Assessment of Ecosystem Service Urban Recreation – A Case Study of Leipzig, Germany

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Abstract: The World Health Organization (WHO) notes that outdoor recreation prevents diseases and improves urban residents' health. Recent rapid population growth in industrial cities, coupled with high demand for housing and amenities, negatively impacts green spaces and indirectly impedes outdoor recreation. Green spaces are the key factor in improving the quality of life in urban settlements, and in the spirit of social justice, everyone should have the right to access them. In this paper, the city of Leipzig serves as a case study to analyze urban green spaces with recreational functions and explore ways to achieve sustainable urban development. This study relies on GIS as an analytical instrument and ATKIS Basic DLM (Digital Landscape Model) as a base dataset.

Keywords: Ecosystem services, assessment, outdoor recreation

1 Introduction

The German city of Leipzig, a growing municipality with high green ambitions, ranks third nationally in the European Community Quality of Life Report 2020, with an overall satisfaction rating of 96.3%. In Germany, one-third of the population lives in cities with over 100,000 inhabitants, while three-quarters live in urban areas (GRUNEWALD et al. 2017). Urbanization significantly increases the pressure on remaining urban open spaces. Therefore, parks and green spaces are crucial for stable and balanced urban growth. "Outdoor recreation" refers to recreational activities in a natural setting. Several research studies have shown how it enhances the quality of life and contributes to the well-being of urban residents. In public residential areas, recreational opportunities are significant for residents with limited mobility and without cars (GODBEY 2009). In addition, recreational areas should also be accessible to all social groups in the interest of social equity (ARTMANN et al. 2019). Ecosystem services (ES) comprise the conditions and processes by which natural ecosystems sustain and fulfil human life. They can be provisioning, regulating, or, as in our case, cultural services (BISE 2022). Culture refers to the non-material benefits humans derive from ecosystems (FAO 2022).

Urban green spaces (UGS) are essential for cultural ecosystem services such as outdoor recreation opportunities. Residents, especially the elderly and children, of urban areas need equal access to green recreational spaces, (ARTMANN et al. 2019). Sufficient open and green spaces set higher standards for sustainable urban development. German cities measure public open spaces with different orientation values ranging from 6 to 15 m^2 per inhabitant. Sports and play areas represent unique UGS uses for which accurate values or ranges of deals are available, while exact values for other functions are challenging to obtain. Based on the German Association of Towns and Municipalities guidelines from the 1970s, many cities still assume a minimum size of 0.5 hectares for open or green spaces close to settlements and ten hectares for landscape-oriented open spaces (CHRISTA et al. 2016).

Both national and international studies, and the WHO, propose various indicators that can aid in assessing housing quality, leisure quality, and health promotion. Therefore, indicators

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for recording and evaluating ES are essential for operationalizing and measuring success. The evaluation parameters chosen for this study were the accessibility of green spaces from residential areas, the supply of urban residents, and the ratio of supply to total area. ES "Urban Recreation" is quantified using three key parameters: the percentage of green space in urban areas with recreational potential, availability, and accessibility. This study aimed to answer the following questions: Are sufficient UGS available, and are they accessible to residents? Where are there deficits or need for action?

The assessment utilized GIS tools to identify the most suitable open spaces for recreation and proximity analysis to measure the degree of accessibility.

2 Methodology

The chosen approach is in line with the recommendations of WHO (2016) on the design and measurement of health indicators for public health services and in line with the proposal for national-level indicators to describe and evaluate public health services (GRUNEWALD et al. 2017).

Supply (indicator one) identifies the extent of greening within the study area and calculates the ratio to the entire study area. Method of data collection: ratio of green space to the total study area (GRUNEWALD et al. 2017).

Provision (indicator two) calculates the percentage of green space in an urban area and determines its compatibility with the total population of the study area. Method of data collection: the quotient of total green area and people within a defined commuting belt (m^2/inh.) (GRUNEWALD et al. 2017).

Accessibility (indicator three) indicates the proportion of people with access to UGS compared to the total population of the study area. Method of data collection: ratio of served residential areas/population within parameters (commuter area, minimum size) to total residential areas/population. (GRUNEWALD et al. 2017).

Based on the national benchmarks (CHRISTA et al. 2016), two classes of size and proximity of urban recreation areas (Ur) were defined to analyse the level of accessibility as follows:

- 500 m walking distance for less than 10 Ha and greater than 1 ha = Ur.1
- 1000 m walking distance for UGS greater than 10 ha = Ur.2.

The second step determined the ratio of the population/residential areas served within the parameters (catchment area, minimum size) to the total population. (GRUNEWALD et al. 2017). Finally, the degree of accessibility was measured on three scales: (a) Accessibility within 500 m walking distance; (b) Accessibility within 1000 m walking distance; (c) Accessibility within 500m and 1000m walking distance.

2.1 Recreation-relevant UGS Land Uses

UGSs with recreational functions open to the public and do not charge fees are defined as urban recreation areas (Ur) for this study. The land types representing the stock of green spaces were selected regarding available recreational opportunities and public access. In terms of land use class, these ATKIS Basic DLM features are suitable for everyday outdoor recreational activities (Fig. 1).

43001 Agriculture	**43002** Forestry	**41008** Sport, Leisure & Recreation	**71006** Nature, Environment, Soil protection	**44006** Stagnant waters	**44001** Flowing waters
Grassland, Orchard meadow	Coniferous wood, Hardwood, Hardwood & Softwood	Park, Green area	Natural reserve, Natural park, Landscape protected area	Lake, Pond	River

Fig. 1: Codes and functions of selected land use suitable for recreational use

Park, Green area, and Forestry categories are uncontroversial, as they contribute significantly to the recreation of city residents. "Water bodies" can provide a variety of recreational uses on, in, and around water, including green riparian areas, and can be accessed by the public. Grassland (meadows or pastures with natural elements) has a renaturation effect, among other things (GRUNEWALD et al. 2017). Natura 2000 network (N2K) areas have become increasingly crucial as recreation possibilities promote physical and mental health through natural experiences (ROCCHI et al. 2020). Due to entrance fees, membership, or fences, these land-use functions do not apply: 41008 – allotments, equestrian sports, golf, outdoor theatres, wildlife parks, swimming pools, traffic practice areas, weekend home areas, zoos, amusement parks, open-air museums, and campgrounds (GRUNEWALD et al. 2017).

2.2 Assessment Models Flowcharts

Two models arise from the first selection: As baseline information for indicators one and two, the first model unifies the land use selections and subtracts them from the study area.

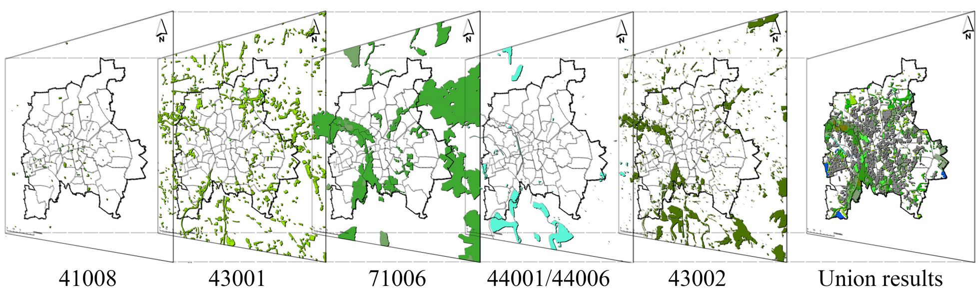

Fig. 2: Workflow process for indicators one and two

As the basis for assessment indicator three, a second model combines the land use selections into two new classes based on defined parameters. Unlike conventional practices, the proposed methodology includes accessible green spaces beyond the study area. Ur.1 also includes UGS outside the study area up to 500 m aerial proximity, and Ur.2 areas include UGS up to 1000 m. In the absence of a formal database of Ur-pedestrian access points, one is created by inverting the features into points and representing the linkage between Ur pathway entrances and pedestrian-friendly streets. Then the outcome was subjected to proximity analysis ("Create Time Areas" tool), and as a result, we got planes of the primary service areas based on the specified distances. Finally, the generated layers were pruned with residential land use to get the served neighborhoods. At this point, were created three new layers:

a) Served residential areas at 500 m walking distance.
b) Served residential areas at 1000 m walking distance.
c) Served residential areas at 500 and 1000 m walking distance.

The served residential areas are expressed as a percentage of the total residential area. The outcome was augmented with population information using Data Enrich with Census 2021 Nexiga GmbH variable to obtain the population served.

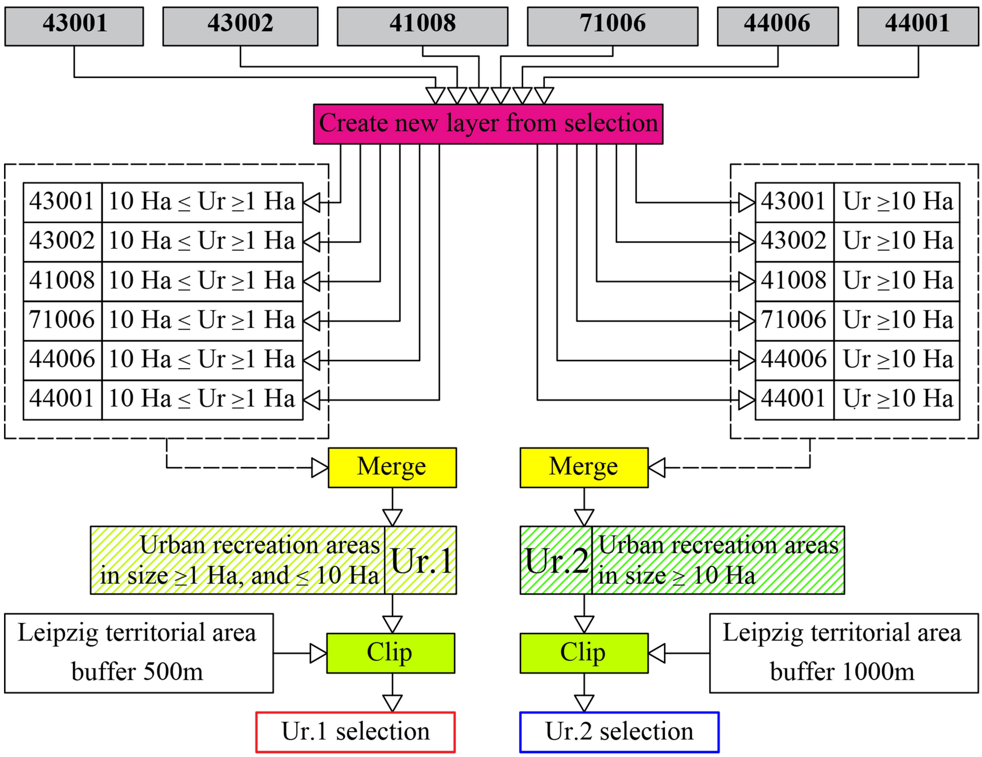

Fig. 3: Workflow diagram model for indicator three (1/2)

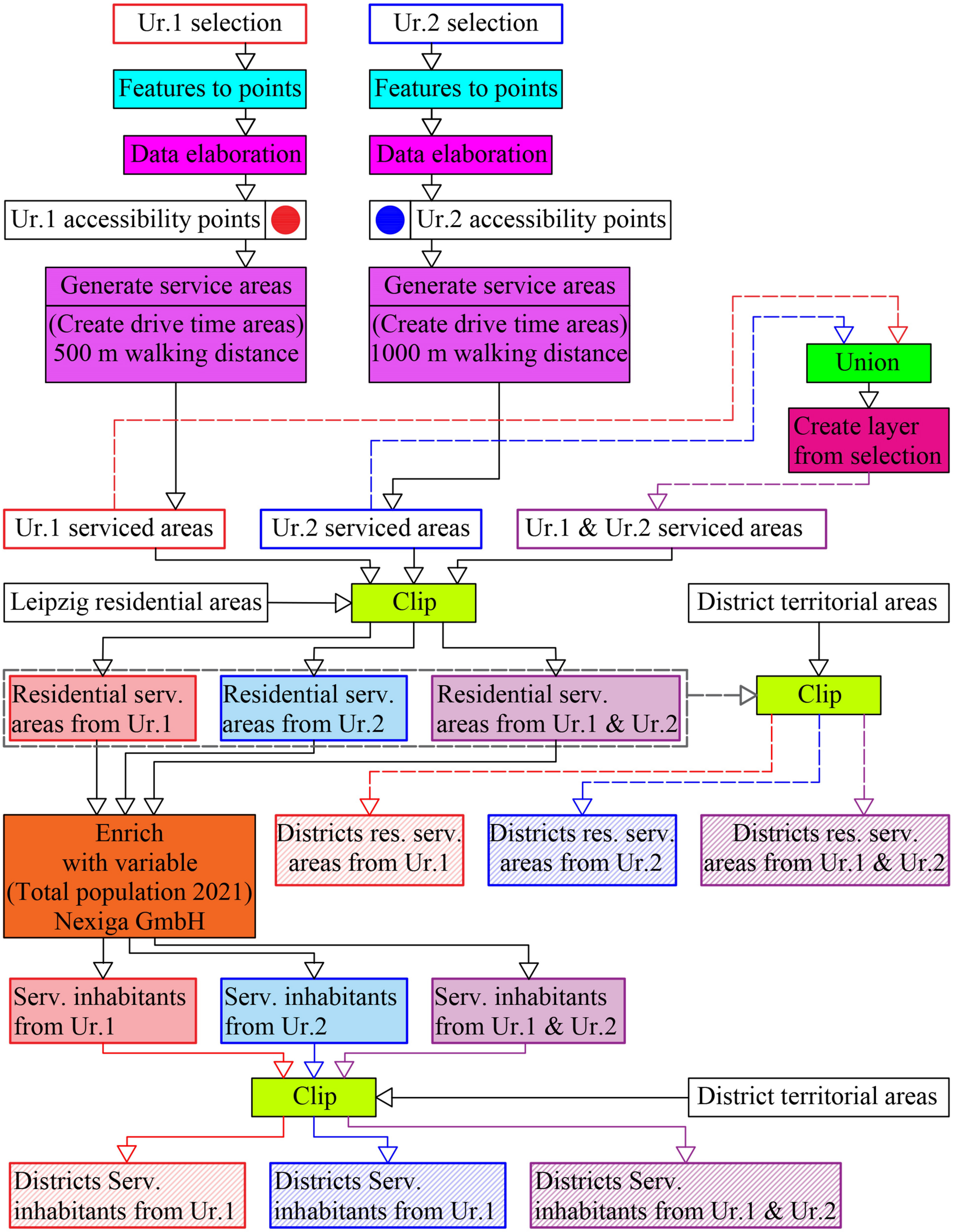

Fig. 4: Workflow diagram model for indicator three (2/2)

3 Results

Leipzig has an area of approximately 8195 ha of UGS used for recreation, which corresponds to about 28 % of the city's total area. The proportion is highest in the South district, with 987 ha (58%), and lowest in the North district, with only 340 ha (9%). The average is 29%; the median is 28%.

As a result of the essential provision at the city level, the per capita value is 134 m^2, which is about 893% above the German guideline value (15 m^2/inh). The highest value is in the north-western district with 397 m^2 per capita, 2646 % above the guideline value. The lowest value is 49 m^2 per capita in the north, still 327 % above the value. The average is 151 m^2/inh; the median is 120 m^2/inh.

Regarding accessibility to Ur, only about 52% (318847 residents) of the total population can reach both distances. About 67% (410140 residents) can get within 500 meters, and 86% (527256 residents) within 1000 meters. Regarding residential development, only 59% (3219 ha) are within both distances. About 80% (4271 ha) have access within 500 meters, and 71% (3803 ha) within 1000 meters.

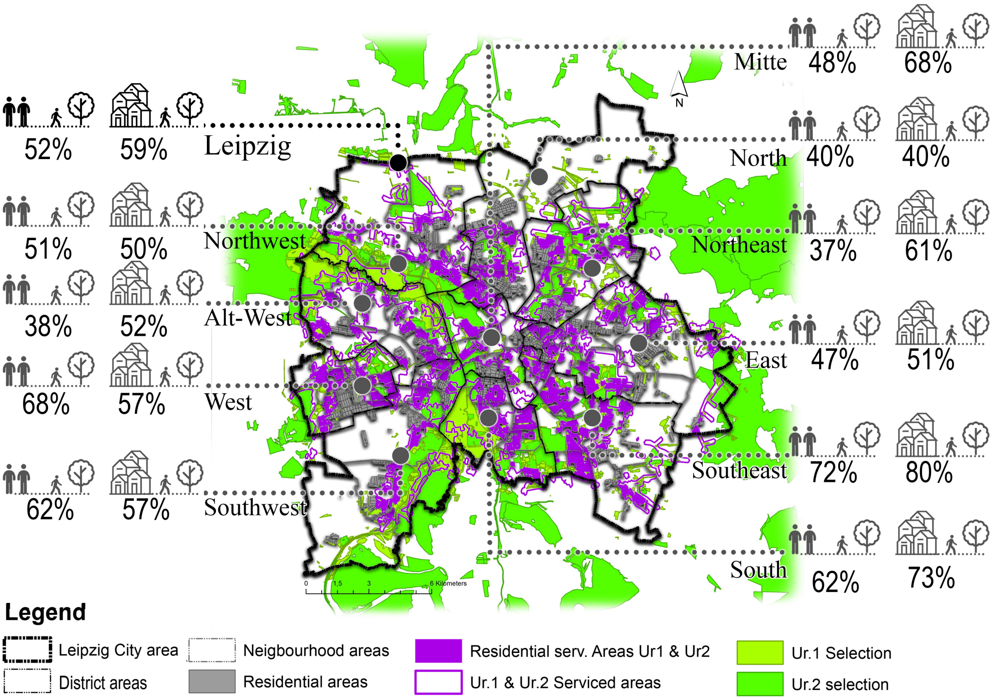

Fig. 5: Results of accessibility assessment at 500 and 1000 m walking distance

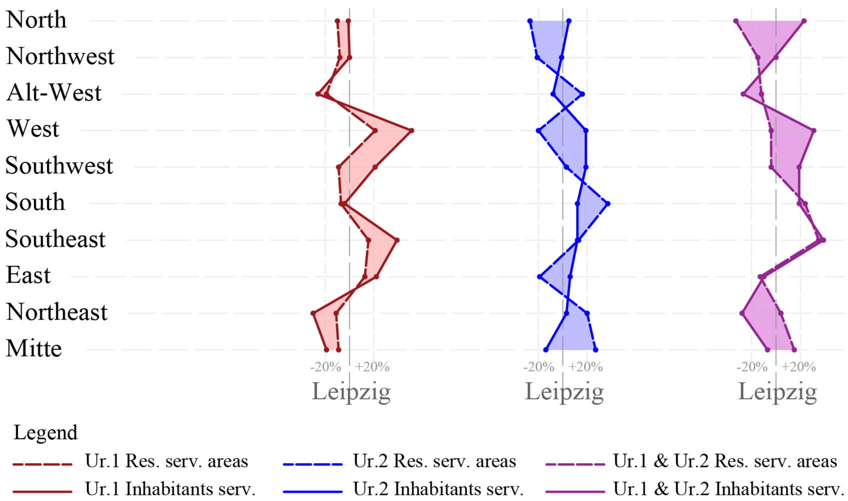

Fig. 6: Accessibility comparison charts of districts relative to the overall result

The results show that the provision of green space in our case study is indeed above the national quantitative standards:

About 48% of the population and 41% of the residential areas need direct access to green spaces within walking distance of 500 and 1000 meters. On average, 49% and 41%, while on a median, 52% and 43%. About 33% of the population and 20% of residential areas need direct access within 500 meters. On average, 33% and 22%, while on a median, 36% and 27%. About 14% of the population and 29% of the residential areas need to be within 1000 meters. On average, 14% and 27%, while on a median, 14% and 23%.

4 Discussion

Policymakers and planners need objective and comparable measures and indicators that reflect the provision of urban green space in terms of its type, size, quality, and functions. The methodology should allow for a reproducible assessment of urban green areas. It is based on reliable and quantifiable measurements to provide measurable reference values comparable to national and international standards. The indicators are operationalized through a GIS-based working method. They include several dimensions whereby errors and uncertainties due to the approximation of natural phenomena are an inevitable part of spatial data. According to GRUNEWALD et al. (2017), a fundamental distinction must be made in the Basis-DLM between areas with a high or low proportion of green space, i. e., modelling rules prevent the mapping of greenspace between row developments or perimeter block developments, which makes it impossible to examine private green areas or spacing green in the context of residential accessibility to recreation-relevant areas. The accuracy of the GIS tools in processing the input data should also not be negligible, as the machines' inside calculations are unknown to the user. Analyzing public health statistics in areas with direct access to recreation and those without would be interesting to highlight the importance of distance between residences and recreation areas.

5 Conclusions

Primary indicators of green space quality in urban areas are essential to show reference values for decision-making processes. In this regard, the methodology provides a basis for pursuing more sustainable urban development, considering that green infrastructure is an essential health determinant in city life quality. Furthermore, adopting this analytical approach to various cities can provide a general approach to analysing the cultural functions of green spaces. Traditionally, study areas have been limited to city limits, ignoring peripheral green spaces that are of practical use to city inhabitants. As a buffer, green space outside the study area with defined access distances is considered to broaden this methodology. Given the disparity in residential accessibility and population shown in Figure 6, this analysis can also help in planning for new residential development to ensure fair and controlled coverage with this service.

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