

Monitoring changes of NDVI in the function of green urban tourism in urban areas: the example of Belgrade parks

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Abstract.

Green urban tourism gives possibilities for additional economic activities and opportunity for developing further tourist offer of Belgrade. The Belgrade's parks are frequent venues for various festivals and events. The primary role of parks are the space intended for sports, recreation and natural landscape, which additionally motivate the tourists to visit the green oases of urban areas.

The main goal of the paper is to analyze the change of urban green space using LANDSAT satellite data for period 1990 - 2020 in selected Belgrade's parks. The trend of decreasing forest cover and increasing urban area in the analyzed parks is shown during the monitoring period of 30 years. Based on satellite imagery, areas covered by forests of selected parks have the biggest changes for analyzed period (areas of forest decreased by 3.47%). For the same period, the urban area increased by 1.66%.

The dynamics of NDVI change was ascertained on the monitoring of satellite imagery, remote sensing and the use of GIS techniques as a modern and efficient way of examining changes in urban vegetation cover.

Keywords: urban green tourism, Belgrade's parks, remote sensing (NDVI, LANDSAT), change, analysis

Introduction

The technological revolution also affected the development of tourism, as well as other sectors (transportation, communications, etc.). In the past, when technology was rarely used in the tourism sector, most services were of poor quality. With the use of new technologies in tourism, the level of services has been improved and raised to a higher level. The biggest application of new technology is in getting answers to questions about information: what types of media do tourists use to get information? How do people get new information? How do they find certain information? What e-tool is available to them? Answers to these questions are made possible by the new technology that provides them with digital data: text, video, photo, blogs, social networking, Internet, etc.

Modern tourists can find, use and share information in various ways: Internet (sites), search engines, blogs, e-mail, PDA, GPS mapping, laptops, tablets, social networks, etc. (New Technologies In Tourism).

Application of remote sensing technology with GIS enables data monitoring and management, and their integration results in a better data utilization system. Monitoring of green and recreational areas is important in order to create an environment that is pleasant and suitable for living in urban areas (Rusli & Ludin, 2009).

The city's green areas provide opportunities for recreation and experiencing nature. These functions are essential to improve the quality of life of citizens (Rafiee, et al., 2009). Open space or green space in the urban area is any open part of the land that is undeveloped (no buildings or other structures have been built) and is publicly accessible to any subject. Under open space in urban areas are areas of different purposes: from spaces intended for recreation to environments with a natural landscape. Area outside the city limits, such as open space in the countryside does not constitute an urban area (open urban area).

Green space is land that is partially or completely covered by different urban vegetation: grass, trees, bushes, etc. Green space includes parks, playgrounds, courtyards, public seating areas, squares, etc. Urban parks are an important part of urban vegetation that are cooler than their surrounding built-up areas (Ren, et al., 2013). Green areas represent space for recreation, rest, and leisure. Also, they represent an important factor of influence on the environment in urban settlements. The standard green area of an urban area: park, square, sports and recreation area, etc., is defined as an open space within the urban fabric in which plants (main structural

elements) combine with abiotic elements (additional structural elements) in order to achieve the highest and aesthetic effects (Atanasijević, et al., 2009).

Parks, as a tourist asset, can also have their own landscapes, such as Schönbrunn (Vienna), Hyde Park (London), Tivoli (Ljubljana) (Atanasijević, et al., 2009). In Belgrade, such a park is the Botanical Garden "Jevremovac" (0.044 km²) located in an open area with over 350 species of trees and shrubs, native, European and exotic plants, and the total plant fund today consists of over 1500 trees, shrubs and herbs of plants (<http://www.bfbot.bg.ac.rs/>).

A beautiful image of the city is one of the most important conditions for tourism. Trees and green spaces in urban areas and communities can create a positive image and provide an aesthetic experience for both residents and tourists (Zheng, et al., 2009). In addition to the aesthetics, parks provide psychological, health and social benefits. Greenery helps people to relax and reduce aggression, accumulated by a fast and stressful lifestyle in urban areas. Today's green spaces play an important role in improving the urban landscape towards adaptation with nature. The most significant effects of urban green areas affect the quality of life, mental health of residents, reduction of air pollution, more oxygen production, wind flow control, etc. (Jafar & Bozorgnia, 2011).

The role and importance of urban green tourism is best illustrated by the city of Växjö. The international TV channel BBC awarded the city of Växjö (Sweden) as "the greenest city in Europe". In addition to large green areas in the city, forests, parks and lakes are included. Växjö also develops and harmonizes environmental protection measures such as lower carbon dioxide emissions, greater use of bicycles in the city center, and the creation of modern and ecological living conditions. The city of Växjö has the potential to create ecological and urban tourism, which can represent a unique destination, making it attractive for modern tourists looking for a natural and green part of the city destination (Urban tourism in the city of Växjö, Current development and future limits, 2010). As such, Växjö has managed to attract a large number of foreign tourists from all over the world.

Like ecotourism, green urban tourism is a new emerging concept. The concept of green urban tourism was originally proposed by a group of interested individuals and organizations who came together to explore the potential and commerciality of ecotourism in Toronto. They considered it important to encourage travel and research in and around the city that would support the natural and cultural aspects, the preservation of the city's resources (Dodds & Joppe, 2001).

Urban green tourism includes several aspects:

- Buildings: construction, standards and policy in construction, renovation to save energy, etc.
- Attractions and events: protection and preservation of historical and natural attractions,
- Infrastructure: represents the importance of transportation of a community where priority is given to rail traffic (metro, light metro, etc.), bicycle, walking, etc.

Parks are places for special events and festivals that attract tourists. They are a frequent choice for various festivals and events, because they have a favorable location - they are mostly located in the city center, they are places for gatherings, recreation and they can accept temporary infrastructure without major disruption of the original function. The aesthetic, historical and recreational values of urban parks increase the city's attractiveness and promote it as a tourist destination (Chiesura, 2004). One of the most famous manifestations in the analyzed parks of Belgrade are:

1. Belgrade Flower Festival in Manjež Park,
2. "Organic live fest" in Topčider Park - the first festival in Southeastern Europe that promotes organic production,
3. "Street Workout Festival" in Tašmajdan Park - street gymnastics festival,
4. International Beekeeping Fair in Tašmajdan Park,
5. Festival "Classical Music Light" in Kalemegdan.

Green areas provide places for sports tournaments, which can contribute to economic benefits through tourism. Sports tournaments can contribute the most to local communities, especially if a larger number of overnight stays is achieved. Some of the examples of sports tournaments in the function of tourism development of green areas of cities:

1. Chess tournament in the ethno-park in Senjak, Belgrade
2. Friendly archery tournament in Park Goran, Bečej
3. Memorial beach volleyball tournament "Aleksandar Gigović" in Veliko Park, Kragujevac
4. Table football tournament in the City Park, Pančevo.

Larger visits to parks are recorded with different attractiveness and content: zoo, monuments, museums, cultural heritage, historical sites, fields for various sports activities, etc. The best example that combines all the mentioned elements is Kalemegdan (area 0.44 km²) with the The winner and the Monument of Gratitude to France; museums: Museum of Natural History, Military Museum, Art Pavilion "Cvijeta Zuzorić"; Church of St. Petke and Ružice; Kalemegdan fortress and landscaped basketball and tennis courts (www.beogradskatvrđjava.co.rs).

The focus of the work is the analysis of the city's green area using LANDSAT satellite data for 1992 and 2020 in selected parks of Belgrade, using remote sensing and GIS, as a modern method and technique of monitoring the green cover of parks as an important factor in promoting (urban green) tourism in urban areas.

Study area

The geographical space of the analyzed parks includes the area between the following farthest points: the northernmost point is located at 44° 49' 30" north latitude and 20° 24' 36" eastern longitude (a point in the City Park, Zemun municipality), the southernmost point is located at coordinate 44° 42' 33" north latitude and 20° 26' 56" eastern longitude (point in Miljkovačka forest, municipality of Rakovica), the westernmost point is located at 44° 49' 26" north latitude and 20° 24' 22" eastern longitude (point in the City Park, Zemun municipality) and the easternmost point is located at 44° 46' 46" north latitude and 20° 29' 59" eastern longitude (point in the Park near VI Belgrade Gymnasium - Nightingale's stream, Zvezdara municipality).

Table 1. Presentation of the parks analyzed in the paper

ID	NAME	MUNICIPALITIES	AREA (km ²)
1	City park	Zemun	0,085
2	Friendship Park and Danube Quay	Zemun, Novi Beograd	0,691
3	Big war Island	Zemun, Novi Beograd	2,011
4	Kalemegdan Park	Stari Grad	0,443
5	Student park	Stari Grad	0,016
6	Pioneer Park	Palilula	0,026
7	Bristol Park	Stari Grad	0,014
8	Park near the Faculty of Economics	Stari Grad	0,012
9	Park Tašmajdan	Palilula	0,105
10	Park Manjež	Vračar	0,030
11	Financial park	Stari Grad	0,021
12	Park near Slavija Square	Vračar	0,007
13	Park near the Old and New Courts	Vračar	0,006
14	Park at the Temple of St. Sava	Vračar	0,050
15	Park Čubura	Zvezdara	0,014
16	Forests Park	Zvezdara	0,140
17	Park near VI Belgrade High School – Nightingale's stream	Zvezdara	0,015
18	Košutnjak, Pioneer city and Topčider parks	Savski Venac, Rakovica, Čukarica	3,832
19	Hyde Park	Savski Venac	0,153
20	Miljkovac forest	Rakovica, Voždovac	1,677
21	Terrace Terazije	Stari Grad	0,011
22	Botanical Garden "Jevremovac"	Palilula	0,044
23	Cyril and Methodius Park	Palilula	0,018

The green area with the largest area represents the Great War Island, 2.01 km². This green area is under the protection of the state as an area of exceptional characteristics. The Great War Island is included in the analysis as an area where it is in zone III of the level of protection and constitutes the Zone of Tourism (swimming pool, beach "Lido"), while zone II of the level of protection is the Zone of Recreation. The first zone is the Nature Protection Zone and all tourist activities are not carried out in it because they must not have a

negative impact on the existing flora and fauna - biodiversity. In this zone, scientific work is allowed, the performance of actions necessary for the preservation and improvement of natural values.

The parks, with almost identical, smallest area, are the Park near Trg Slavija (0.007 km²) and the Park near Stari i Novo dvor (0.006 km²).

The starting point for the selection of 23 parks was the inner city core and the peripheral zone of Belgrade. Within the inner city core, the selection was based on several categories: accessibility to important roads, park area, proximity to monumental and other important buildings, tourist attractions, accessibility to food establishments, etc.

Material and methods

For the analysis of selected parks on the territory of Belgrade, satellite images from the Landsat Thematic Mapper 4 - 5 satellites taken on August 7, 1992 and from the Landsat 8 Optional Land Image satellite taken on August 9, 2020 were used. After the detection, the analysis and processing of the data with the GIS tool was started. For the purposes of obtaining the NDVI (Normalized Difference Vegetation Index), a combination (image from the Landsat Thematic Mapper 4 - 5 satellite) band 3 Visible Red (0.63 - 0.69 μm) and band 4 Near-Infrared (0.76 - 0.90 μm) was used; and a combination (Landsat 8 Optional Land Image satellite image) band 4 Visible Red (0.630 – 0.680 μm) and band 5 Near-Infrared (0.845 – 0.885 μm).

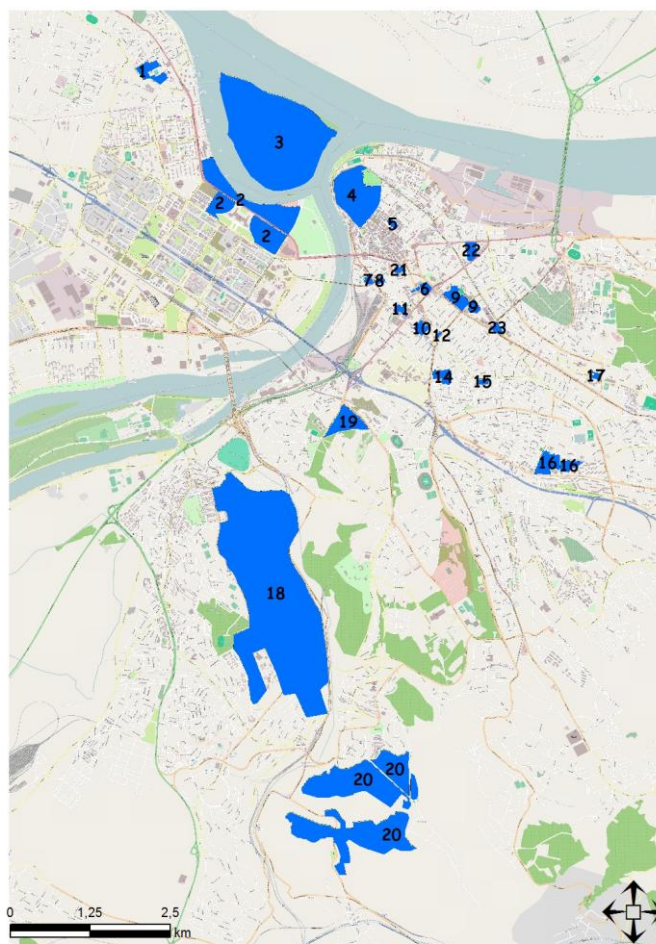


Figure 1. Location view of analyzed parks in Belgrade

1. City park,
2. Friendship Park and Danube Quay,
3. Great War Island
4. Kalemegdan,
5. Student's park,
6. Park Bristol,
7. Park at the Faculty of Economics,

8. Terazije Terrace,
9. Financial park,
10. Pioneer Park,
11. Botanical Garden "Jevremovac",
12. Park of Ćirilo and Metodije,
13. "Park Tašmajdan",
14. Park Manjež,
15. Park near of Slavija Square,
16. Park near the Old and New Palace,
17. Park near the Temple of St. Sava,
18. Čubura Park,
19. Park Forests,
20. Park near the 6th Belgrade Grammar School – Nightingale’s stream,
21. Košutnjak, Park Pioneer City and Topčider,
22. Hayd Park and
23. Miljakovac Forest Park

The magnitude of NDVI refers to the level of photosynthesis activity in the observed vegetation. It shows the amount of lush vegetation on the surface of the earth. In principle, higher NDVI values indicate greater strength and presence of vegetation. The value of NDVI varies between -1 and 1, ie. from water surfaces (-1) to 1, which represents dense vegetation cover. NDVI is calculated from visible (VIS) and infrared (NIR) reflected light (Jovanović, et al., 2013):

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

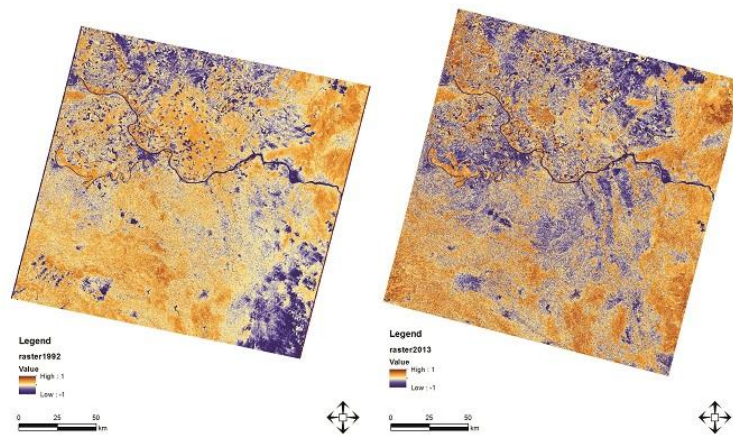


Figure 2. NDVI for 1992 and 2013, LANDSAT satellite image

By obtaining the value of the vegetation index, each pixel was assigned a value from -1 to 1 and thus reclassified into 3 categories: forest (1), grass (2) and urban - built objects, barren areas, stone, sand, asphalt, etc. (3), where the classification based on the natural groupings of spectral properties of pixels is performed - assigning pixels to the same class, because they have similar values. Reclassification was approached using the method of supervised classification (so-called hybrid classification).

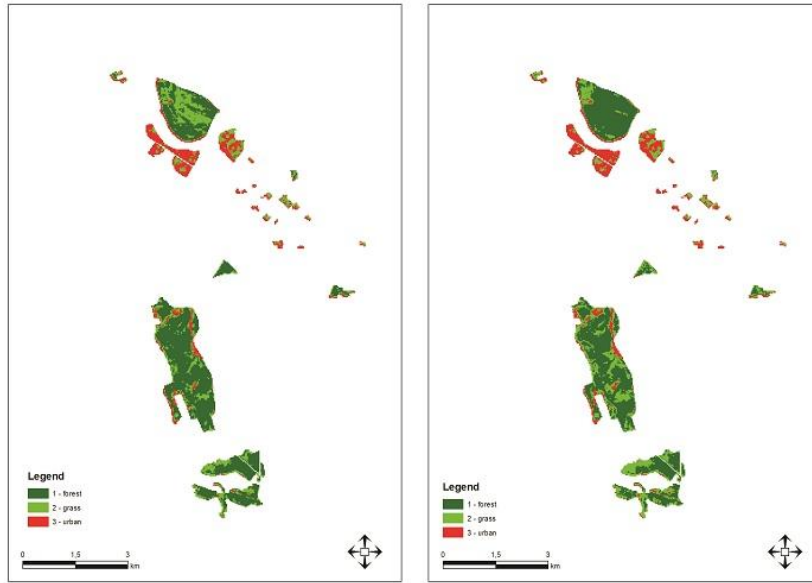


Figure 3. Map of reclassification of NDVI index values for 1992 and 2020

The sum of all pixels within the analyzed territory is 10472, with the maximum value in category 1 (area under forest) 5969 for 1992 and 5606 for 2020. The minimum value is represented by category 3 (urban area) with 1757 pixels from the 1992 image and 1931 from the 2020 image (Tables 2 and 3).

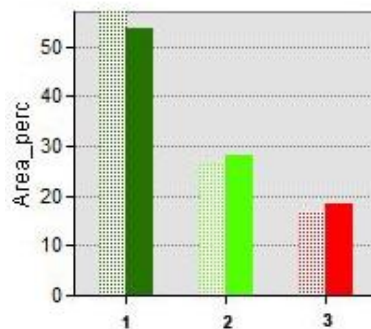
Table 2. Reclassification of NDVI index values in the analyzed parks based on the LANDSAT satellite image for 1992

Value	Count	Area_perc
1	5969	57,00
2	2746	26,22
3	1757	16,78

Table 3. Reclassification of NDVI index values in the analyzed parks based on the LANDSAT satellite image for 2020

Value	Count	Area_perc
1	5606	53,53
2	2935	28,03
3	1931	18,44

The biggest changes in the analyzed parks, based on the monitoring of satellite images from 1992 and 2013, affected the areas under forests. During 1992, it amounted to 57% of the total area. For 2020, it is noticeable that the same area was reduced by 3.47% of the total area. The urban area for the twenty-year period increased by 1.66%, as well as the grass area by 1.81%. Loss or degradation of green space can deprive habitats for creating biodiversity and change the structure and process of the urban system (Shahabi, et al., 2012).



Graph 1. Comparative display of area changes (%) for 1992 (hatched) and 2020 (solid color)

From the total area of the analyzed parks (9.42 km²), urban forest vegetation covered 5.36 km² in 1992, and 5.04 km² in 2013, which shows that it has decreased by 0.32 km² over the twenty-year period. The grass area covered an area of 2.46 km² in 1992, and 2.64 km² in 2020, which increased it by 0.18 km². The urban area in the analyzed parks has the smallest value, and it was 1.58 km² in 1992, and 1.73 km² in 2020 (an increase of 0.15 km²). On the maps (picture 3), the most red color can be seen in the parks that are closer to the city center, while the green color is more dominant in the green areas that are in the peripheral zone compared to the center (Big war Island, Košutnjak, Topčider, Pioneer city Park and Miljakovac forest). The moderate intensity of red and green colors is most pronounced in Hyde Park and Forests Park.

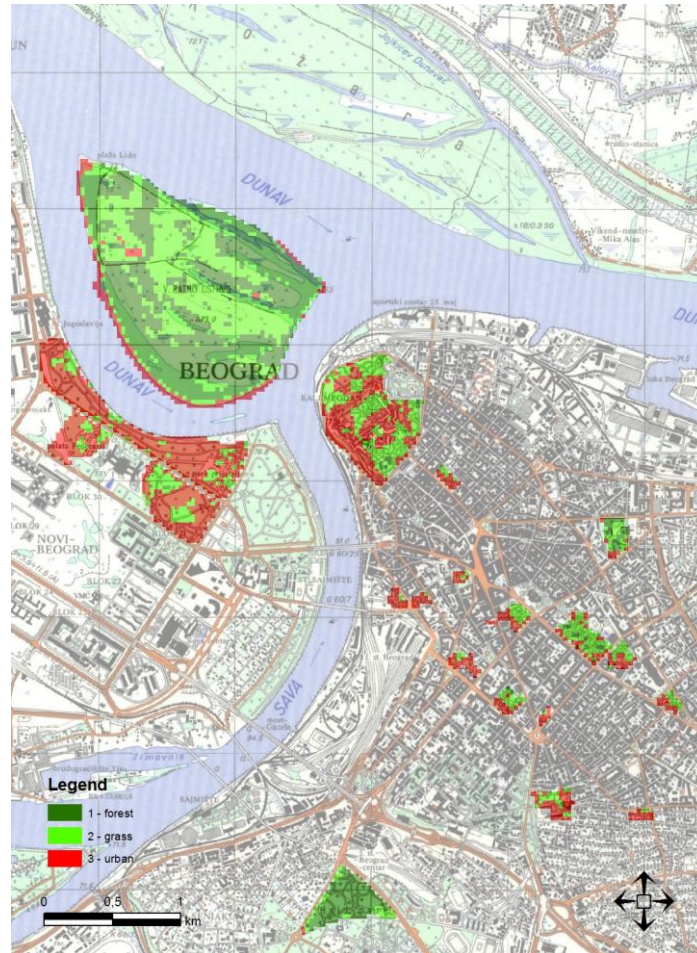


Figure 4. Overlay of a 1:25,000 topographic map with a LANDSAT satellite image

In the last phase of the analysis, the topographic map layer and NDVI were checked and overlapped (transparency of the topographic map layer of 50%). As a reference layer, the NDVI for 1992 was taken, which is the closest to the year of printing the topographic map sheet (Belgrade 2 4, Belgrade West, 1990). On the overlapped layers, it can be seen that the red color (category 3) is most present along the roads and peripheral parts of the parks in the inner city core. Green color (categories 2 and 3) are represented more towards the interior of the analyzed parks: namely, category 3 in the interior itself, ie. away from roads surrounding green areas.

Conclusion

The modern achievements of technology greatly improve the development of tourism and today it directly depends on it. On the one hand, the improvement of computer technology gives tourists faster access to information about the desired destination, while, on the other hand, it enables the observation and analysis of the state of natural elements in urban areas. Today, the process of urbanization follows a rapid growth trend (based on the 1991 census, Belgrade had a total of 1,602,226 inhabitants; the 2011 census recorded 1,639,121

inhabitants), and by monitoring green areas, measures against the degradation of green areas can be taken and prevented. oasis of the city. Green areas in densely populated cities today have a greater importance and role compared to past periods. Remote sensing and GIS, as a modern tool in modern computer technologies, enable the monitoring of changes in the use of green (city) areas. Some of the key elements of GIS in vigilance where profit can be realized in tourism is planning including the possibility of data manipulation and spatial analytics (Sheikh & Yahiy, 2012). On the territory of the City of Belgrade, in selected parks, for the twenty-year period (1992-2013), categories 2 and 3 recorded an increase (the urban area increased by 0.15 km², and the grass area by 0.18 km²), while category 1 (forest urban vegetation), reduced its area by 0.32 km². The reduction of green areas directly reduces the possibility of developing green urban tourism, and thus additional resources for local communities, i.e. Belgrade municipalities (this paper lists some of the events and festivals that take place in selected parks, where with a little better marketing, they can contribute to and improve the tourist offer in Belgrade).

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