

Developing a Municipal Greenery Concept: GIS-Driven Approach to Strategic Planning in Ostrava

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Abstract

Urban green infrastructure (UGI) provides essential ecosystem services, ranging from microclimate regulation and stormwater management to public health benefits. However, in post-industrial cities like Ostrava, the historical spatial configuration often dictated by heavy industry and mining logistics has led to a highly fragmented urban fabric. Ostrava presents a unique case study: despite an even 50/50 split between urban development and vacant peri-urban landscape, the perceived and functional accessibility of these spaces for citizens remains significantly low. Contemporary urban planning requires a shift from qualitative descriptions of 'more trees' toward quantitative, data-driven frameworks that can justify municipal spending and guide infrastructure development. The primary objective of this research is to evaluate the methodology of the Ostrava Greenery Concept, a strategic document developed by MAPPA (Municipal Studio for Urban Planning and Architecture). This strategy leverages advanced GIS tools to bridge the gap between high-level strategic policy and site-specific technical implementation, providing a replicable model for post-industrial transition.

Keywords: Blue-Green Infrastructure (BGI), Accessibility, Post-industrial cities, Urban Resilience

Introduction

In the face of escalating climate change and urban densification, the strategic management of urban greenery has transitioned from an aesthetic consideration to a critical pillar of urban resilience. This paper presents a multi-scale GIS-driven methodology developed for the Ostrava Greenery Concept, a strategic municipal document prepared by the Municipal Studio for Urban Planning and Architecture (MAPPA). Ostrava, a major post-industrial hub in Central Europe, is characterized by a fragmented landscape legacy from years of intensive coal mining, with these areas often being large and poorly maintained (Langhorst and Bolton 2017). Similar to other post-industrial hubs in the Central and Eastern European (CEE) region like Katowice or Miskolc, Ostrava's BGI development faces the unique challenge of retrofitting this fragmented landscape left by heavy industry. The Concept addresses this challenge by defining a long-term, systematic approach focusing on three core objectives: developing riparian corridors, connecting fragmented urban green spaces, and linking residential centers with the peri-urban landscape.

The proposed framework utilizes high-resolution geospatial datasets, integrating aggregated and anonymized mobile signaling data with network-based accessibility modeling. This modeling is normalized to a 5-minute (approximately 400m) walking threshold, which serves as a strategic normative objective for the City of Ostrava, aligning with international '15-minute city' benchmarks to identify systemic spatial deficits. To ensure realistic demand-side modeling, human movement dynamics were calibrated using signaling data provided by a major Czech

carrier (T-Mobile). For the Ostrava Greenery Concept, the peak afternoon window (14:00–16:00) was prioritized to capture maximum daily greenery usage by both residents and visitors. These data provided a high-resolution density layer essential for identifying areas where functional demand exceeds current physical infrastructure. A distinctive feature of this work is the development of a 'Typological-BGI Matrix', assigning 13 categories of Blue-Green Infrastructure measures to 11 specific urban space types. By transforming structural geospatial assessment into a technical passportization system (Greenery Cards), this framework acts as a Decision Support System for municipal investments, enabling more efficient project planning and improved access to grant funding. Recent studies highlight the importance of connectivity over mere acreage, suggesting that the ecological and social value of greenery increases exponentially when connected into a coherent system (Forman, 2014). GIS-based accessibility modeling, utilizing pedestrian network analysis, has emerged as the global standard for evaluating social equity in greenery distribution (Apparicio et al., 2010), accounting for actual physical barriers. Furthermore, integrating BGI into city-wide typologies allows for a 'standardized resilience' framework where every urban intervention contributes systematically to hydrological stability and climate adaptation (Berragan et al., 2022). In CEE post-industrial cities, advancing such strategies often faces institutional inertia; therefore, integrating data-driven approaches provides evidence-based justification to facilitate political support.

Data and Method

The methodology covers the entire administrative territory of Ostrava (approx. 214 km²) and its surroundings. A total of 284 green public spaces has been defined, covering 1,139 ha (40 m² per resident), while peri-urban greenery covers 10,675 ha (377 m² per resident). The methodology is structured into four primary geospatial phases:

1. **Synthesis of Multi-Source Datasets:** We integrated traditional datasets with specialized geodata. These include high-resolution orthophotos for assessing vegetation health and water stress through the Normalized Difference Vegetation Index (NDVI) and Normalized Difference Moisture Index (NDMI). Furthermore, we utilized 'GESVOD' (Municipal Stormwater Management Masterplan), a localized hydrological model providing data on stormwater runoff and infiltration capacity.
2. **Network-Based Accessibility Analysis:** Moving beyond simple Euclidean buffers, the study utilized a GIS Network Analyst approach. Walking distance was modeled based on the actual path network, accounting for physical barriers. The standard was set to a 5-minute walk from the entrance points of green spaces.
3. **Human Movement Calibration:** To validate the theoretical accessibility model, anonymized geolocation data from mobile network operators were processed to provide insights into actual utilization rates and identify functional 'entrance points'.
4. **Typological Passportization:** The study categorized Ostrava's public spaces into 11 distinct types (Fig. 1). Each type was mapped and evaluated based on its 'attractiveness' and 'ecological potential'. The Accessibility Deficit Index (ADI) was calculated as a standardized ratio between the simulated residential load and the effective area of available attractive greenery within a 5-minute service network polygon. The formula is expressed as: $ADI = (Population\ Density / Aggregate\ Greenery\ Area) * k$, where k is a normalization constant. The extent to which the current state corresponds to the desired target state is evaluated across mapped parameters. The final overall assessment (as presented in Results, Fig. 2) is calculated by aggregating the scores of these specific parameters and comparing them against a predefined normative target state. Based on this, each green space is ultimately categorized as 'good', 'satisfactory with reservations', or 'poor'.

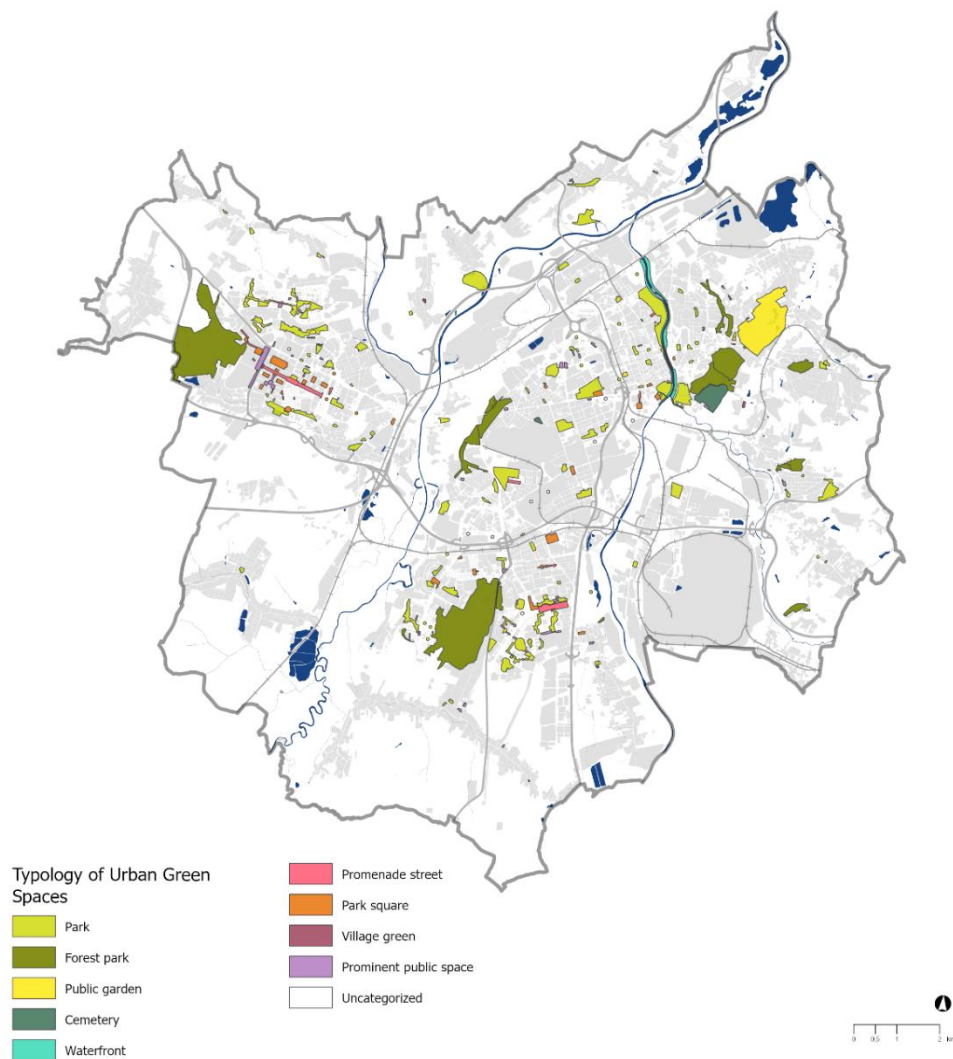


Fig. 1: Typology of Urban Green Spaces, Ostrava 2025.

Results

The applied GIS methodology resulted in the development of three interconnected technical frameworks: the Green Spine, the Typological BGI Matrix, and the Digital Greenery Passport.

The Green Spine (Zelená kostra) The analysis confirmed that Ostrava's four main rivers (Ostravice, Lučina, Odra, Opava) and their adjacent landscapes represent the city's most significant ecological assets. The GIS framework identifies these river systems as primary 'Blue-Green Axes'. By revitalizing riparian corridors and establishing continuous pathways, the city achieves a functional spatial network that mitigates industrial fragmentation and provides a structural framework for active mobility.

Technical Implementation: The Typological BGI Matrix A critical outcome is the translation of strategic connectivity goals into technical mandates. We identified 13 categories of BGI measures cross-referenced with the 11 urban typologies. For example, for the 'Street' typology, the matrix mandates structural soils and retention rifts. The relationship between BGI technical measures and spatial typologies is based on a systematic evaluation of physical limitations and underground infrastructure constraints. The 11 urban typologies act as a spatial filter for the 13 BGI categories. For spatially constrained typologies like 'Streets', the matrix prioritizes sub-

surface interventions that do not conflict with utility networks. Conversely, open typologies like 'Parks' are assigned nature-based surface solutions with larger footprint requirements.

Digital Passportization: Greenery Cards Each identified green public space was assigned a digital 'Greenery Card'. This GIS-based passport contains: (A) Current quality assessment, (B) Maintenance priority, (C) Accessibility deficit index, and (D) Recommended BGI interventions, allowing the city to prioritize investments effectively.

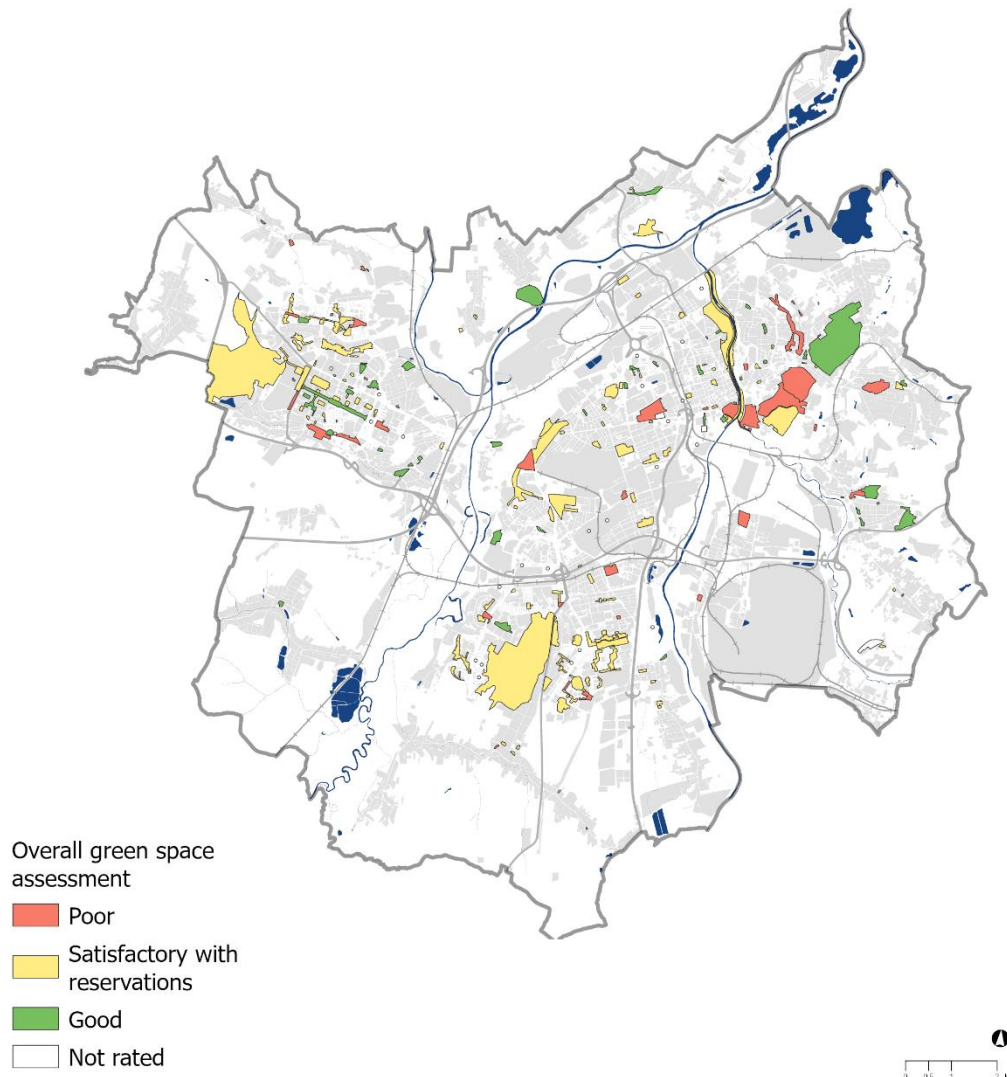


Fig. 2: Overall green space assessment, Ostrava 2025.

Regarding accessibility, we found that 97% of Ostrava residents have access to greenery within a 5-minute walk, fulfilling the city's strategic normative objective. However, the quality of this greenery varies significantly.

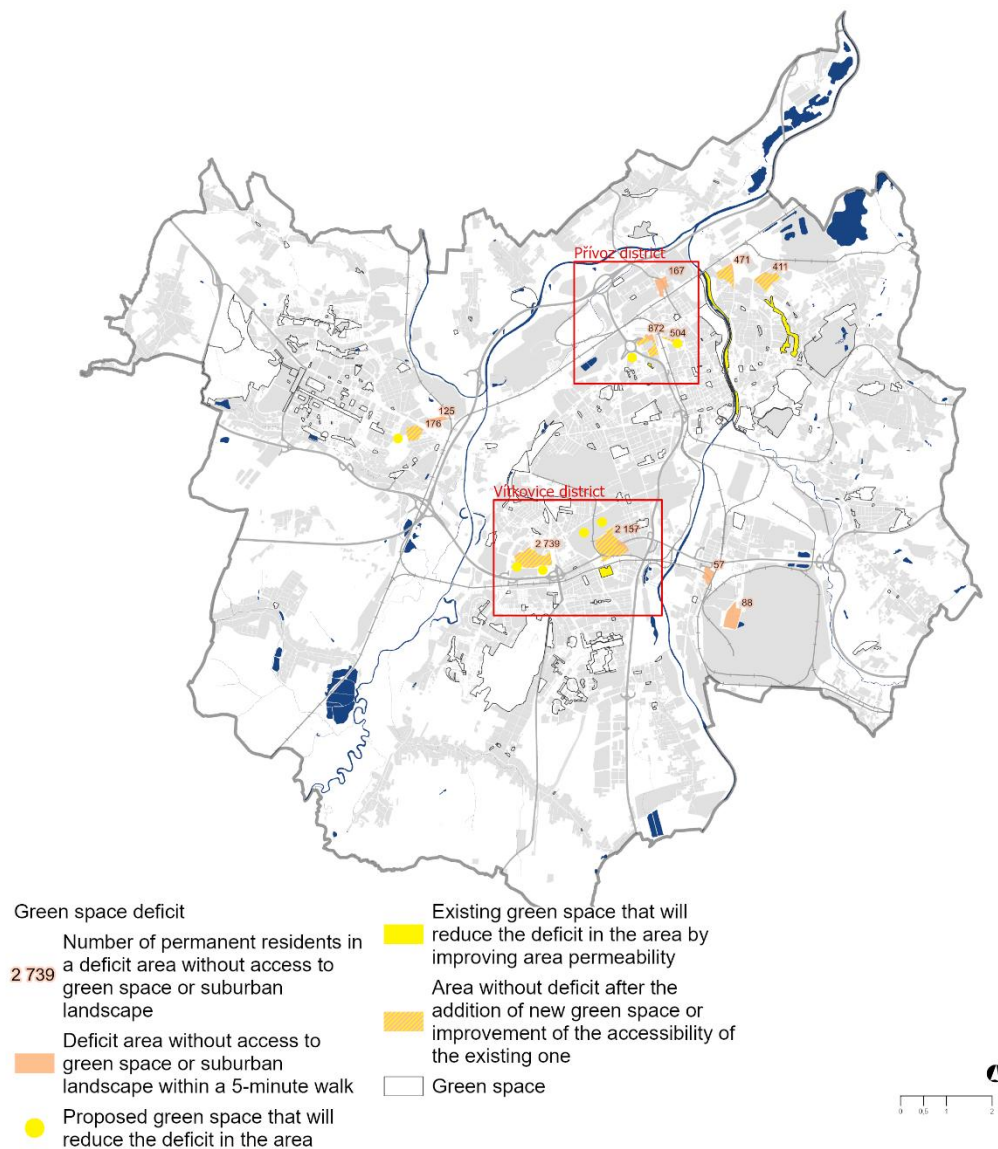


Fig. 3: Deficit of green spaces, indicating the number of permanent residents in deficit areas. Ostrava 2025.

Fig. 3 shows that 7,767 residents lack accessible green space. Significant deficiencies occur in former industrial districts like Vítkovice and Přívoz, which are considered segregated areas. Improving access to greenery here can help revitalize these localities heavily burdened by industrial physical barriers.

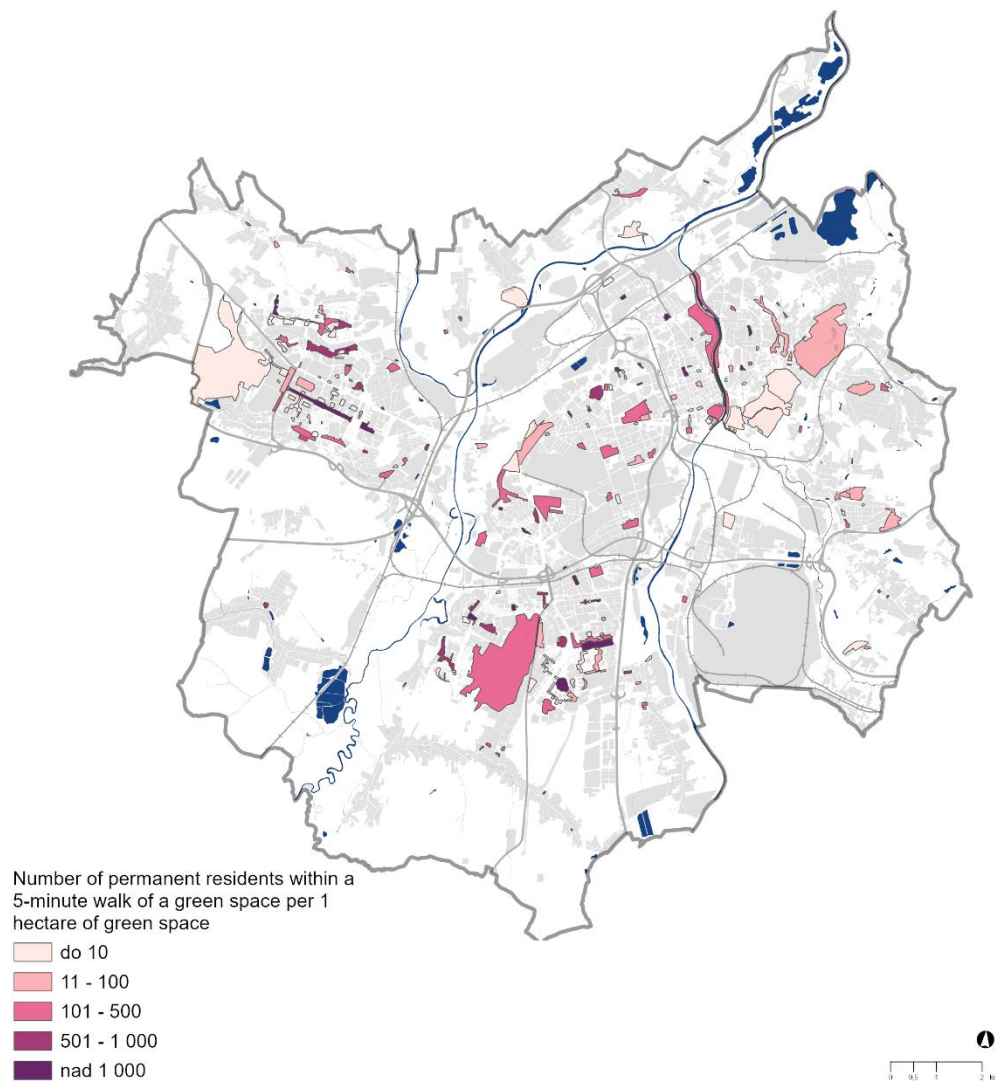


Fig. 4: Number of permanent residents within a 5-minute walk of a green space per 1 hectare of green space, Ostrava 2025.

For the analysis of usage intensity, we employed two types of data. Initially, 2021 census data assigned residents to accessible green spaces, yielding a baseline resident-to-hectare ratio (Fig. 4) highlighting burdened spaces in Ostrava-South and Přívoz. However, this static metric underestimates actual usage.

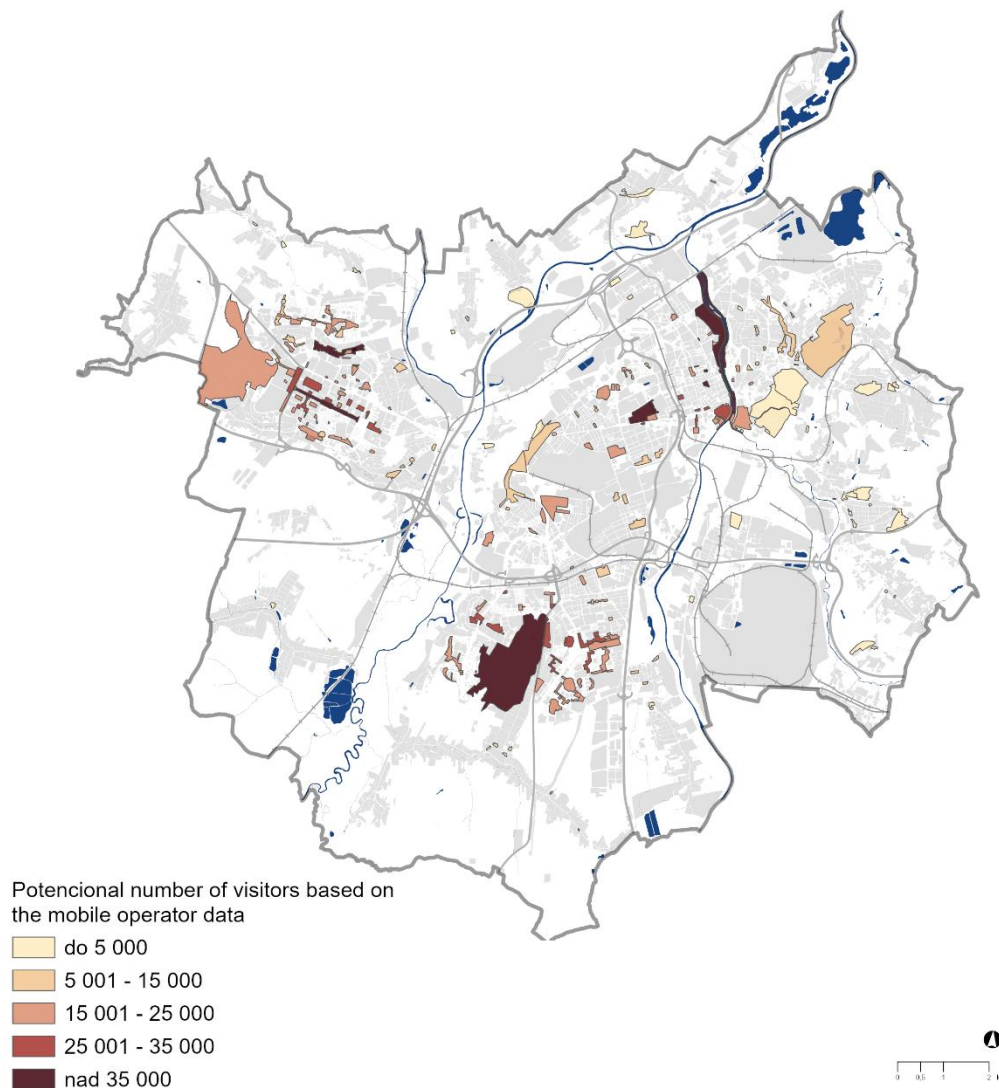


Fig. 5: Potential number of visitors based on mobile operator data during the peak afternoon window (Wednesday, 14:00–16:00), Ostrava 2025.

The accessibility analysis using 2024 mobile operator data (Fig. 5) provides a critical complement. While census data indicates residential proximity, mobile signalling data reveals the actual spatio-temporal presence of the population, exposing the true potential visitation load. For instance, the main park 'Komenského sady' has a relatively low number of permanent residents in its immediate vicinity. However, mobile data revealed that over 35,000 people are present within a 5-minute walking distance during the examined peak window (14:00–16:00). This discrepancy demonstrates that central parks experience functional loads far exceeding what static residential data suggests. Consequently, municipal planning, maintenance budgets, and BGI infrastructure capacity must be calibrated according to this dynamic visitation potential to prevent degradation.

Conclusion

This research demonstrates that systematic GIS-driven planning transforms urban greenery from a qualitative aspiration into a quantifiable municipal asset. The Ostrava Greenery Concept provides a replicable framework for post-industrial cities facing landscape fragmentation and climate adaptation. While physical proximity to greenery in Ostrava is generally high, our

analysis revealed significant disparities in quality and usage intensity—particularly when contrasting static census data with dynamic mobile operator data. This highlights that proximity alone fails to deliver ecosystem services.

The proposed BGI Matrix translates abstract sustainability goals into specific technical interventions, allowing municipal departments to implement climate adaptation measures systematically. Furthermore, prioritizing riparian corridors as primary 'Blue-Green Axes' provides structural coherence. Municipal budgets should prioritize interventions that strengthen this Green Spine network, utilizing the Greenery Cards as a decision support system to rank investments.

The transition from static master planning to dynamic asset management represents a fundamental shift. Future work will focus on integrating real-time environmental monitoring into the Greenery Card system. The Ostrava case ultimately proves that geoinformatics serves as a crucial bridge between strategic policy and technical implementation. Furthermore, the GIS framework is not merely static; it allows urbanists to model future variants and assess the impact of proposed greenery on the Accessibility Deficit Index. Strategically, the 'Blue-Green Axes' are fully aligned with active mobility plans, supporting pedestrian and cycling routes. Lastly, while the matrix primarily guides investments on city-owned land, its transparent methodology provides a strong foundation for future negotiations with private landowners, whose support is vital for the realization of the Green Spine.

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