Mid-Term Project –
End Report

Walkability Assessment of Graz, Austria

as part of the course:
VU GIS analysis techniques 2

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Contents

List of Figures

List of Tables

1 Original Study Context

Kević et al. (2024) explored how open data and open-source GIS tools can assess walkability in cities, specifically how freely available datasets such as OpenStreetMap and national open government data can be combined with the OS-WALK-EU walkability index to support urban planning in Zagreb. The authors used the OS-WALK-EU method (Fina et al. 2022) to the 11 districts in Zagreb, to answer this question. They calculated this walkability index from two viewpoints: At first, how suitable is the area for free-time activities? And second, how well it supports daily tasks? The analysis used environmental information (for example, population density and green/blue areas) together with accessibility measures based on distances to different types of points of interest. All data used in the study was openly available and processed in a GIS environment. The results show that walkability is highest in the city centre and decreases toward the suburbs. Even though the two perspectives use different weightings of amenities, the overall pattern is almost the same. So many important amenities are well distributed across the districts. Lower walkability values were found in industrial and low-density areas. The study shows that open data can successfully support data-driven decision making in urban planning. But there is always a challenge to have good data quality and coverage.

2 Reproducibility Challenges

Reproducing the OS-WALK-EU approach for Graz in Python brought several strengths of the original method to light, but also some limitations. The overall structure of the index, its two user perspectives, the six POI categories, and the way accessibility and environmental factors are combined could be transferred without major difficulties. The publication explains the POI groups, the distance ranking and the 0–100 normalisation clearly enough to follow these steps in a new setting. Some technical aspects, however, are not described in sufficient detail to allow a one-to-one reproduction. This applies to how the DEM is processed, how internal normalisation is handled inside the plugin, and which default settings are used for routing and threshold values. Because of these gaps, the Python implementation can mirror the concept, but not the exact numerical output of the QGIS plugin.

Differences in data availability between Zagreb and Graz also complicate reproducibility. For Graz, population and environmental indicators are not available in the standard INSPIRE grid; instead, they are mostly published at district level or in other formats. This made an additional aggregation step to the H3 grid necessary. OSM data add another layer of uncertainty, as the coverage of POIs varies across the city and some categories are noticeably under-mapped, which can influence the resulting walkability patterns. Further sources of variation arise from the computational effort many hexagons combined with many POIs lead to long runtimes and from differences in how tools such as kepler.gl handle visualisation and rendering. Taken together, the workflow remains transparent and can be reproduced in principle, but exact numerical agreement with the original plugin cannot be achieved.

3 Methodological Adaptations

Our approach is inspired by the OS-WALK-EU method used by Kević et al. (2024) for Zagreb, but we transfer the idea into a fully Python-based analysis and adapt it to open data available for Graz. Instead of using the OS-WALK-EU QGIS plugin, we implement all steps as code: we load district boundaries from Overpass and join them with official population data from the City of Graz, we download POIs directly from OpenStreetMap via OSMnx and classify them into the six OS-WALK-EU categories (retail, food, civic, sport, office, entertainment), convert all geometries to points, and merge them into one GeoDataFrame. For the environmental component we use Copernicus Urban Atlas 2018 to extract only "Green urban areas" and "Water" for Graz instead of the Zagreb-specific datasets used in the original study, and we build our own pedestrian network with `graph_from_place(..., network_type="walk")` rather than relying on routing handled internally by the plugin.

A key methodological change is the choice of spatial units and how distances and scores are calculated. While Kević et al. use a standard 500×500 m INSPIRE grid, we generate an H3 hexagonal grid at resolution 8 that produces cells of similar size but different shape, and we fill this grid by converting district polygons to H3 indices and then back to hexagon geometries. We assign each POI to a hex cell, compute hex centroids, and then calculate distances from each centroid to multiple nearest POIs per category using our own Haversine function (great-circle distance) rather than the plugin's network-based proximity with a pedestrian radius. Following the two user perspectives in the paper ("enjoying free time" and "daily obligations"), we implement the POI weight schemes in dictionaries and assign weights by distance rank in code, then compute accessibility contributions as weight divided by distance plus one and aggregate them per hexagon into leisure and daily accessibility scores (see Table 1 in the Appendix).

For environmental indicators, we derive population density by distributing district-level population across hexagons and computing density from hex area, compute the mean slope per hexagon from a 30 m DEM of Graz, and normalise green/blue coverage, population density, and a "flatter is better" slope score before combining them into a single environmental index with explicitly chosen weights. Specifically, we assign weights of 0.8 to green/blue coverage, 0.2 to population density, and 0.5 to the slope score, reflecting the dominant role of greenery, a moderate positive effect of density, and a clear penalty for steep terrain. While the original OS-WALK-EU specification effectively sets the population-density weight to zero and does not explicitly include slope in the environmental component, our adaptation for Graz incorporates all three factors to better capture local topography and built-environment conditions. Finally, we combine POI accessibility and environmental scores into raw walkability values for leisure and daily life, normalise them to a 0–100 scale with our own function, and visualise both indices as choropleth maps over the H3 grid and in kepler.gl, which keeps the logic of OS-WALK-EU but makes all assumptions and parameters explicit and reproducible in code.

4 Results

The walkability patterns for Graz show a clear centre–periphery gradient that is consistent with the expectations from the original OS-WALK-EU study for Zagreb (Figure 1). In both perspectives, the highest values occur in the compact inner districts, while walkability gradually decreases towards industrial areas and low-density residential neighbourhoods. The separate indices for leisure and daily activities follow similar structures but differ in that leisure walkability is strongest in and around the historic centre and along major green corridors, whereas daily walkability extends medium to high values further into surrounding mixed-use neighbourhoods.

The comparison between Haversine-based and network-based distance calculations highlights how the choice of distance metric influences these patterns (Figure 1). In the central, well-connected parts of the city both approaches produce very similar results, suggesting that straight-line distances are a reasonable approximation of walking effort where the street network is dense and permeable. At the urban fringe, however, the network-based scores are systematically lower in areas separated from amenities by rivers, railways or major roads. In these locations, Haversine distances tend to overestimate accessibility, which underlines the added value of a network-based approach for capturing local barriers and detours, while still confirming that great-circle distances are sufficient for describing broad city-wide gradients.

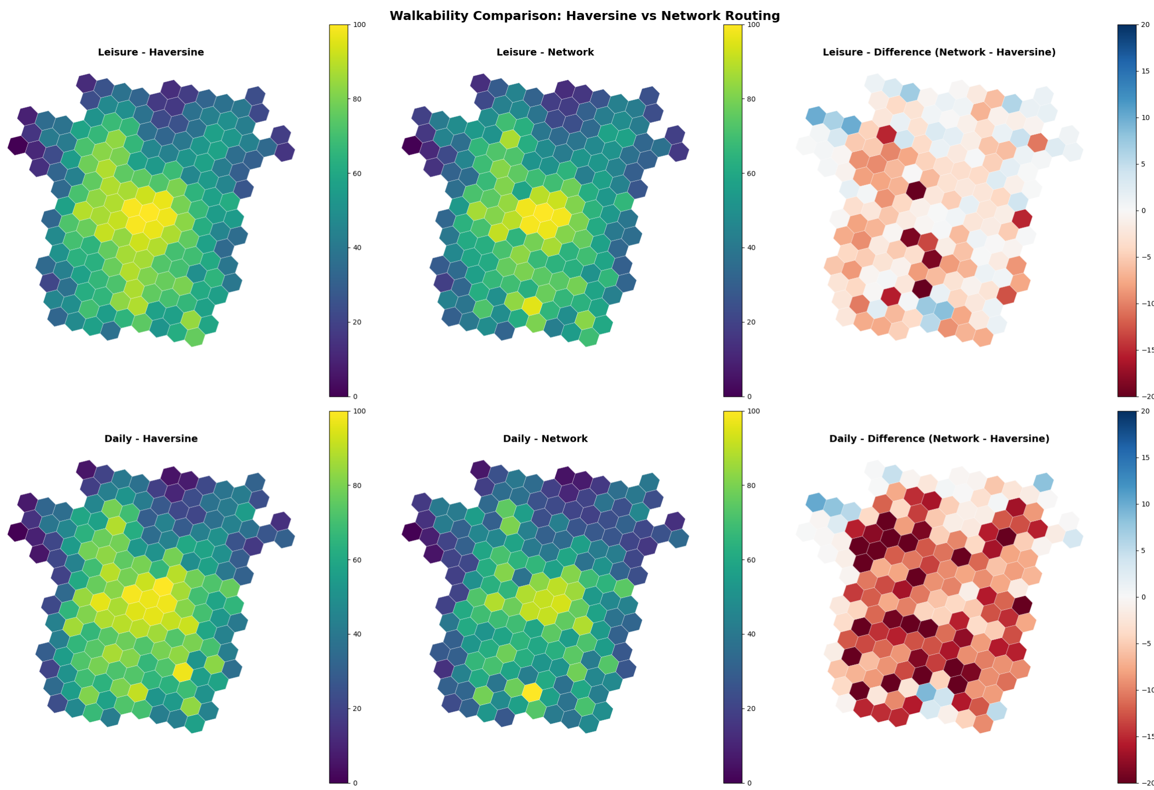

Figure 1: Walkability based on haversine vs network-approach Graz, Austria

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Appendix

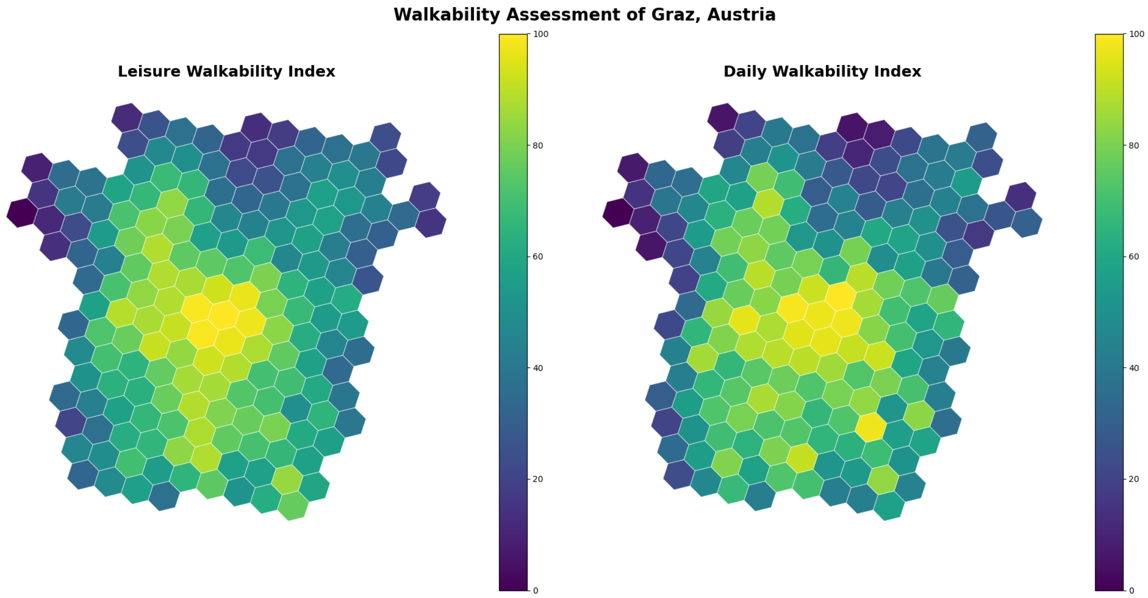

Figure 2: Walkability assessment of all districts of Graz, Austria (Final version)

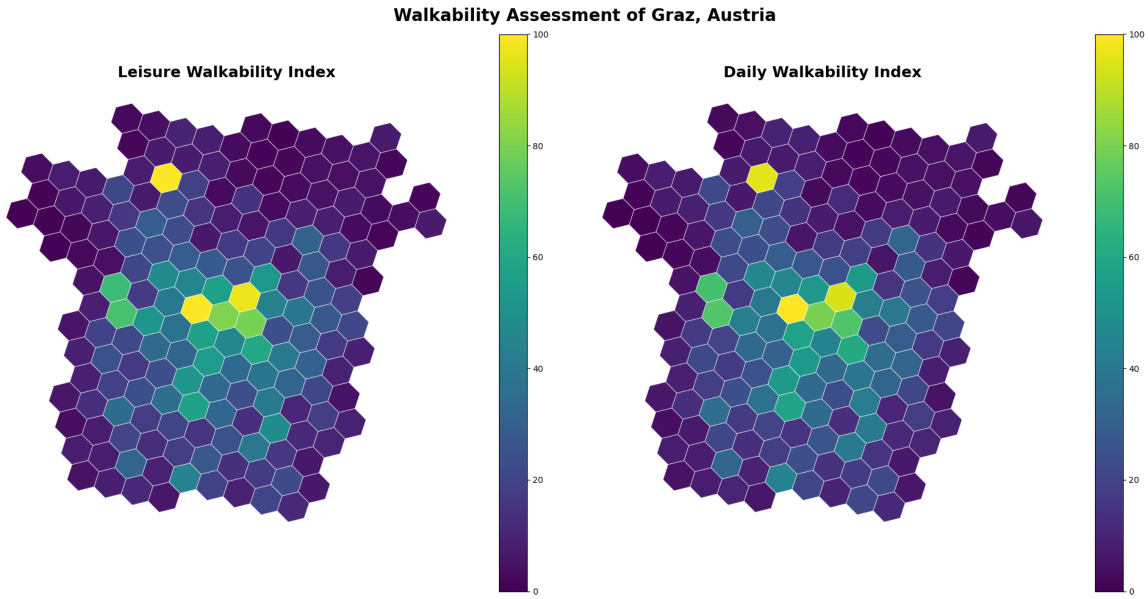

Figure 3: Walkability assessment of all districts of Graz, Austria (First version)

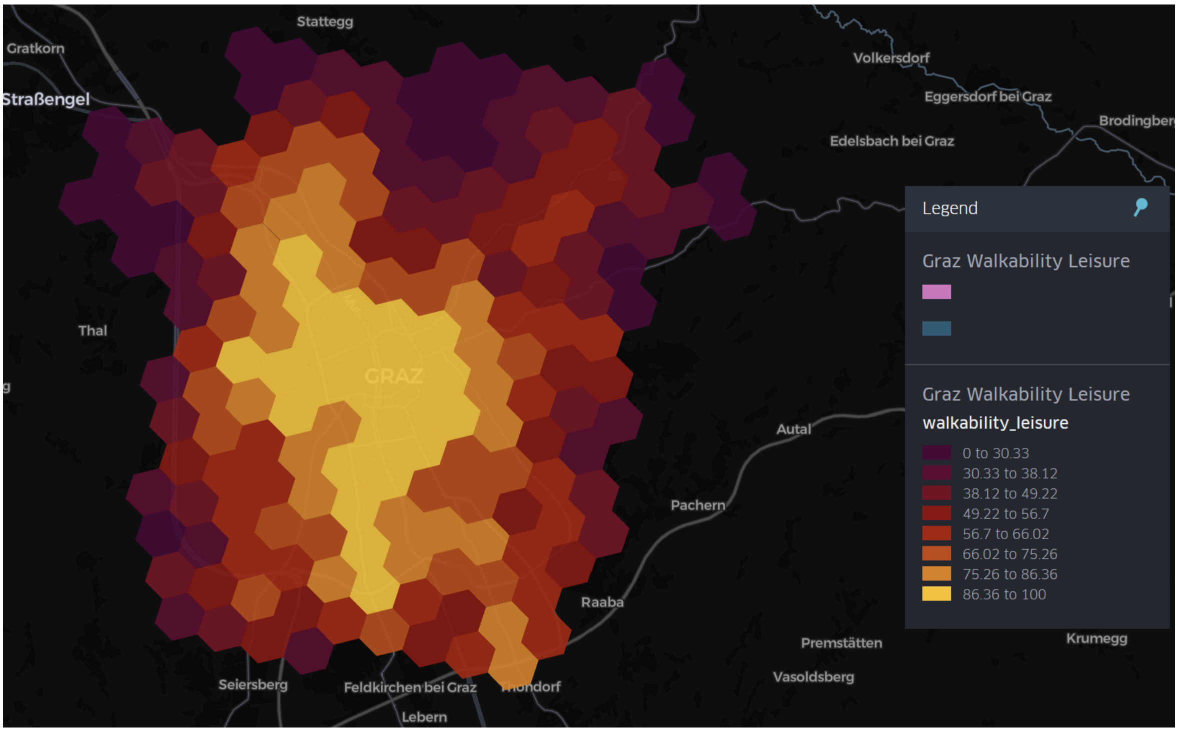

Figure 4: Leisure walkability of Graz, Austria (Visualization with Kepler)

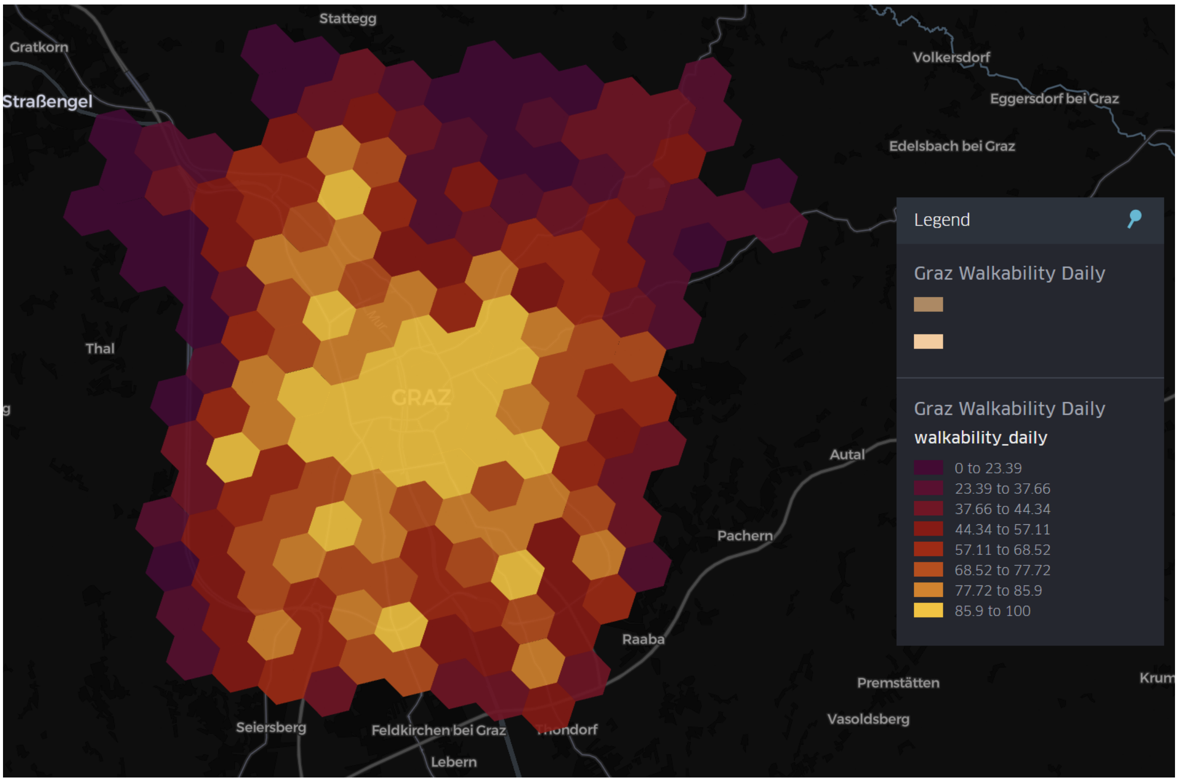

Figure 5: Daily walkability of Graz, Austria (Visualization with Kepler)

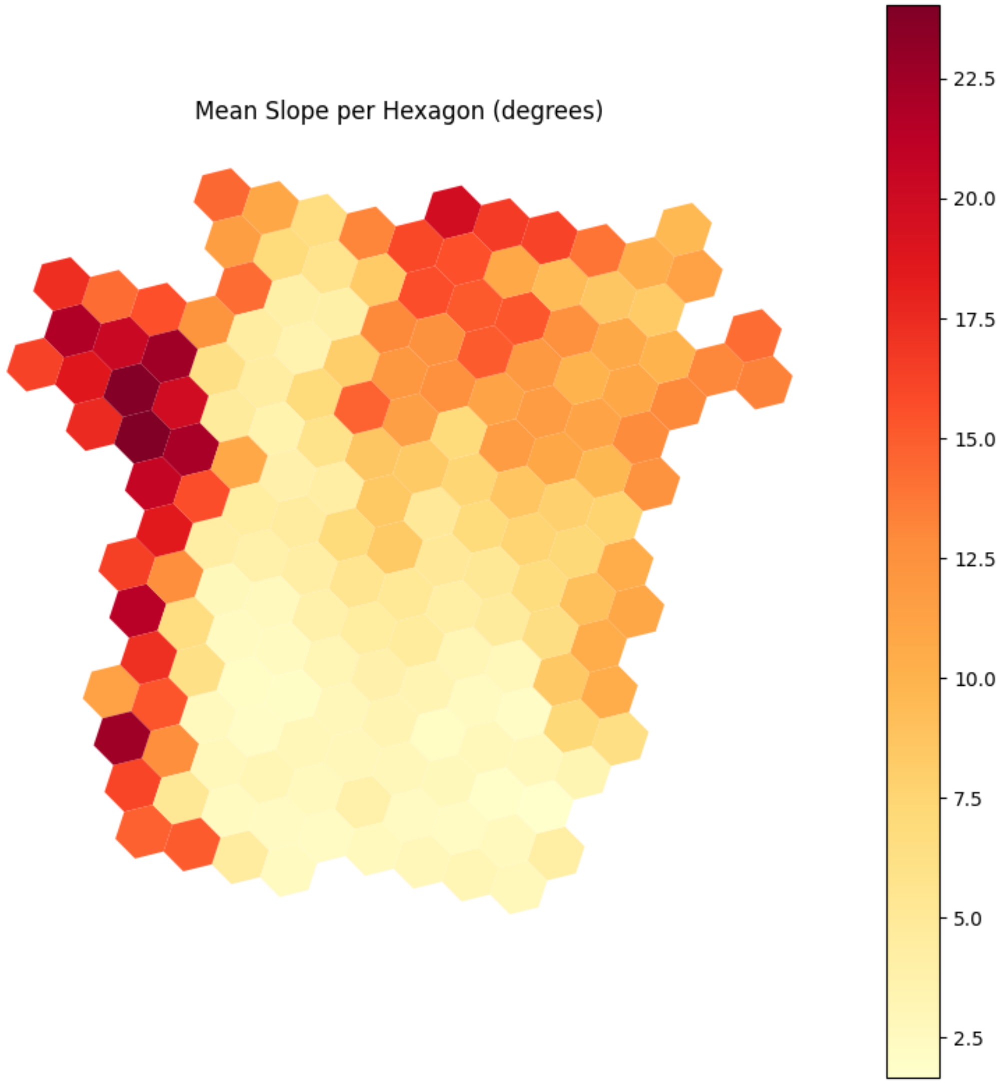

Figure 6: Mean slope of Graz, Austria

Table 1: POI weighting scheme for leisure and daily obligations perspectives

POI category	**Leisure weights**	**Daily obligations weights**
Retail	[2, 1]	[5, 2]
Food	[5, 3, 2]	[4, 1]
Entertainment	[5, 3]	[0, 0]
Office	[0]	[5, 3]
Civic	[1]	[5, 3, 2]
Sport	[3, 2]	[1]