sciendo

Leveraging Green Tourism and Digital Innovation for Sustainable Urban Development: A Case Study of Belgrade

Radmila JOVANOVIĆ*
Institute of Agricultural Economics, Belgrade, Serbia; University of Málaga, Málaga, Spain
Corresponding author, jogurada@yahoo.com

Fernando ALMEIDA-GARCÍA
University of Málaga, Málaga, Spain
falemida@uma.es

Roxana-Elena LEPADATU
Bucharest University of Economic Studies
lepadaturoxana20@stud.ase.ro

Abstract. *Green tourism and emerging digital technologies integration towards sustainable urban development is discussed in this topic, with special reference to urban parks of Belgrade. Green tourism has come up as a rising alternative for mass tourism in efforts to offset adverse environmental consequences of tourism practices and enhance the overall tourism experience. The role of urban green spaces towards enhanced urban living and their sustainability-potential towards promoting tourism growth is examined here. By applying GIS and remote sensing technologies, that is, LANDSAT satellite data from 1992 and 2022, the transformation in the composition of Belgrade's urban parks is examined, where forest cover diminished by 0.34 km² and grassland expanded by 0.45 km² during the last three decades. These alterations suggest that the dynamics of urbanization and infrastructure development are impacting the ecological equilibrium of green areas. The importance of using digital tools (such as mobile devices and augmented reality) to enhance the visitor experience and support park management is also emphasized. These results underline the importance of monitoring-wise ways that the two can develop simultaneously, or do not. The findings indicate the need for careful monitoring and management to achieve a balance between urban growth and the preservation of green spaces. Other studies must target research on efficient ways of mitigating the negative effects of urbanization on green spaces so that they remain to serve ecological, recreational, and tourism functions.*

Keywords: green tourism, sustainable urban development, urbanization, digital tools, gis, remote sensing, Belgrade.

Introduction

Parks, in addition to their aesthetic value, provide psychological, health, and social benefits. Green spaces help people relax and reduce stress and aggression caused by the fast-paced lifestyle in urban environments. Modern green areas play a vital role in enhancing the urban landscape, creating a balance between nature and human activity. The most significant effects of urban green spaces include improving quality of life, mental health of residents, reducing air pollution, increasing oxygen production, and controlling wind flow. Open space or green areas in urban areas refer to any undeveloped land (without constructed buildings or other structures) that is publicly accessible to all individuals. Open spaces in urban areas include a variety of land uses, ranging from recreational spaces to areas with natural landscapes. Land outside urban boundaries, such as open spaces in rural areas, does not constitute an urban (open urban area).

DOI: 10.2478/picbe-2025-0392

The development of urban green spaces is crucial for creating safer, cleaner, and healthier urban environments (Vrećić, 2010), which are significant for sustainable urban and tourism development. On the other hand, these areas are threatened by excessive construction due to urbanization and tourism growth (Perković & Opačić, 2020).Among the most famous events organized within Belgrade parks are the Festival of Flowers in Belgrade, "Organic Live Fest" in Topčider Park, Street Workout Festival in Tašmajdan Park, International Fair of Beekeeping at Tašmajdan Park, and "Classical Music Light" Festival at Kalemegdan. In addition, sports events such as a chess tournament in the Ethno Park on Senjak and table football tournament in the City Park in Pančevo may be another source to develop business due to tourism.

Geographic Information Systems (GIS) in tourism help assess resources, visitor trends, and infrastructure for sustainable development through planning and environmental impact assessments. They assist in identifying conflicts and achieving a balance between economic development and the preservation of nature and culture (Wei, 2024; Bahaire & Elliott-White, 1999; Tiwari et al., 2014). Green tourism is an important sustainable alternative to mass tourism, especially in cities like Belgrade. Its goal is to reduce negative environmental impacts and promote sustainable tourism (Ivanović et al., 2016). In Belgrade, applying green principles in tourism helps preserve the environment and improve the tourism offer (Šimičević et al., 2024).

Green tourism management and promotion are being revolutionized by digital transformation. Most cities and countries have adopted new systems that not only make cities more sustainable but also create new tourist experiences, such as the Italy-Switzerland INSUBRI.PARKS project of open-source software for tourism management (Oxoli et al., 2020). These innovations involve using technologies like augmented reality, artificial intelligence, and data analytics to improve the management of city parks and the overall tourist experience (Pristouris et al., 2021; Jha, 2024; A'yun et al., 2023).

Digital transformation is reshaping the management and promotion of green tourism. Many cities and countries have adopted new systems that not only increase the sustainability of cities but also create new tourist experiences, such as the INSUBRI.PARKS project between Italy and Switzerland using open-source software for tourism management (Oxoli et al., 2020). These advancements incorporate technologies like augmented reality, artificial intelligence, and data analysis to improve the management of urban parks and the overall tourist experience (Pristouris et al., 2021; Jha, 2024; A'yun et al., 2023).

The technological revolution has impacted the development of tourism, transport, and communications. The use of new technologies has improved the quality of services in tourism. Digital tools like mobile apps, GIS systems, and visitor data allow tourists to quickly access information. Modern tourists use the internet, search engines, blogs, social media, and GPS mapping. The application of remote sensing technology and GIS enables precise monitoring of changes in green spaces and better integration of data to enhance tourism. Urban parks in Belgrade are extremely significant in the provision of green infrastructure and ecosystem services for the improvement of the well-being of the people. Community greening has emerged as a viable approach to the enhancement of local green infrastructure quality as a substitute for institutional maintenance regimes (Simić et al., 2017). The potential use value and value of Belgrade urban parks have been studied, highlighting their contribution in urban planning of the city (Galečić et al., 2016). The elimination of ecological pollution and stimulation of citizen participation in maintaining parks would immensely contribute to Belgrade's park ecological value and public health benefit.

The focus of the paper is the analysis of urban green spaces using LANDSAT satellite data from 1992 and 2022 in selected parks in Belgrade, employing remote sensing and GIS. These methods enable monitoring and data management, enhancing the use of data for tourism purposes. The application of remote sensing and GIS allows better tracking of changes in green spaces, improving the quality of the tourist offering. Monitoring green spaces is important for creating a pleasant and suitable living environment in urban areas (Rusli, N., Ludin, A.N.M., 2009).

Similar to ecotourism, green urban tourism is a relatively new concept, which was initially launched by a group of stakeholders and organizations interested in exploring the potential of ecotourism in Toronto. It aims at maintaining the conservation of natural and cultural attractions by traveling to urban places. Urban green tourism includes features like building and renovating using energy-efficient construction, preservation of historical and natural sites, and constructing sustainable transport infrastructure like railway networks, cycling routes, and walkways, all of which minimize environmental footprint and ensure environmentally friendly mobility within cities (Dodds & Joppe, 2001).

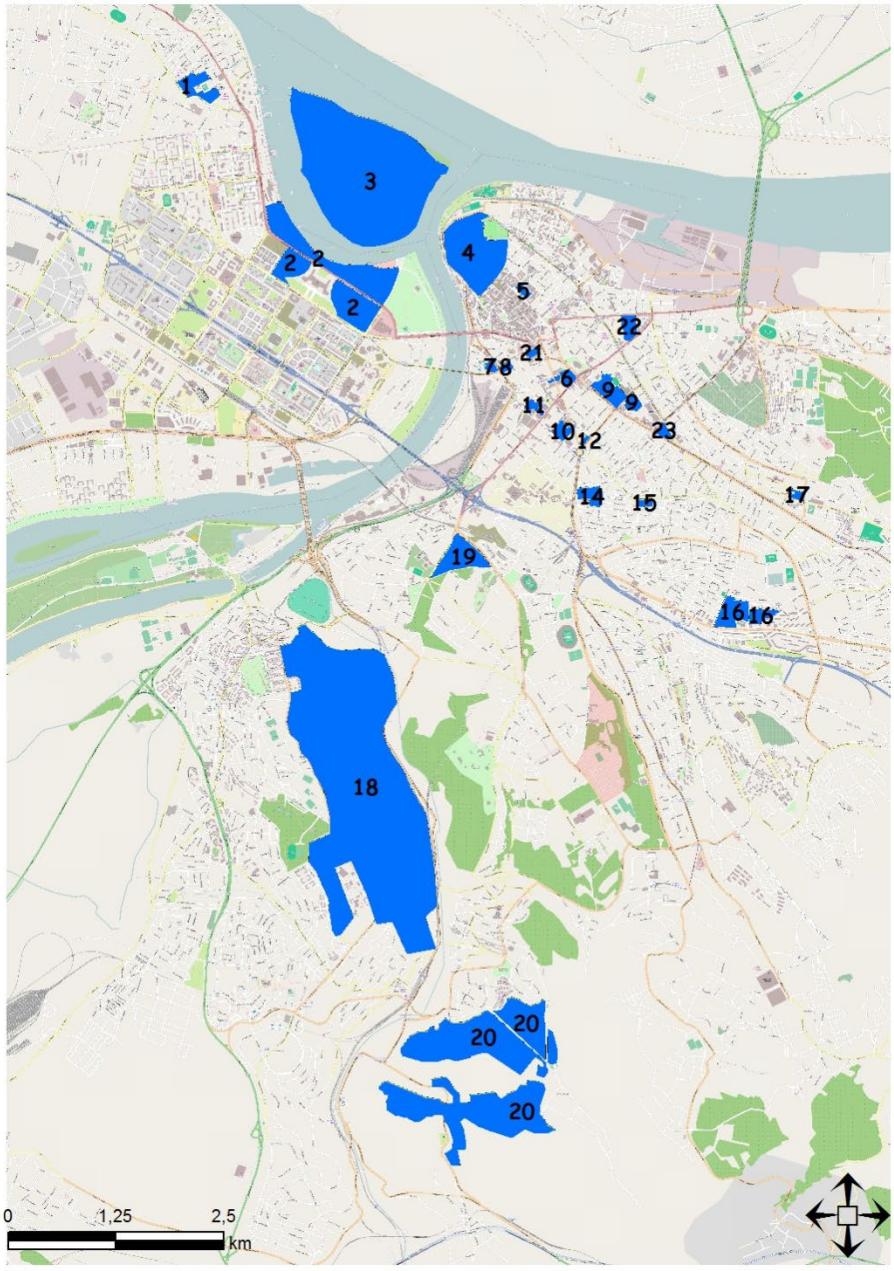
The park visit experience can be valorized with mobile applications and augmented reality systems, such as in Pristouris et al. (2021) and Štetić et al. (2020). These applications may give information about flora, fauna, and points of interest, making the tours more interactive and interesting, as found by Ferentinos et al. (2020). They can also support park managers in organizing events or analyzing visitors' data, among other ways of improving the overall quality of the parks (Pristouris et al., 2021).

Public spaces in Belgrade have gone through a series of changes that have improved urban mobility, accessibility, and comfort (Vuković et al., 2021). Using digital tools for park management, Belgrade can become more attractive to tourists and locals, while at the same time raising environmental awareness and green tourism (Ferentinos et al., 2020; Pristouris et al., 2021).

Belgrade was chosen for this study over other cities in the region due to its unique status as a rapidly emerging urban center, one which in recent decades has emerged as a leading site of construction and a key node of road, rail, and river access and the hub of the Balkan Peninsula. Being the capital city of Serbia, Belgrade is also a major emission center, enabling tourists to move in smaller distances and reside for longer, thus making it a tourist destination. Belgrade is an escalating intensive case of the smart city phenomenon, where smart technologies are being installed and the collaboration between various actors playing a determining role in its attainment. Due to the combination of historical, cultural, and natural aspects, Belgrade represents a prime case study of the notion of tension between urban development and preserving green areas, which makes it sit well within relevance in the context of ecotourism. Although other capitals like Zagreb or Sarajevo face similar problems, Belgrade has a greater population basis, more ample park areas, and is a capital city, a large city for sustainable tourist development and employment of digital technologies like GIS and remote sensing in effective park administration and tourism product development.

Study area

Great War Island, with an area of 2.01 km², represents the largest green space and is protected by the state as an area of exceptional natural value, divided into three protective zones: Zone III (tourism and "Lido" beach), Zone II (recreation), and Zone I (nature and biodiversity protection). In comparison, parks in the central zone of Belgrade, such as the park near Slavija Square (0.007 km²) and the park near the Old and New Palaces (0.006 km²), have significantly smaller areas. However, these smaller parks still play an important role in the analysis (Map 1).



Map 1. Geographical Overview of Analyzed Parks in Belgrade

Source: Elaborated by Authors.

1 - City Park, 2 - Friendship Park and Danube Quay, 3 - Great War Island, 4 - Kalemegdan, 5 - Student Park, 6 - Pioneer Park, 7 - Bristol Park, 8 - Park near the Faculty of Economics, 9 - Tašmajdan Park, 10 - Manjež Park, 11 - Financial Park, 12 - Park near Slavija Square, 13 - Park near the Old and New Palaces, 14 - Park near the Church of St. Sava, 15 - Čubura Park, 16 - Šumice, 17 - Park near the VI Belgrade High School - Slavujev Potok, 18 - Košutnjak, Pioneer City, and Topčider, 19 - Hajd Park, 20 - Miljakovac Forest, 21 - Terazije Terrace, 22 - Botanical Garden "Jevremovac", 23 - Cyril and Methodius Park

On the other hand, larger green spaces such as Great War Island, Košutnjak, Topčider, Pioneer City, and Miljakovac Forest are characterized by larger areas and a greater share of urban vegetative cover, which further highlights their importance in the urban ecosystem.

Methodology

The Normalized Difference Vegetation Index (NDVI) serves to evaluate vegetation in urban parks, which differ in size and plant coverage (Bilgili, 2013). Gamarra et al. (2016) and de Souza Pinto et al. (2021) highlight that NDVI is crucial for assessing ecological variability, plant structure, and for grasping the effects of human actions while evaluating ecological resilience by tracking alterations in land use and vegetation quality over time in parks and nearby regions.The range of NDVI values varies from negative (indicating water bodies or bare soil) to positive (signifying dense vegetation), allowing for an in-depth spatial assessment of vegetation distribution in urban parks (Jasim, 2019). These findings indicate that when combined with remote sensing and GIS technologies, NDVI provides a cost-efficient and effective approach for overseeing and managing urban green areas. The data gathered in this research was sourced from Landsat Thematic Mapper 4-5 (1992) and Landsat 8 (2022). The Landsat images were processed using GIS tools to estimate NDVI and analyze the vegetation changes.

In the context of Belgrade, satellite imagery from Landsat Thematic Mapper 4-5, captured on August 7, 1992, and from Landsat 8 Optional Land Image, captured on August 9, 2022, was used to analyze selected parks. After detection, the data was processed and analyzed using GIS tools. For the purpose of calculating NDVI (Normalized Difference Vegetation Index), a combination of bands was used: for Landsat Thematic Mapper 4-5, Band 3 (Visible Red, 0.63 – 0.69 μm) and Band 4 (Near-Infrared, 0.76 – 0.90 μm); and for Landsat 8 Optional Land Image, Band 4 (Visible Red, 0.630 – 0.680 μm) and Band 5 (Near-Infrared, 0.845 – 0.885 μm).

The NDVI value represents the level of photosynthetic activity in the observed vegetation, providing a measure of vegetation density on the Earth's surface. Higher NDVI values indicate stronger and more abundant vegetation. NDVI values range from -1 to 1, where -1 typically corresponds to water bodies or bare soil, and 1 represents dense vegetation cover. NDVI is calculated from reflected visible (VIS) and near-infrared (NIR) light.

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$$

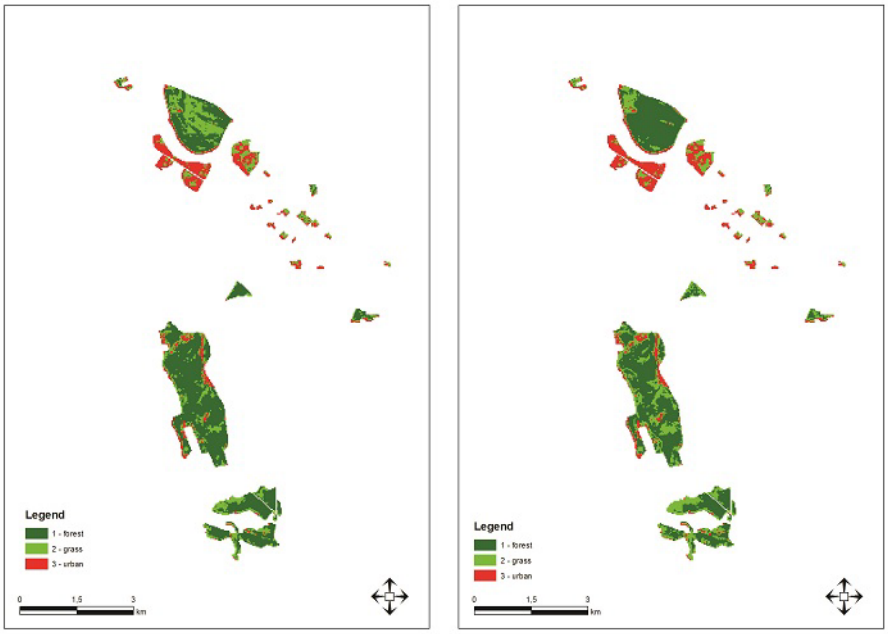
This approach is crucial for overseeing and monitoring urban parks and green areas, offering a comprehensive overview of their ecological well-being and possibilities for sustainable urban development. It is enhanced by the digital shift utilizing satellite imagery and GIS technology.

The limitations related to the application of this methodology concern the accuracy of data, which is related to remote sensing and, as such, depends on the resolution and frequency of satellite images. This is particularly important for green belts in urban areas, where they are fragmented and highly subdivided. Another limitation that complicates the analysis is data access, as some images are commercial, making access to them restricted, especially for very small spatial units that were processed and analyzed in this study.

Results and discussions

On Map 2, it is noticeable that the most red color, which indicates urbanized areas, is found in the parks closer to the city center, while the green color is dominant in the peripheral parks, such as

Great War Island, Košutnjak, Topčider, Pioneers' Town, and Miljakovac Forest. This pattern may suggest that central urban areas are more prone to the expansion of urban zones, while green spaces in the periphery still maintain a significant share of forest and grassland vegetation.



Map 2. NDVI Index Distribution Map for 1992 and 2022 period

Source: Elaborated by Authors.

In the analysis of changes in the structure of green spaces in cities over a three-decade period, the results show significant changes in the composition and spatial distribution of vegetation. Of the park's total area, 9.42 km², urban forest vegetation covered 5.46 km² in 1992, and in 2022 it covered 5.12 km², i.e., it decreased by 0.34 km² during the period. This can be explained by processes of urbanization and infrastructure development, which can have affected the decrease in forest areas in the city center and its vicinity.

Meanwhile, grassland land increased from 2.36 km² to 2.81 km², an increase of 0.45 km² over the period of twenty years. The rise in grassland land might be the spread of urban parks and green areas used as recreational sites by the populace. The urban area, though less than the other types, also grew, from 1.38 km² to 1.70 km², showing that urbanized areas in the parks being researched have increased marginally, with additional infrastructure construction in these regions.

The spread of grassland and urban development in certain parks, such as Hajd Park and Park Šumice, may be the result of efforts to increase the functionality of urban green areas, but it is also an indication of a trend that is not entirely compatible with sustainable development goals.These changes indicate that while the amount and character of green cover are increasing, strict control of the spread and preservation of forest patches and natural vegetation within urban zones should be performed so as to provide properly balanced development which does not compromise ecological stability.

Conclusion

Modern technology has opened great space for tourism development, and in the era of technology tourism is greatly depends on technology. On the one hand, the development of computer technology allow tourists access to information of destination that they want in a short time. In contrast, it serves as a platform for the observation and analysis of both natural elements and urban elements. The process of urbanization today is accompanied by a rapid growth trend (based on the 1991 census, Belgrade had a population of 1,602,226; the 2011 census recorded 1,639,121 inhabitants). So monitoring green spaces already allows to ledger and avoid the deteriorations of the green oases of the city.

The research findings on GIS, remote sensing, and green tourism in Belgrade can be applied to other cities facing similar challenges. Barcelona, Berlin, and New York can use GIS to organize urban development and preserve green areas. Mumbai and Tokyo can use real-time data and GIS to combat rapid urbanization. Copenhagen and Stockholm can construct green tourism via digital technologies, Amsterdam and Paris can enhance park management systems, Vienna and Prague can commercialize parks via ecotourism activities, preserving development and protecting green spaces. All these means can help the world's cities in enhancing sustainability and tourist attractiveness.

Green areas in densely populated cities enjoy more importance and a bigger part today than they did before. As new generation computer technological tools, remote sensing and GIS enhance the monitoring of successive changes in the use of green (urban) spaces. Some of the key elements of GIS that can be profitable for tourism in the future include planning, along with the manipulation of data and spatial analysis. In Belgrade, selected parks have witnessed changes over a twenty-year period (1992-2022), with categories 2 and 3 showing increases (urban land increased by 0.15 km², and grassland by 0.18 km²), while category 1 (forest urban vegetation) decreased by 0.32 km². The reduction of green spaces directly diminishes the potential for green urban tourism development, which can lead to reduced additional sources for local communities and Belgrade's municipalities. This paper has highlighted some events and festivals held in selected parks, which, with improved marketing, could contribute to enhancing Belgrade's tourist offer.

Urban parks are an integral element of urban development and are key to the tourist experience. As shown in this study, remote sensing and GIS technologies provide crucial tools for the monitoring and management of these sites, conserving them while also being part of a more sustainable tourism model. The green tourism of Belgrade's sustainable development, as well as the application of new technologies, provides a way to protect the environment and build tourism, particularly as thematic ensembles, with a focus on economic development, especially through tourism, while prioritizing green sustainability and preservation of these sites.

Green tourism in Belgrade, with the application of new and smart technologies, can be developed alongside sustainable development, balancing modern urbanization and the protection of green spaces. Future research directions can be seen through the use of drones and real-time satellite monitoring to better manage green parks and areas. In the future, research should focus on the commercialization of parks, particularly as thematic units, with an emphasis on economic development, especially through tourism, while simultaneously prioritizing the sustainable protection of green spaces.

Acknowledgement

The paper is a part of research financed by the MSTDI RS, agreed in decision no. 451-03-136/2025-03/200009 from 4.2.2025.

The research was funded by the project: Adaptation strategies and alternatives from inland tourism destinations in times of change (ADAPTATUR) (PID2020114186RB-C22), Ministry of Science and Innovation, Government of Spain.

This paper was co-financed by The Bucharest University of Economic Studies during the PhD program.

References

A'yun, M., Ratnasari, C., & Pratama, A. (2023). Digital transformation in heritage tourism management: The case of Kampung Wisata Kauman Yogyakarta. *AIP Conference Proceedings*, *2508*, 020025. https://doi.org/10.1063/5.0119548

Bahaire, T., & Elliott-White, M. (1999). The application of geographical information systems (GIS) in sustainable tourism planning: A review. *Journal of Sustainable Tourism, 7*(2), 159–174. https://doi.org/10.1080/09669589908667333

Bilgili, B. C., Şatır, O., & Müftüoğlu, V. (2013). Using NDVI values for comparing parks in different scales. *Journal of Food, Agriculture & Environment, 11*(3&4), 2451–2457.

de Souza Pinto, J., Pinto, A., Pinto, V., Oppliger, E., & Oliveira, A. (2021). Análise das mudanças do uso e cobertura da terra em dois parques urbanos e seus entornos em Campo Grande, Mato Grosso do Sul. *Boletim de Geografia, 39*, 33–48. https://doi.org/10.4025/bolgeogr.v39.a2021.e59194

Dodds, R., & Joppe, M. (2001). Promoting urban green tourism: The development of the other map of Toronto. *Journal of Vacation Marketing, 7*(3), 261–267. https://doi.org/10.1177/135676670100700306

Ferentinos, K. P., Stavrakas, Y., Nakos, H., Pristouris, K., & Barda, M. S. (2020). Initial design and features of an augmented reality system for urban park touring and management. *International Journal of Computer Theory and Engineering, 12*(5), 106-112. https://doi.org/10.7763/IJCTE.2020.V12.1273

Galečić, N., Tomičević-Dubljević, J., Ocokoljić, M., Vujičić, D., & Skočajić, D. (2016). Quality and utilization potential of urban parks: Case study Tašmajdan Park, Belgrade, Serbia. *Šumarski list, 140*(9-10), 6. https://doi.org/10.31298/sl.140.9-10.6

Ivanović, V., Gasic, M., Perić, G., & Krulj Mladenović, M. (2016). Zeleni turizam kao deo zelene ekonomije u funkciji buduće održivosti [Green tourism as part of the green economy in the function of future sustainability]. *Ecologica, 23*(81). https://ssrn.com/abstract=2962446

Jasim, A.-F. (2019). Study of spatial distribution of vegetation index of Al-Zawra Amusement Park in Baghdad area using geotechnics. *Iraqi Journal of Agricultural Sciences, 50*(Special). https://doi.org/10.36103/ijas.v50iSpecial.188

Jha, M. (2024). The role of digital transformation in business and its impact on sustainable development goals (SDGs) in the tourism sector. *SDGs Studies Review, 5*(1). https://doi.org/10.37497/sdgs.v5igoals.10

Macedo Gamarra, R., Teixeira-Gamarra, M. C., Gutiérrez Carrijo, M. G., & Paranhos Filho, A. C. (2016). Uso do NDVI na análise da estrutura da vegetação e efetividade da proteção de unidade de conservação no cerrado. *RAEGA - O Espaço Geográfico Em Análise, 37*, 307–332. https://doi.org/10.5380/raega.v37i0.42454

Oxoli, D., Terza, V., & Brovelli, M. (2020). An open IT infrastructure for green tourism management and promotion: The INSUBRI.PARKS project. *ISPRS - International Archives of the Photogrammetry Remote Sensing and Spatial Information Sciences*, *XLIII-B4-2020*, 277–281. https://doi.org/10.5194/isprs-archives-XLIII-B4-2020-277-2020

Perković, D., & Opačić, V. T. (2020). Metodološki pristupi istraživanjima urbanih zelenih površina u kontekstu turističkog razvoja obalnih područja [Methodological approaches to the research of urban green spaces in the context of coastal area tourism development]. *Geoadria, 25*(1). https://doi.org/10.15291/geoadria.3017

Pristouris, K., Nakos, H., Stavrakas, Y., Kotsopoulos, K. I., Alexandridis, T., Barda, M. S., & Ferentinos, K. P. (2021). An Integrated System for Urban Parks Touring and Management. *Urban Science, 5*(4), 91. https://doi.org/10.3390/urbansci5040091

Rusli, N., & Ludin, A. N. M. (2009). Integration of remote sensing technique and geographical information system in open space and recreation area evaluation. Paper presented at the *10th SENVAR & 1st CONVEEESH*, Manado, Indonesia.

Simić, I., Stupar, A., & Djokić, V. (2017). Building the green infrastructure of Belgrade: The importance of community greening. *Sustainability, 9*(7), 1183. https://doi.org/10.3390/su9071183

Šimičević, D., Leković, J., & Ilić, M. (2024). Green practices in management of sustainable tourist destinations: The case of Belgrade. *Tourism International Scientific Conference Vrnjačka Banja - TISC, 8*, 87–97. https://doi.org/10.52370/TISC2487DS

Štetić, S., Šimičević, D., Aksentijević, J., & Trišić, I. (2021). Mobile apps as a tool for destination management - case study of Belgrade. In *TMT 2020: Tourism in Modern Society* (pp. 569-584). https://doi.org/10.31410/tmt.2020.569

Tiwari, A., Merugu, S., & Rai, A. (2014). Ecological planning for sustainable development with a green technology: GIS. *International Journal of Advanced Research in Computer Engineering & Technology, 3*(3), 636–641.

U.S. Geological Survey. (1992). *Landsat Thematic Mapper (TM) data*. U.S. Department of the Interior. https://www.usgs.gov

U.S. Geological Survey. (2022). *Landsat 8 OLI/TIRS data*. U.S. Department of the Interior. https://www.usgs.gov

Vrećić, S. (2010). Strategija razvoja zelenih površina na primerima Plimuta i Beograda [Strategy for the development of green spaces in Plymouth and Belgrade]. *Nauka + Praksa, 13*, 157–160. https://doi.org/10.62683/NiP13.157-160

Xing, W. (2024). Leveraging GIS for sustainable tourism development: A comprehensive spatial approach. *Applied and Computational Engineering, 106*, 13-18. https://doi.org/10.54254/2755-2721/106/20240911