



A SCALABLE GIS-BASED APPROACH TO MAPPING ECOSYSTEM SERVICE CAPACITY USING CORINE LAND COVER DATA AND BURKHARD MATRIX: APPLICATION ON THE CITY OF NIŠ

Petar Vranić¹, Ivana Petkovski²

Abstract

Ecosystem services (ES) represent the benefits that natural and semi-natural ecosystems provide to human societies, yet their spatial distribution remains insufficiently integrated into urban and spatial planning practice in Serbia. This study presents a GIS-based assessment of ES capacity for the administrative territory of the City of Niš, combining CORINE Land Cover (CLC 2018) vector data with the Burkhard matrix scoring framework to quantify and spatially map provisioning, regulating and maintenance, and cultural ecosystem services across 22 land cover classes covering 59,622 ha.

The analysis reveals a pronounced center-periphery gradient, with the urbanized core forming a persistent cold spot of Very Low to Low ES capacity, while forested uplands and heterogeneous agricultural landscapes in the periphery constitute extensive hot spot zones. Total ES capacity is High to Very High across 68.46% of the territory, with only 2.29% classified as Very Low. A key contribution of this study is the full automation of the analytical workflow through a QGIS Python script, making the approach directly transferable to any Serbian municipality without reliance on commercial software and aligned with the EU Nature Restoration Law (2024). Principal limitations include the 25-ha minimum mapping unit, which underestimates ES provision by urban green infrastructure, and the absence of a regionally validated Burkhard matrix for Balkan ecosystem types. Future research should address higher-resolution data integration, field-based score validation, and demand-side ES analysis.

Key words: *ecosystem services, CORINE Land Cover, Burkhard matrix, urban and spatial planning, Niš, GIS, hot spot analysis*

¹ PhD, Senior Research Associate, Mathematical Institute, Serbian Academy of Sciences and Arts, Belgrade, Serbia, petarvv@mi.sanu.ac.rs, ORCID 0000-0002-9671-992X

² PhD, Research Associate, Mathematical Institute, Serbian Academy of Sciences and Arts, Belgrade, Serbia, ivana993@turing.mi.sanu.ac.rs, ORCID 0000-0001-7692-8436

1. INTRODUCTION

Green infrastructure (GI) together with ecosystem services (ES), are well known as core ideas in spatial and urban planning, and also in land use management. At the EU level, the biodiversity policy and the biodiversity legislation, incl. the EU Nature Restoration Law from 2024 [1], and Mapping and Assessment of Ecosystems and their Services framework (MAES), set up a required ES assessment and mapping, as baseline for decision-making [2]. Furthermore, the EU Green Deal officially folds in climate neutrality by 2050, and it's supposed to cover all essential sectors, too [3]. When Serbia signed the Sofia Declaration in 2020, it agreed to harmonize its growth in line with the Green Agenda for the Western Balkans, which means making Chapter 27 operational [4, 5]. In planning terms, this commitment is directly tied to weaving in ES like climate regulation, water safeguarding, erosion control and biodiversity conservation into spatial and urban planning, where ecosystems move beyond the matters of protections and turn into working infrastructural resources for the green transition [6].

Understanding spatial distribution of ES lets urban planners detect a supply-demand mismatch i.e., underserved population who can have low ES provision [7-10], and support informed decisions in protecting, restoring and designing green spaces in location in need. Thus, high resolution ES data can support identification of hotspots and cold spots in the urban areas informing tailored nature-based solution interventions [8, 11], and co-occurrences and segregation of multiple services for design of multifunctional sites or sites that resolve conflicting objectives (for example, heat mitigation often goes along with runoff retention, and in a few high carbon storage zones, there can be a trade off with other regulating services too) [12, 13]. When services clash, planners can sort out the trade-offs by zoning, conserving particular high-value areas, or creating multifunctional green spaces that serve more than one task. Another alternative is to prioritize services in specific neighborhoods depending on need [12].

Eco-friendly urban concepts such as Nature-based Solutions (NbS), Ecosystem-based Adaptation (EbA), Urban Green Infrastructure (UGI), and Blue-Green Infrastructure (BGI) effectively tackle these challenges. These concepts support urban planning practice that protect and rehabilitates metropolitan ecosystems. GI provides environmental and social ES that protect the environment, enhance public health, and facilitate adaptation to climate change. They decrease air temperature to mitigate urban heat island effects (UHI), filter pollutants, facilitate precipitation infiltration into the soil for urban water management, diminish flooding risk and alleviate pressure on drainage systems, and promote urban biodiversity [13-15].

Mapping and research of ES and GI in Serbia increased in recent years, prominently focusing on Belgrade and Novi Sada, while studies of other urban regions and smaller cities remain inadequately represented in scholarly literature. One of the first studies are related to the conceptualization of GI in Serbian context by [16] who analyzed Belgrade's GI at the residential block level looking at the communal green spaces as instrument for achieving multifunctionality and biodiversity. By applying various landscape metrics, [17] developed a framework for application of GI concepts in planning of urban forests in Belgrade, proving that ES can be quantified. Reference [18]



integrated GI principles studying urban-rural transitions in Novi Sad, Subotica, and Zrenjanin using Voronoi diagrams and landscape graphs to understand ES connectivity.

At the level of individual ES, [19] assessed the potential of ES of ornamental dendroflora in public green areas in Novi Sad. Reference [20] highlighted the potential of NBS tactics like green roofs, rain gardens, porous surfaces as a fundamental element of multifunctional ES in planning of GI of Novi Sad. A study of [21] suggests a geodesign framework for ES integration in planning of GI under uncertainty. Reference [22] makes attempts to quantify carbon sequestration capacity and biomass of urban trees in Topčider park in Belgrade, offering empirical evidence for the assessment of regulatory ES in urban environment.

Even with some progress on the international scene, Serbia still seems to miss standardized, reproducible quantitative tools that can really assess ecosystem service capacity, especially at local and regional level, and then be plugged into the everyday urban and spatial planning practice. Local governments, and also spatial planners, do not really get access to methodologies that are simple enough to carry out in practice, but also at the same time scientifically solid and aligned with the EU framework.

In line with the above mentioned this paper attempt to answer following research question: Is it possible, using publicly available data (CORINE Land Cover - CLC 2018) and standardized expert matrices [23] to develop a spatially explicit assessment of the capacity of ES for an urbanized administrative territory — and to what extent can such an assessment support urban and spatial planning decision?

2. METHODOLOGY

2.1. Study area

The City of Niš, with an area of 596.73 km², has a population of 178,976 in the urban area and 249,816 across the administrative territory, making it the third most populated city in Serbia. Since 2004, Niš has been administratively segmented into five municipal districts: Medijana, Palilula, Pantelej, Crveni Krst, and Niška Banja. In addition to the metropolitan areas of Niš and Niška Banja, the administrative jurisdiction included 68 rural communities. This study examines the entire administrative territory of the city.

2.2. Data

As an input this study used CLC seamless vector database Version 2020 20u1 (dated 02/2020) in ESRI GeoDatabase format. All features in original vector database were classified and digitised based on satellite images with 100 m positional accuracy (according to CLC specifications) and 25 ha minimum mapping unit (5ha MMU for change layer) into the standardized CLC nomenclature (44 CLC classes).



2.3. CICES V5.2 Classification Framework

ES were classified according to the Common International Classification of Ecosystem Services, CICES version V5.1/V5.2. The classification arranges ES in a five-level hierarchy: Section, Division, Group, Class and Class Type, so it is structured yet still flexible, and it supports assessments across different spatial scales, and thematic contexts too. 14 CICES V5.2 classes were assessed grouped into three sections: Provisioning services, Regulating and Maintenance, Cultural services.

2.4. Quantification method: Burkhard Matrix — expert based ecosystem service capacity assessment

The Burkhard matrix approach, first proposed by Burkhard et al. in 2009, and later updated in 2012 and 2014 [23-25], produces semi quantitative scores from 0–5 for each pairing of land use/land cover type and ES class (0 - No relevant capacity, 1 - Low capacity, 2 - Relevant capacity, 3 - Medium capacity, 4 - High capacity, and 5 - Very high capacity). In this study, the matrix spans 14 ES classes across the three CICES sections, and 22 CLC land cover classes identified as relevant to the land cover composition of the Niš administrative area, based on the CLC classes that were present in the dataset, which results in 308 assessed CLC × ES combinations (Figure 1). Each CLC class gets its own scoring pattern, meant to show provisioning, regulating and cultural capacity.

CLC land cover classes \ ES classes	Crops	Livestock	Wild foods	Timber	Energy biomass	Freshwater	Global climate regulation	Local climate regulation	Flood protection	Erosion regulation	Water purification	Pollination Biodiversity	Recreation & aesthetic	Cultural heritage
Continuous urban fabric	0	0	0	0	0	0	1	1	0	0	0	0	1	0
Discontinuous urban fabric	0	0	1	0	0	0	1	2	1	1	0	1	2	1
Industrial or commercial units	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road and rail networks and associated land	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Airports	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mineral extraction sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Green urban areas	1	0	1	0	0	0	2	3	2	2	1	2	4	2
Sport and leisure facilities	0	0	0	0	0	0	1	2	1	1	1	1	4	1
Non-irrigated arable land	4	1	1	0	2	1	1	1	1	2	1	2	1	2
Vineyards	4	0	2	0	1	1	2	2	1	3	1	3	3	4
Fruit trees and berry plantations	4	0	2	0	1	1	2	2	1	3	1	4	2	3
Pastures	1	4	2	0	2	1	2	2	2	3	2	3	2	2
Complex cultivation patterns	3	2	2	0	2	1	2	2	2	3	2	4	2	3
Land principally occupied by agriculture	2	2	3	1	2	2	3	3	3	3	3	4	3	3
Broad-leaved forest	0	0	3	4	3	3	5	4	4	4	4	4	4	4
Coniferous forest	0	0	2	5	4	3	5	4	4	4	4	3	3	3
Mixed forest	0	0	3	4	3	3	5	4	4	4	4	5	5	4
Natural grasslands	0	2	3	0	2	2	3	3	3	3	3	5	3	3
Transitional woodland-shrub	0	1	2	2	2	2	3	3	3	3	3	3	3	3
Inland marshes	0	0	2	1	1	3	4	3	5	3	4	5	3	3
Water courses	0	0	0	0	0	4	2	2	3	2	3	3	3	2

Figure 1. Evaluation matrix, Source: author

For the ES estimates per LULC class, several sources were blended, such as statistical data, model outputs, expert judgement, interview results, and also monitoring information, all of it gathered and then synthesized at a European scale. The method basically supports a kind of swift sorting of which ES could be delivered in an area, while



still being adaptable enough to ingest a whole set of evidence [25]. It's also worth noting that the original matrix model, plus the ES estimates within it, were refined step by step through tests and small corrections to individual ES estimates [24,25].

Here, the original matrix was applied as is, no regional recalibration is conducted, partly to keep the workflow reproducible, and partly to enable comparisons across studies. This is a deliberate Tier 1 methodological choice [26] even if it also brings a drawback: the scores were not cross checked against local ecosystem conditions in the Balkan biogeographical region. The approach also has well known weak points connected to uncertainty in expert judgements, and to differences between different scorers, which was already highlighted by [27] and [28].

2.5. CLC-to-CICES Mapping and GIS Implementation

Each CLC class present in the Niš administrative territory was mapped to its corresponding CICES V5.2 classes based on the Burkhard scoring matrix. Scores were then aggregated into three section-level composite indicators — Provisioning, Regulating & Maintenance and Cultural, computed as arithmetic means across all services within each section, preserving the 0–5 reference scale. The entire workflow was implemented in QGIS 3.x using the Python console.

3. RESULTS

The analysis of the vector layer identified a total of 402 polygons covering an area of 59,622.17 ha, spread across 22 CORINE Land Cover (CLC) classes. The landscape seems mostly deciduous forests, taking up 29.25% of the total area (17,439.75 ha), then come complex cultivation patterns with 19.31% (11,515.83 ha), and non-irrigated arable land at 19.07% (11,368.13 ha). Put together these three classes cover more than two-thirds of the study area, so it really points to a predominantly rural and forested character.

Urban fabric makes up around 7.54% of the territory, while water bodies and wetlands stay marginal at just under 1%. When it comes to provisioning ES there is this striking 88.53% of the whole area that ends up in the High and Very High groups, which suggests quite a strong ability of the Niš hinterland to provide those provisioning types of services like food production, timber, and freshwater (Table 1).

Table 1. Provisioning ES

Class	Min value	Max value	No. Polygons	P (ha)	Share (%)
Very Low	0	0.466	66	6150.22	10.32
Low	0.466	0.932	2	298.05	0.5
Medium	0.932	1.398	7	385.17	0.65
High	1.398	1.864	202	23416.47	39.27
Very High	1.864	2.33	125	29372.26	49.26
Total			402	59622.17	100

Regulating services look a bit less one sided in space, because around 58% of the area is labeled as High or Very High, while almost 29% drops into the Low to Medium



band, so overall it implies there is some real spatial heterogeneity in how climate regulation, water purification, and erosion control are delivered (Table 2). Cultural services somewhat mirrors that, with 58.55% of the area gathered in the higher value categories, meaning the recreational, aesthetic, and heritage potential is actually embedded within the varied land cover mosaic (Table 3). The overall ecosystem service value supports what has been said, with 68.46% of the study area put in the High or Very High group, while just 2.29% lands in the Very Low categories, which feels close to what we would expect from urbanized and somewhat degraded land surfaces (Table 4).

Table 2. Regulating and Maintenance ES

Class	Min value	Max value	No. Polygons	P (ha)	Share (%)
Very Low	0	0.866	20	1363.34	2.29
Low	0.866	1.732	77	15951.85	26.75
Medium	1.732	2.598	86	7696.87	12.91
High	2.598	3.464	161	16490.52	27.66
Very High	3.464	4.33	58	18119.59	30.39
Total			402	59622.17	100

Table 3. Cultural ES

Class	Min value	Max value	No. Polygons	P (ha)	Share (%)
Very Low	0	0.9	20	1363.34	2.29
Low	0.9	1.8	74	15806.55	26.51
Medium	1.8	2.7	85	7547.2	12.66
High	2.7	3.6	174	17182.18	28.82
Very High	3.6	4.5	49	17722.91	29.73
Total			402	59622.17	100

Table 4. Total ES

Class	Min value	Max value	No. Polygons	P (ha)	Share (%)
Very Low	0	9.6	20	1363.34	2.29
Low	9.6	19.2	43	4583.72	7.69
Medium	19.2	28.8	58	12856.58	21.56
High	28.8	38.4	228	22962.1	38.51
Very High	38.4	48	53	17856.43	29.95
Total			402	59622.17	100

4. DISCUSSION

Figure 2 shows clear but also consistent spatial patterns for ES capacity across the four assessed dimensions. There is a prominent contrast between the central urban core, and the surrounding rural and forested landscapes.

Provisioning ES capacity seems to have the sharpest spatial polarization. Cold spots—areas with Very Low to Low provisioning capacity (0.00–0.67) are mostly



grouped in the central, and south-central part of the study area, and these line up with the urban fabric of the city of Niš plus its immediate peri-urban zone. These cold spots end up forming a spatially contiguous patch, it stretches along the Nišava river corridor, running roughly east-west. On the other hand, hot spots of High to Very High provisioning capacity (1.66–2.33) are more common across the northern, western, and southern edges of the study area. There, forested land and agricultural cover basically dominate the scene.

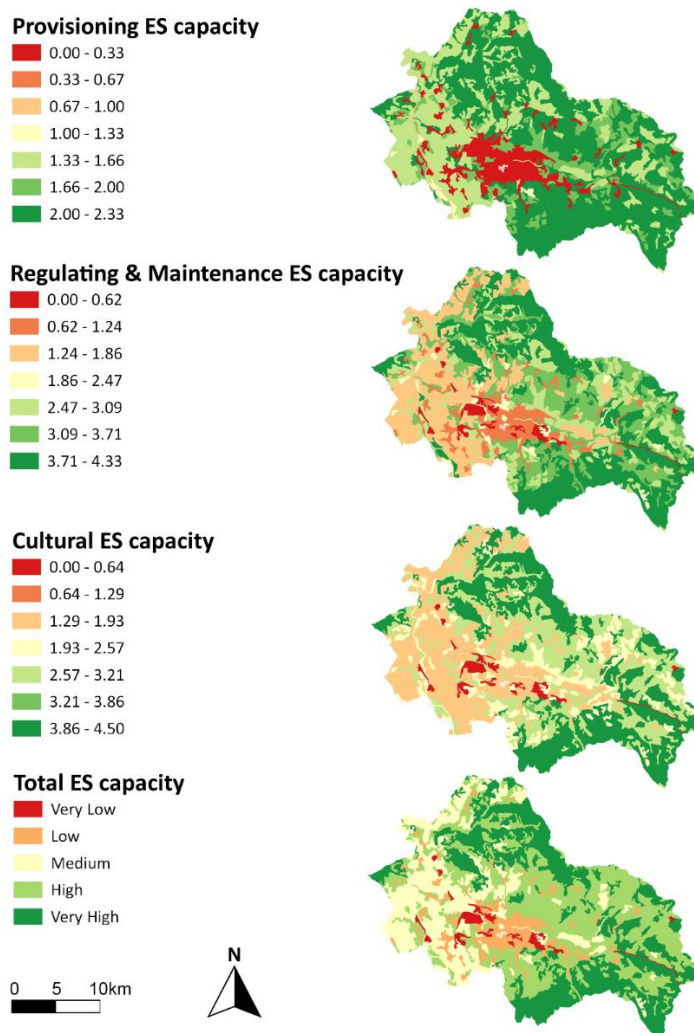


Figure 2. Spatial distribution of ES capacities, Source: author

When it comes to Regulating and Maintenance ES capacity, the displays are a bit more gradual and also rather spatially diffuse, not as sharply set out. Those cold spots stay anchored over the urban core, but they're noticeably less pronounced than what you see in the provisioning dimension. The shift from the lower to higher values moves

outward in a centrifugal gradient, and the strongest regulating capacity (about 3.71–4.33) sits mainly along the northern and southeastern forested uplands. There is also this intermediate area, not too high, not too low, moderate capacity (around 1.86–2.47) that shows up as a wide transitional belt, wrapping around the urban cold spot. This is probably tied to heterogeneous agricultural patterns, and mosaic land cover types.

For Cultural ES capacity, the overall spatial story follows the regulating pattern quite closely, though the details differ. Cold spots are locked to the urbanized central zone, and hot spots (3.21–4.50) appear along the forested northern and southern edges of the study area. The cold-spot zone seems slightly more extensive than in the regulating services, so cultural ES provision might be more sensitive to land cover fragmentation—especially in that peri-urban transition belt, where things tend to break up and mix.

The total ES capacity basically brings together all three dimensions and reaffirms the bigger spatial setup. The urban core functions as the main cold spot across the whole study area, it is labeled mostly as Very Low to Low, while the nearby forested and semi-natural landscapes create this wide hot spot ring, classified as High to Very High. There is also a clear secondary cold spot in the southeastern part of the study area, it looks like it could be tied to intensively managed cropland, or maybe smaller local settlement clusters.

In general, the spatial assessment shows that a center–periphery gradient is the key organizing principle for ES capacity in the Niš area, with the built-up fabric staying a persistent multi-dimensional cold spot, and the forested uplands essentially becoming the main hot spot area for every ecosystem service category that was checked.

5. CONCLUSION

This study shows that mapping ES capacity with CORINE Land Cover data and using the Burkhard matrix, can be a reproducible approach that's also low cost and policy relevant. It works for Serbian municipalities that don't have access to commercial GIS tools, or high-resolution spatial datasets. The results point to a clear center–periphery gradient which is consistent: the urban core keeps showing Very Low to Low ES capacity, across every dimension that was checked. Meanwhile, forested and semi-natural peripheral areas are basically the main hot spots for provisioning, regulating, and cultural services. Deciduous forests and mixed agricultural landscapes are the top ES providers, and together they span almost half of the study area.

From a methodological point of view, the fully automated QGIS based workflow developed here is directly transferable to any other local government unit in Serbia that has CLC data, and it gives a scalable baseline for ES monitoring at national level, still staying inside the MAES framework and the EU Nature Restoration Law (2024) in a pretty straight way. Still, there are two main limitations. First, the 25-ha CLC minimum mapping unit tends to systematically underestimate ES capacity in urban green infrastructure which is a bit problematic. Second, the Burkhard matrix, which was originally calibrated for ecosystems in northern and central Europe, has not been regionally validated for Balkan Forest types including communities that are typical for the Nišava basin. In particular, to our knowledge, there is currently no regional



adaptation of the matrix for the Western Balkans or for Serbia, so this remains an open methodological gap in the literature.

Future research should consider four directions. First, attempt for higher-resolution land cover inputs, like Urban Atlas or even local orthophoto imagery, so the green infrastructure details don't get flattened. Second, field work for validation and then recalibrate Burkhard scores across Balkan ecosystem types, because the local reality is never exactly the "same" everywhere. Third, build dynamic ES models that actually consider ecosystem condition and degradation, instead of assuming that structurally identical land cover classes are, somehow, functionally equivalent in practice. Fourth, bring in demand-side analysis using socioeconomic data, so you can run a more complete supply–demand ES assessment rather than only describing supply in isolation.

Also, making ES capacity mapping a mandatory step inside urban and spatial planning process would turn these results into planning tools one can use right away. That means the detected hot spot zones get explicit protection, and not just vague recommendations about avoiding land-use conversion.

ACKNOWLEDGMENT

This work was supported by the Serbian Ministry of Science, Technological Development and Innovation through the Mathematical Institute of the Serbian Academy of Sciences and Arts. We acknowledge the QGIS community's contribution.

LITERATURE

- [1] European Commission (2024). Regulation (EU) 2024/1991 on nature restoration. Official Journal of the European Union, L.
- [2] Maes J., et al. (2020). Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment. *Publications Office of the European Union*, Luxembourg. <https://data.europa.eu/doi/10.2760/757183> (15.5.2026.)
- [3] European Commission. (2019). The European Green Deal. *European Commission*, Brussels. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en (15.5.2026.)
- [4] Ministarstvo za evropske integracije Republike Srbije. (2020). Deklaracija iz Sofije o Zelenoj agendi za Zapadni Balkan. *MEI*, Beograd. <https://www.mei.gov.rs/srl/dokumenta/eu-dokumenta/zelena-agenda-za-zapadni-balkan/> (15.5.2026.)
- [5] Mladi istraživači Srbije / Koalicija 27. (2024). Izveštaj iz senke za Poglavlje 27 — Životna sredina i klimatske promene. *Mladi istraživači Srbije*, Beograd. <https://mis.org.rs/wp-content/uploads/2024/11/Koalicija-27-izvestaj-2024.pdf> (15.5.2026.)
- [6] European Parliament: Green Deal: key to a climate-neutral and sustainable EU. <https://www.europarl.europa.eu/topics/en/article/20200618STO81513/green-deal-key-to-a-climate-neutral-and-sustainable-eu> (15.5.2026.)
- [7] Ortiz M.S.O., Geneletti D. (2018). Assessing Mismatches in the Provision of Urban Ecosystem Services to Support Spatial Planning: A Case Study on Recreation and Food Supply in Havana, Cuba. *Sustainability*, Vol. 10, No. 7, p. 2165.
- [8] Baró F. et al. (2016). Mapping ecosystem service capacity, flow and demand for landscape and urban planning: A case study in the Barcelona metropolitan region. *Land Use Policy*. <https://doi.org/10.1016/J.LANDUSEPOL.2016.06.006> (15.5.2026.)



- [9] Yang Y., Ma J., Liu H., Song L., Cao W., Ren Y. (2023). Spatial Heterogeneity analysis of urban forest ecosystem services in Zhengzhou City. *PLOS ONE*, Vol. 18, No. 6, pp. e0286800.
- [10] Castillo-Cabrera F.J., Scheuer S., Cobos C.R., Santos G., Haase D. (2024). Implications from a Spatial Assessment of Urban Ecosystem Services for Guatemala City's Urban Planning. <https://doi.org/10.2139/ssrn.4724606> (15.5.2026.)
- [11] Vignoli F., Luca C.D., Tondelli S. (2021). A Spatial Ecosystem Services Assessment to Support Decision and Policy Making: The Case of the City of Bologna. *Sustainability*, Vol. 13, No. 5, p. 2787, doi: 10.3390/f16010017.
- [12] Karimi J.D., Corstanje R., Harris J.A. (2021). Bundling ecosystem services at a high resolution in the UK: trade-offs and synergies in urban landscapes. *Landscape Ecology*, Vol. 36, No. 6, pp. 1817–1835.
- [13] Li M. et al. (2024). Ecological Management Zoning Based on the Supply–Demand Relationship and Synergies of Urban Forest Ecosystem Services: A Case Study from Fuzhou, China. *Forests*, Vol. 16, No. 1, pp. 17–17.
- [14] Pandey, Bhanu, Annesha Ghosh. (2023). Urban ecosystem services and climate change: a dynamic interplay. *Frontiers in Sustainable Cities*, Vol. 5, 1281430. doi.org/10.3389/frsc.2023.1281430
- [15] Wang Dong, et al. (2024). Urban green infrastructure: Bridging biodiversity conservation and sustainable urban development through adaptive management approach. *Frontiers in Ecology and Evolution*, Vol. 12, 1440477. doi.org/10.3389/fevo.2024.1440477
- [16] Djokić V, Zeković S, Furundžić D, Milovanović A. (2017). Building the Green Infrastructure of Belgrade: The Importance of Community Greening. *Sustainability*, Vol. 9, No. 7, str. 1183.
- [17] Vasiljević N., Radić B., Gavrilović S., Šljukić B., Medarević M., Ristić R. (2018). The concept of green infrastructure and urban landscape planning: a challenge for urban forestry planning in Belgrade, Serbia. *iForest — Biogeosciences and Forestry*, Vol. 11, str. 491–498.
- [18] Gavrilović S., Vasiljević N., Radić B. (2022). A Green Infrastructure Planning Approach: Improving Territorial Cohesion through Urban-Rural Landscape in Vojvodina, Serbia. *Land*, Vol. 11, No. 9, str. 1550.
- [19] Ljubojević M., et al. (2023). Assessment and potential of ecosystem services of ornamental dendroflora in public green areas. *Environmental Science and Pollution Research*, Vol. 30, No. 2, str. 2850–2865.
- [20] Pušić M., et al. (2022). Rethinking Horticulture to Meet Sustainable Development Goals — The Case Study of Novi Sad, Serbia. *Horticulturae*, Vol. 8, No. 12, str. 1222.
- [21] Polovina S. (2025). Geodesign Framework in Green Infrastructure Planning: Prioritizing Uncertainty in the Future of Urban Ecosystem Services. U: *Digital Dreams, Urban Realities*, Springer, Cham, str. 79–101.
- [22] Ocokoljić M., et al. (2026). Diversity, Growth Parameters, and Ecosystem Services of Urban Trees Under Climate-Change Conditions: A Case Study of Topčider Park. *Forests*, Vol. 17, No. 1, str. 114.
- [23] Burkhard B., Kroll F., Müller F., Windhorst W. (2009). Landscapes' Capacities to Provide Ecosystem Services – a Concept for Land-Cover Based Assessments. *Landscape Online*, 15, 1–22. DOI:10.3097/LO.200915
- [24] Burkhard B., Kroll F., Nedkov S., Müller F. (2012). Mapping ecosystem service supply, demand and budgets. *Ecological Indicators*, 21, 17–29.
- [25] Burkhard B., Kandziora M., Hou Y., Müller F. (2014). Ecosystem service potentials, flows and demands. *Landscape Online*, 34, 1–32.
- [26] Grêt-Regamey A., et al. (2015). Tiered approach for rapid ecosystem service assessment. *One Ecosystem*, 2.
- [27] Jacobs S., et al. (2015). The Matrix Reloaded: A review of expert knowledge use for mapping ecosystem services. *Ecological Modelling*, 295, 21–30.
- [28] Hou Y., Burkhard B., Müller F. (2013). Uncertainties in landscape analysis and ecosystem service assessment. *Journal of Environmental Management*, 127, S117–S131. DOI:10.1016/j.jenvman.2012.12.002