje in zdravstvo). Ena od možnih rešitev je uporaba hibridnih pristopov, ki združujejo objektivne statistične razlike in mnenja strokovnjakov. Z vključevanjem navedenih dinamičnih meritev bi se prihodnje raziskave lahko usmerile k uporabi napovednega analitičnega okvira, ki bi pokazal, kako dodajanje posameznih fizičnih virov vpliva na vitalnost naselij.

6 Sklep

Avtorji so v članku predstavili indeks vitalnosti kot prilagodljivo orodje za prepoznavanje neenakosti in oblikovanje prostorskih strategij na podobčinski ravni. Pri tem je treba poudariti, da se izračunane uteži nanašajo na specifično obravnavano okolje ter odražajo strukturo podatkov in razlike na lokalni ravni. To potrjuje potrebo po prilagajanju analiz vitalnosti posameznim lokalnim razmeram in kaže, da je pristop mogoče prilagoditi tako, da omogoča odkrivanje pomembnih razlik med mestnimi območji.

V praksi lahko izsledki in metodološki pristop predstavljene raziskave prispevajo h krepitvi na dokazih temelječega odločanja, saj so lahko podlaga za lokalne načrtovalske strategije, ki temeljijo na virih in upoštevajo edinstvene značilnosti posameznega naselja. Hkrati so lahko izhodišče za nadaljnje izboljšave na podlagi vključevanja dinamičnih in demografskih kazalnikov, ki omogočajo boljši vpogled v vitalnost mest.

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