MAPPING URBAN GREEN EQUITY: A GIS-BASED ACCESSIBILITY ANALYSIS OF PARKS IN SUBOTICA

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ABSTRACT:

This study explores urban green equity in Subotica, Serbia, through the lens of spatial accessibility to public parks. By leveraging QGIS and open datasets from OpenStreetMap, we mapped buffer zones of 100 meters around park areas and assessed population access using digitized building data. The methodology includes spatial querying, attribute calculations, and statistical summaries, enabling precise identification of underserved neighbourhoods. Results indicate that nearly half of the city's population lacks adequate access to nearby green spaces, with significant disparities between different parts of the city. The findings support planners in prioritizing zones for future green infrastructure investments and illustrate the effectiveness of open-source GIS tools in urban analysis.

KEYWORDS:

urban green equity, GIS, QGIS, spatial analysis, public green space, urban planning

1 INTRODUCTION

Green spaces are essential components of urban life, improving microclimate, reducing pollution, and supporting social and recreational activities [1] [2]. Their spatial distribution and accessibility greatly influence the quality of life. The aim of this research is to assess the accessibility of parks in Subotica using GIS tools, and to identify zones with insufficient coverage.

In recent years, equitable access to urban green spaces has become a growing concern in spatial planning literature. Grădinaru et al. [3] demonstrate that in Romania, despite efforts to expand green infrastructure, equity considerations are often only superficially addressed in strategic plans. Grabowski et al. [4] argue that urban green infrastructure planning in the United States must be transformed to explicitly address social inclusion and environmental justice. Similarly, Pipitone and Jović [5] explore how the COVID-19 pandemic shifted perceptions of access and belonging in New York City parks, reinforcing the importance of equitable distribution of green spaces, particularly in multicultural urban settings.

These international insights reinforce the relevance of this study and justify the need to explore spatial accessibility of parks in Subotica from the perspective of urban green equity.

2 DATA AND METHODOLOGY

2.1 DATA SOURCES AND PREPARATION

The project started with collecting spatial data from OpenStreetMap, which served as the base for identifying public park locations. Park polygons were manually drawn in QGIS based on visual interpretation of satellite imagery. Since no official building dataset was available, we manually digitized residential buildings by placing point features on visible structures. Each point represented one building. For population data, we made estimates based on the average number of residents per floor and multiplied that by the number of floors for each building.

We also ensured that all vector layers shared the same coordinate reference system (EPSG:32634) to maintain consistency in spatial operations.

2.2 GIS OPERATIONS AND ANALYTICAL TOOLS

In QGIS, we began with generating 100-meter buffer zones around each digitized park using the Buffer tool. These buffers served as our accessibility threshold. We then used the Select by Location function to determine which digitized buildings fell within these buffers, classifying them as “with access.”

To differentiate between accessible and non-accessible buildings, we added an attribute field using the Field Calculator. We assigned categorical values that indicated access status and then performed a statistical breakdown using the Group Stats plugin to estimate the number of people served versus underserved.

Finally, we used the Print Layout Manager to prepare maps (Figure 1) that display the spatial results of our analysis [1].

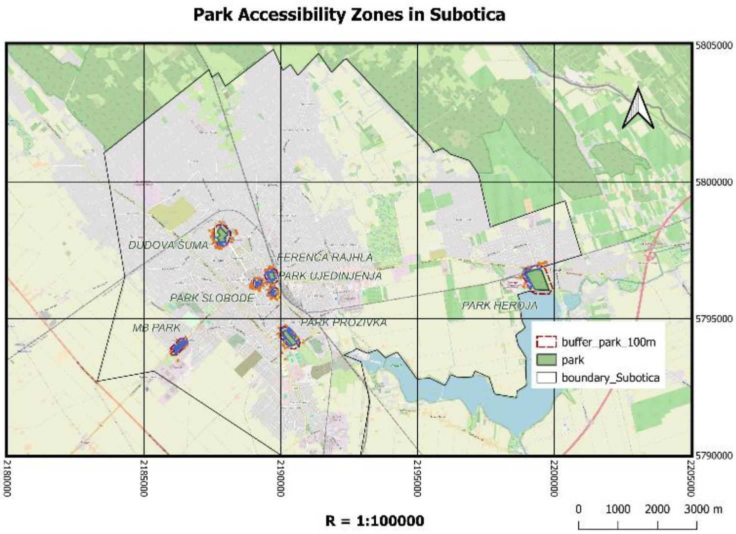

Figure 1. Distribution of park polygons and 100 m buffer zones in Subotica used for accessibility analysis

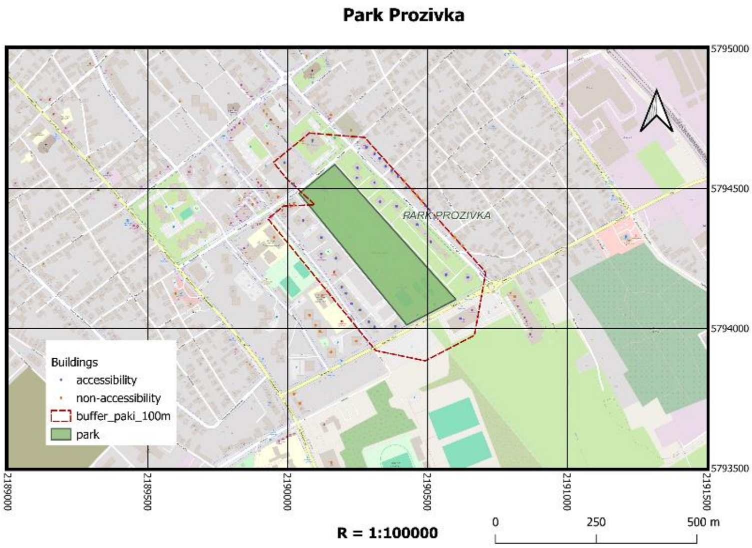

Figure 2. Accessibility analysis of Park Prozivka showing residential building coverage within the 100-meter buffer zone. The analysis reveals a relatively low accessibility score of 38%.

Although Prozivka Park (Figure 2) covers a large area and is in a densely populated neighbourhood, only 38% of the residents live within the 100-meter buffer zone. This indicates that most buildings are located outside the effective walking distance. The data suggest a need for better spatial connectivity, new micro green spaces, or improvements in access infrastructure.

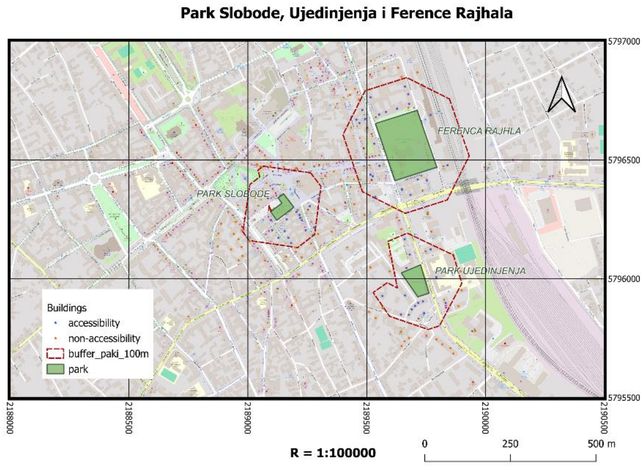

Figure 3. Accessibility buffers for the central parks: Slobode, Ujedinjenja, and Ferenc Rajhl. The combined analysis shows moderate accessibility, covering approximately 52% of nearby residents.

These three parks form a closely connected green zone. The analysis shows that 52% of residents in the area live within the buffer zone (Figure 3). Although this is near the balance point, almost half of the nearby population lacks close park access. The spatial arrangement leaves room for enhancements, especially by expanding usable entrances and improving pedestrian pathways.

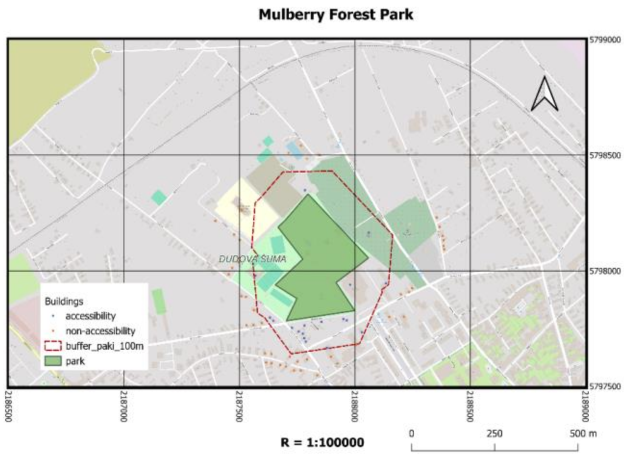

Figure 4. Mulberry Forest Park accessibility map. Only 48% of residents within the surrounding zone have direct park access, suggesting the need for better connectivity or satellite green spaces.

Mulberry Forest Park (Figure 4) is one of the largest and best-known parks in Subotica. However, the analysis reveals that only 48% of residents have direct access within 100 meters. Despite its size, the park's spatial integration is not optimal. There is a clear need for additional entrances or new satellite green spaces in the surrounding blocks.

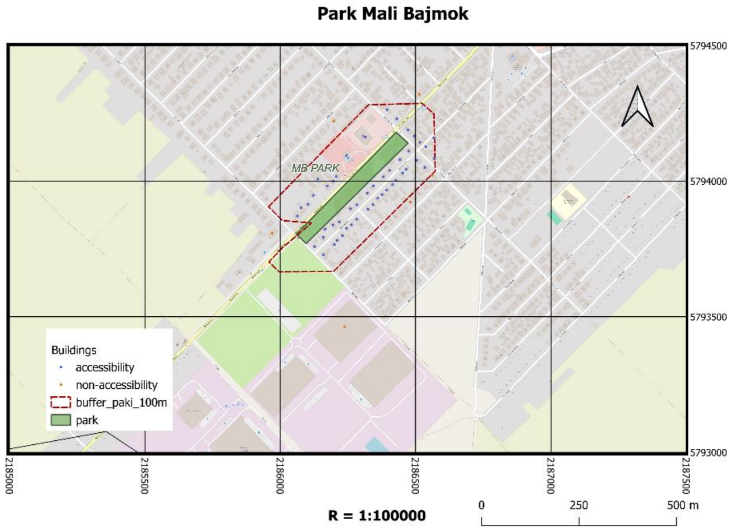

Figure 5. Park Mali Bajmok coverage and accessibility assessment. This park shows high performance, serving 81% of the population in its vicinity—an example of well-integrated green infrastructure

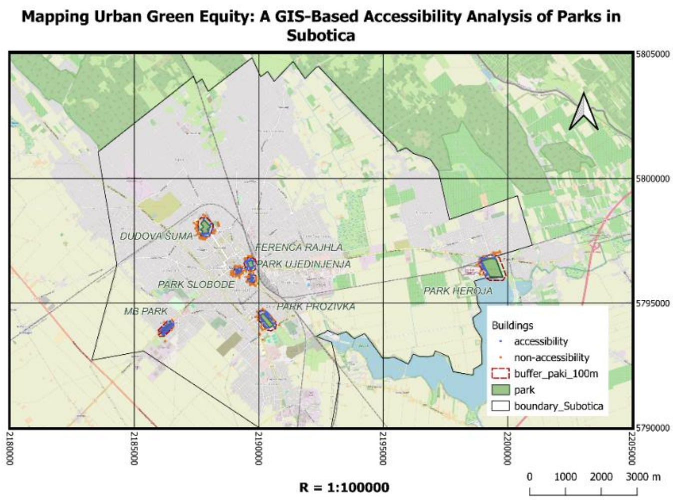

Figure 6. Access analysis of Park Heroja. The spatial distribution reveals that 62% of residents within the analyzed zone have walkable access to the park.

This park demonstrates exemplary spatial distribution. With 81% of residents in the vicinity having direct access, it stands out as a successful example of urban green space planning. Its central location and neighbourhood integration make it highly functional for everyday recreational use (Figure 5).

Located in the Palic area, this park provides access to 62% of the surrounding population (Figure 6). Although this is a solid outcome, about one-third of residents remain outside the optimal walking zone. Introducing smaller green islands or improving the walkability of surrounding streets could improve the situation.

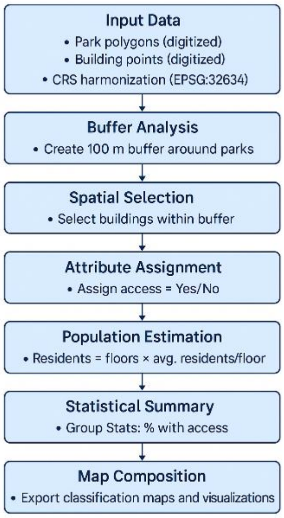

Figure 7. Workflow chart showing the GIS processing pipeline used for park accessibility analysis, including importing spatial data, generating buffer zones, applying spatial selection, and calculating statistics

2.3 ANALYTICAL WORKFLOW

The full analysis consisted of the following procedural steps:

- Import and harmonization: All spatial data layers, including digitized park polygons and building point data, were imported into QGIS and harmonized under the EPSG:32634 coordinate reference system to ensure spatial consistency.
- Buffer zone creation: A 100-meter buffer was generated around each park using the Buffer tool. This zone was used to assess which buildings are considered to have access to nearby green space.
- Spatial selection: Buildings located within the buffer zone were selected using Select by Location, identifying those with direct access to parks.
- Attribute assignment: Access status (Yes/No) was assigned to buildings depending on whether they fell inside or outside the buffer zone.
- Population estimation: Each building was assigned a population value based on the number of floors and average number of residents per floor.
- Statistical summary: Group Stats was used to summarize the proportion of residents with and without access to a park.

- Visualization: Results were exported for mapping and chart production, including accessibility scores and spatial inequality indicators.

The full GIS-based procedure is illustrated in the analytical workflow chart (Figure 7), which summarizes the data processing steps from input preparation to final visualization.

3 RESULTS AND SPATIAL INTERPRETATION

3.1 GENERAL ACCESS OVERVIEW

We found that only 52% of the residential population is located within 100 meters of a public park. Although central areas appear dense in parks, accessibility varies significantly. Some zones with high housing density still showed poor access, hinting at infrastructural barriers or spatial disconnection.

3.2 PARK-SPECIFIC INSIGHTS

Each park was assessed for the number of people it served. Larger parks like Prozivka Park exhibited lower-than-expected access ratios due to spatial disconnection. Meanwhile, smaller parks like Mali Bajmok showed higher accessibility rates due to their central location within neighbourhoods (Figure 8).

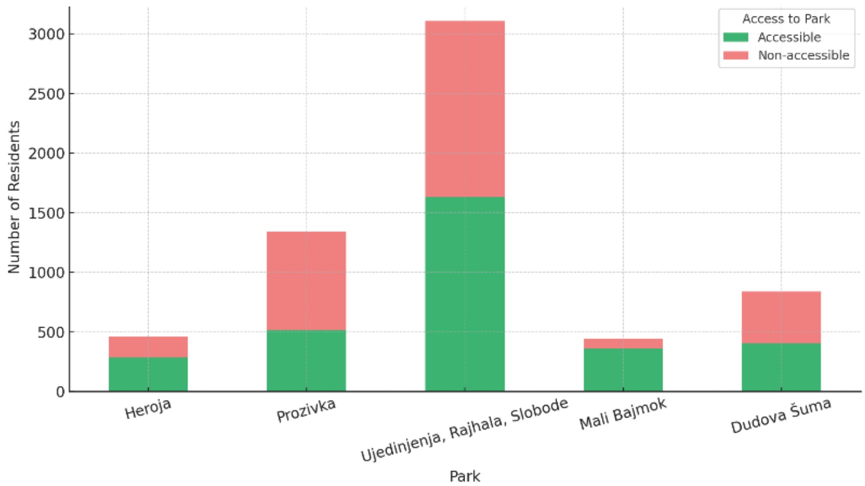

Figure 8. Accessibility scores by park zone visualized with bar charts. The chart compares the number of residents with and without access to each park

3.3 MAPPING SPATIAL INEQUALITY

Thematic maps were used to visualize these disparities. Certain neighbourhoods near large parks were revealed to have poor access due to urban form limitations. This highlights the value of spatial analysis beyond visual impressions Table 1.

Table 1. Accessibility distribution by park area and population status

Park Accessibility	Heroja	Prozivka	Ujedinjenja, Rajhala, Slobode	Mali Bajmok	Mulberry Forest
Accessible population	287	513	1632	358	405
Non-accessible population	175	830	1476	86	432

Table 1 and Figure 9 together illustrate how proximity and urban layout affect accessibility to major parks in Subotica. While Table 1 provides statistical distribution of accessible populations, Figure 9 visually emphasizes spatial disparities.

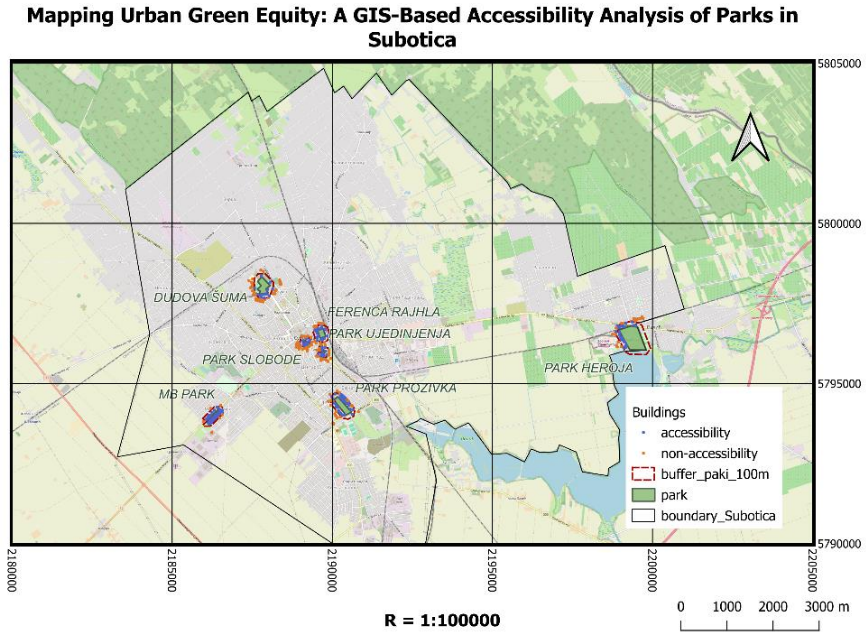

Figure 9. Composite accessibility map of Subotica showing park buffer zones.

4 DISCUSSION AND IMPLICATIONS

The spatial disparities revealed in this study highlight the urgent need for equitable green infrastructure planning in Subotica. Central neighbourhoods such as Prozivka and parts of Mulberry Forest Park are particularly underserved. The workflow in QGIS enabled rapid spatial analysis and supported data-driven conclusions [6] [7].

Planning recommendations include:

- Establishing mini-parks in dense zones like Matije Gupca–Braće Radić.
- Utilizing open land pockets in Palic's residential grid.
- Improving pedestrian connections to existing parks.

These insights may inform sustainable urban policy and support participatory planning.

5 CONCLUSIONS

This GIS-based approach demonstrates how spatial accessibility analysis can be effectively implemented using open-source tools like QGIS to improve urban green equity. The structured workflow—consisting of digitization, buffering, spatial selection, and statistical analysis—offered practical insights into park availability in Subotica. The results emphasized that even areas with a seemingly dense green network may suffer from spatial disconnection, which limits their actual usability for residents.

Furthermore, this approach is scalable and can be applied in other urban areas with limited data availability. It provides urban planners with a replicable, data-driven methodology that can enhance decision-making processes related to green infrastructure planning and environmental justice. As such, it holds potential for integration into municipal planning strategies and academic GIS education alike.

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