GIS-BASED METHODOLOGY FOR COMPLEX UGS PROVISION ASSESSMENT THROUGH THE CASE STUDY OF SZEGED, HUNGARY

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Abstract

Proper urban green space (UGS) provision is an important attribute of a livable city. For urban planners to delineate areas within the city where improvements on either the quality or the quantity of the green infrastructure are needed, an all-encompassing UGS provision analysis could become an invaluable tool. These analyses need to include all of the three aspects of the UGS provision, namely availability, accessibility and attractiveness, as well as evaluate the affected population.

In this present study the UGS provision analysis of Szeged has been carried out with the involvement of various maps and GIS databases (e.g.: isochrone and vegetation maps, population data), through which we aim to delineate areas within the city that are lacking the proper green infrastructure compared to the population density.

We expect results that will be useable by urban planners in Szeged, and also hope that our methodology will be adaptable by professionals from other cities for their own UGS provision assessments.

Introduction

Urban green spaces (UGS) grant access to various ecological and recreational benefits (ecosystem services) to city dwellers [1]. Because of their significant effects on the human well-being, UGS have come to the forefront of many researchers', practitioners' and city administrators' attention [2]. UGS provision assessments are used to evaluate the quality and quantity of UGS supply within a city.

Several researches aimed to define UGS provision and its components, as well as develop methodologies to properly describe them [3]–[7]. One of the most straightforward categorization of the UGS provision components was described by Biernacka et al., (2020) [7]. They defined three levels of UGS provision: availability, accessibility and attractiveness. By their definition, availability is the existence and quantity of UGS within a defined area regardless of whether these green spaces are accessible to the public or not. Accessibility answers if there are any physical or psychological barriers (fences, prohibitions, dangers) that prevent someone to reach UGS. The road network of a city is also a huge influencing factor of UGS accessibility. Attractiveness describes the willingness of potential visitors to use UGS that is both available and accessible within a reasonable distance. Attractiveness has several influencing factors, like size, services and human perception [7], [8]. When assessing UGS provision or any of its components, researchers frequently use population data as well, to evaluate affected inhabitants and their demographic composition [2], [9], [10].

In this summary we aim to present a complex methdology for UGS provision evaluation incorparating availabity, accessibility and attractiveness analyses, as well as a detailed population database in the study area of Szeged, Hungary.

Materials and methods

Study area

Our research was conducted within the administrative area of Szeged, Hungary. With approximately 161.000 inhabitants, Szeged is the third largest city in the country and the largest settlement (as well as regional center) of the Great Hungarian Plain.

Used databases

Throughout the research, various GIS databases were utilized, including different OpenStreetMap layers, a plot boundary layer and the Urban Atlas land use and land cover (LULC) database.

The analysis of availability, accessibility and attractiveness

As UGS availabilty, the area of available ‚local green spaces' was estimated within the plots of the residents' homes and their human scale proximities (100 m). Based on the building regulations document, we have reproduced the plot boundary layer of Szeged in GIS environment. A manually expanded version of the OpenStreetMap building layer (completed with adress-level population data provided by the Hungarian Ministry of Interior) was used to select plots with permanent population. Buffer zones were generated around each of these plots with a 100 m radius to define their human scale proximities.

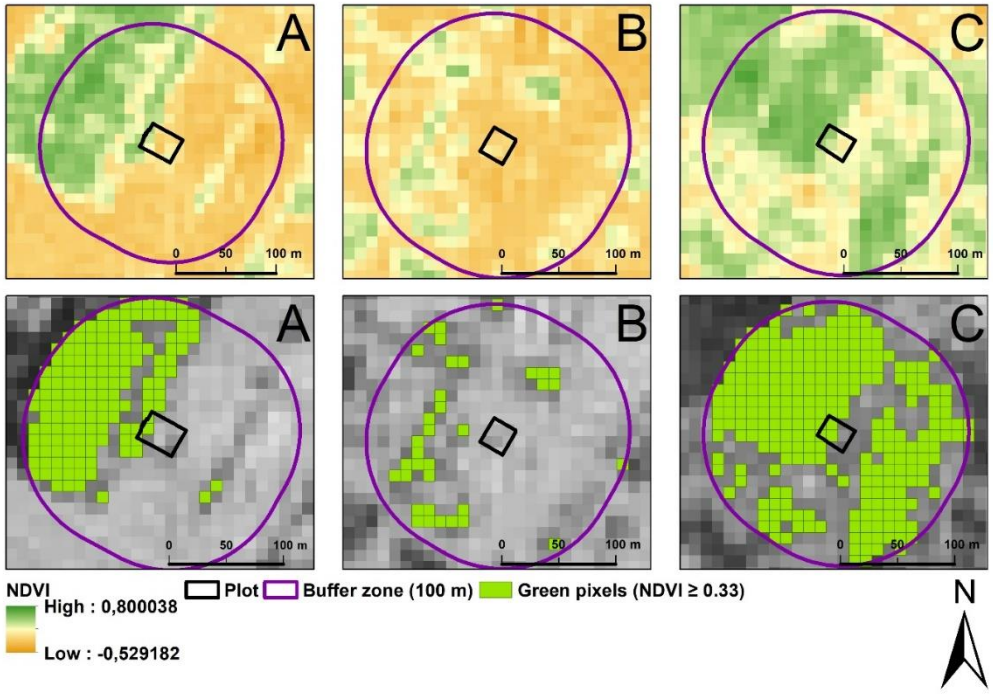

Figure 1. Examples of local green space availability estimations through three randomly selected plots one being close to Széchenyi tér, one of the biggest geen spaces of Szeged (A); one from the downtown with scarce vegetation (B); and one from the suburbian area of Újszeged district (C).

To the availability evaluation an NDVI map was also created based on Sentinel-2 imagey from 2019.08.23. Pixels with vegetation value of 0.33 or higher were selceted and counted within each buffer zone. Knowing the resolution of Sentinel-2 imagery (10 m x 10 m), green space coverage could easily be deduced from the pixel count (Figure 1.).

For the accessibility analysis, UGS polygons were selected from the Urban Atlas LULC database. These areas are mainly categorized by Urban Atlas as Forests or Green Urban Areas. Polygons representing private areas, hence unaccessible to the public were excluded from the

analysis. Using OpenStreetMap's road network layer, entry points were generated where the roads crossed the UGS polygons. With the help of ArcGIS online's Network Analyst tool, we generated service areas around these entry points in one minute resolution (between 1 and 15 minutes). An isochrone map was created from these service areas which shows the accessable public UGS and the required walking time to reach them from any given poit of the city within 15 minutes.

We evaluated the potential attractiveness of the UGS polygons previously selected for the accessibility assessment and modified the maximum considered travel time to their entry points based on their size and functions. The modifications were based on one of the guidelines (National open space guidlines) described by Stessens et al. (2017), but took into account number of point of interests (POI) within these areas as well [8]. For this, the POI layer of OpenStreetMap was used.

Plot-level UGS provision analysis

As the final step of our research we are planning to synthesize the results of the availability, accessibility and attractiveness analyses with the population data at our disposal within the plot layer of Szeged and use the obtained layer to delineate areas within the city, where either the lack of UGS or the high population density justifies the creation of new urban parks or other types of vegetation coverage.

Results, expected results

As partial results, so far the area of availabe ‚local green space' on each plot with permanent residents has been calculated (Figure 2).

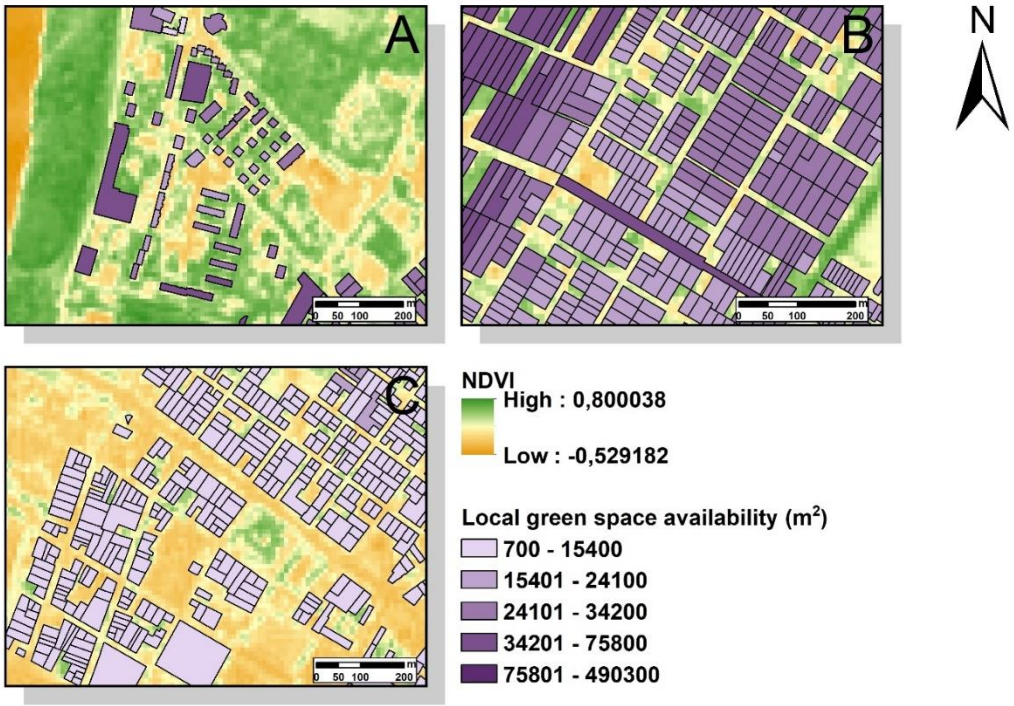

Figure 2. Examples of plot-level local green space availability: (A) in an area close to the urban park, Erzsébet liget and a floodplain forest; (B) in a vegetation-rich suburban area; and (C) in a dense urban area with low vegetation.

These plot-level availability maps provide a good indication about the greeness of the residents' environment and also offers an opportunity to compare them with the population data via additional indicators (e.g.: green area/capita). It can be cleary seen that plots embedded

either in a suburban environment or located close to larger urban parks or forest has better local UGS availability than plots in areas with dense urban fabric.

The acessibility maps of the public UGS weighted by their potential attractiveness was also created (Figure 3). While these maps ignore a significant part of the informal green spces (e.g.: smaller green lots, alleys and private gardens, it shows the pedestrian travel times to the larger and more function rich public UGS which are especially important to residents living in areas which lack proper local green space availability. Based on which aspect of UGS accessibility needs to be emphasized, these maps can be used to define either how long travel time is needed to reach the closest public UGS, or how many public UGS can be reached within a realistic walking duration (1 - 15 minutes) from from any given point of the city.

After the complex analysis with the involvement of these results and the population data, we expect to find areas with the worst overall UGS provision at the northern parts of Móraváros, and the south-western areas of Rókus district.

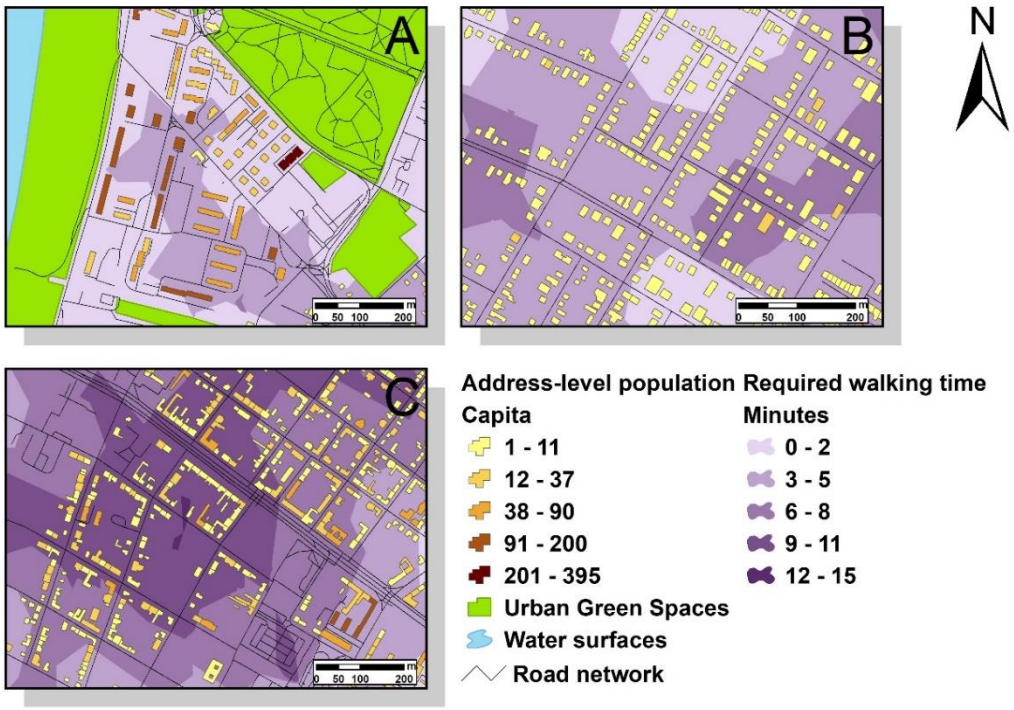

Figure 3. Examples public green space accessibility weighted by attractiveness: (A) in an area close to Erzsébet liget and a floodplain forest, (B) in a vegetation-rich suburban area, and (C) in a dense urban area with low vegetation.

Conclusion

Based on our results so far, we can conclude, that the overall UGS provision of Szeged is in good condition. Our partial result foreshadows the areas of Szeged, where poor UGS provision is expected. In the future further refinement of this methodology is possible through more thorough weighting by the potential attractiveness and the involvement of more attractiveness defining factors next to the size and the POI count. The elaboration of the address level building database and population data by age groups is another possibility to further develop present methodology.

Acknowledgements

We would like to thank the Hungarian Ministry of Interior for providing us with essential detailed population data without which this study would not be possible. We are also thankful to Vanessza J. Kolcsár for proofreading our manuscript.

The financial support of the Ministry of Human Capacities through grant NTP-NFTÖ-20 (R. A. Kolcsár) and TUDFO/47138-1/2019-ITM of the Ministry for Innovation and Technology, Hungary is acknowledged.

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