AN INTERACTIVE WEBGIS FOR GENDER-SENSITIVE WALKABILITY ASSESSMENT IN SALZBURG

FINAL PROJECT

IP: Application Development (GIS)

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Introduction

Walkability in cities is becoming increasingly important as urban planners aim to create more sustainable, resilient and inclusive cities, not least due to the implementation of the Sustainable Development Goals (SDGs) by the United Nations. However, studies on walkability in cities often take a general perspective without considering the individual needs and perceptions of specific pedestrian groups (Gorrini et al., 2021; Shields et al., 2023). For women in particular, walkability is not only about the physical features of the built environment, but also about a feeling of comfort and personal safety (Golan et al., 2019). For instance, women may avoid certain routes due to poor lighting or have accessibility issues when moving around with a stroller or small children (Sethi &Velez-Duque, 2021). Therefore, women-specific indicators need to be considered when ensuring inclusive metrics of walkability. These could include sidewalk width, presence of crime or homeless people as well as lighting conditions as done by *Golan et al.* (2019).

Regarding general walkability, *Stutz et al.* (2025) have introduced a walkability index for Salzburg, which uses characteristics of the built environment as indicators for assessing walkability at street level. The study calculates a walkability index (WI) based exclusively on open spatial data. Eleven indicators, divided into the categories of safety, comfort, aesthetics and functionality, are computed using the NetAScore toolset developed by the Mobility Lab at the Department of Geoinformatics (Z_GIS) at the University of Salzburg. Although the authors provide a general parameterization of their indicators, they claim that the method is scalable and adaptable and can therefore be applied to assess the walkability of certain user groups such as women (Stutz et al., 2025).

Since gender-specific indicators are currently rarely used in the assessment of pedestrian-friendliness, this project aims to use the NetAScore toolbox with customized indicators and weightings to create specific user profiles for women. In this context, a special focus is placed on women walking at night and caretakers with young children or strollers, as their everyday mobility can be severely restricted due to the aforementioned safety and accessibility. The generated results are then efficiently visualized in an interactive WebGIS to ensure transparency. The project leads to the following research questions.

1. How can gender-sensitive walkability in Salzburg be assessed with NetAScore using a set of customized indicators and weights?
2. How must the indicators and weights be adapted to reflect the specific needs and perceptions of caregivers or women at night?
3. How can the results be visualized in a WebGIS considering the specific user profiles of women?

Methods

The first step was to set up the project, which involved creating and cloning a Github repository. Additional steps included implementing the folder structure for using Django as well as creating a virtual environment with all the necessary python packages. NetAScore was done NetAScore was then integrated according to the workflow suggested in the documentation. This involved downloading the original YML file and following running the available Docker image to recreate the environment of NetAScore in our own repository and generate initial results based on the example case in Salzburg. In this context, Docker is optional, but it enables efficient and accurate execution of NetAScore with all its dependencies on any system to minimize conflicts.

To be able to edit the Open Street Map (OSM) data for the specific user profiles of women walking at night and caretakers with strollers or young children, it was important to properly understand the structure of NetAScore. After all, NetAScore uses a wide range of technologies from Python to PostgreSQL and Docker. In this context, particular emphasis was placed on the database structure with PostgreSQL and the PostGIS extension, since this is where the OSM data for Salzburg is stored and queried in accordance with the requirements for the customized walkability analysis. This helped to understand which data had to be additionally loaded for the specific user profiles and which available data could be processed into more valuable information.

Since studies have shown that poorly lit areas are one of the main reasons why people and especially women feel unsafe at night when walking alone (Sethi &Velez-Duque, 2021), the attribute *lit* was queried from the OSM data, which normally occurs in combination with highways and can contain values such as *yes*, *no*, *automatic* or *24/7* (OpenStreetMap Wiki, 2025). To do this, several files had to be modified to ensure the creation of a new column in the database. At the same time, a new indicator called *lit* had to be calculated with SQL, defining how different attributes should be handles Then, the newly defined indicator was added to the walkability index so that it could later be adjusted to the specific YML user profiles.

Although NetAScore already has many predefined indicators that are very important for analyzing walkability for women walking at night or caretakers with strollers or small children, such as sidewalk width, gradient or surrounding buildings, especially the indicator for existing facilities could be further improved to optimize the results for user-specific walkability indices. In this context, two additional indicators were created using the corresponding python script that generates the dataset for the facilities. The first indicator focuses on facilities that are important for women walking at night. Since the existing indicator for facilities covers a wide range of facilities, it made sense to filter the facilities to those that may have longer opening hours, such as bars or restaurants, as well as places that may be equipped with security systems, such as ATMs, all of which can improve women's perception of personal safety. After all, many women report that active street fronts make them feel safe when walking (Sethi &Velez-Duque, 2021). Similarly, the original indicator for facilities may also be too broad for caretakers with stroller or young children, which is why the facilities were also filtered to include their specific needs. Here, it was assumed that this user group especially profits from amenities such as toilets, benches, playgrounds or parks.

After integrating the newly defined indicators for the specific user profiles, the default walkability mode profiles could be adjusted, meaning the specific weights as well as indicator values. For women walking at night, particular emphasis was placed on lighting, facilities that might be open at night and the presence of buildings. For the latter, the indicator values had to be reversed, since it is generally assumed that walkability is improved when there are fewer buildings in the immediate vicinity, whereas for women at night, a cluster of buildings can be a safety feature, as more eyes are on the streets. On the other hand, for caretakers with strollers or young children, a special focus was given to gradient, sidewalk width and pavement type, all of which are features that are less considered when calculating general walkability. In this context, a DEM for Austria had to be downloaded and integrated into the code in accordance with the documentation, while at the same time the index values were adapted to the specific needs of caregivers with children or strollers. .Furthermore, the indicator value for stairs was reduced in particular, as it is assumed that these represent a barrier for this user group.

As a last step, the three walkability indices, namely general walkability, walkability for women at night and walkability for caretakers with stroller or young children, were calculated using the Docker image, referencing the custom walkability mode profiles. The output generated with NetAScore comprises three geopackages, which had to be converted to GeoJSON using a Python script, so they could serve as the input for the WebGIS.

For the WebGIS, a combination of HTML, CSS and JS with Leaflet was used. First, the three walkability indices were loaded into the web map and visualized in five categories ranging from unsuitable to very suitable road segments for each user profile. In this context, an interactive profile control was also implemented so that users can select the user profile that best suits them or compare the different walkability indices with each other. At the same time, a pop-up was created that displays the walkability index. Since the indicators were weighed differently for each profile, the most important indicators per profile are also displayed individually in the pop-ups. Lastly, to improve the overall quality and design of the web map, an introductory text was added as well as some insightful statistics on the distribution of unsuitable road segments across the three user profiles were added to the map

Results

The interactive WebGIS efficiently visualizes the three walkability profiles while introducing the topic and its complexity. The user interface is designed to allow intuitive access to the different walkability profiles. A minimalistic design was chosen to keep the focus on the walkability index. To further ensure inclusivity, a colorblind-friendly color scheme was implemented, allowing for easy differentiation between unsuitable and satisfactory street sections.

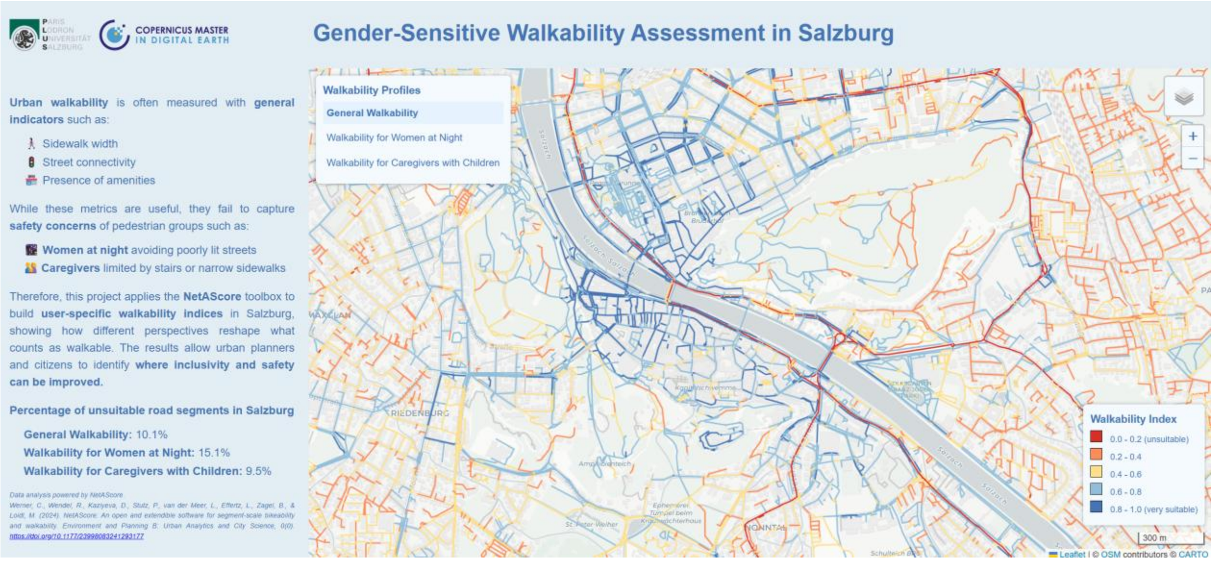

Figure 1. Overview of the interactive WebGIS.

When examining the user-defined walkability profiles, the differences to general walkability become clear, which can be attributed to the implementation of the additional indicator and the indicator weightings. For instance, there are far more unsuitable road sections for women walking at night than for general walkability. Especially in the city center, many unsuitable or less suitable streets become visible for women walking at, which sometimes complements the results of general walkability. Here, especially areas that are not lit at night, such as in Mirabellgarten or Möchnsberg, are particularly unsuitable for women walking at night. On the other hand, these streets can be very attractive to the general public during the day, resulting in a higher WI value for the general walkability profile.

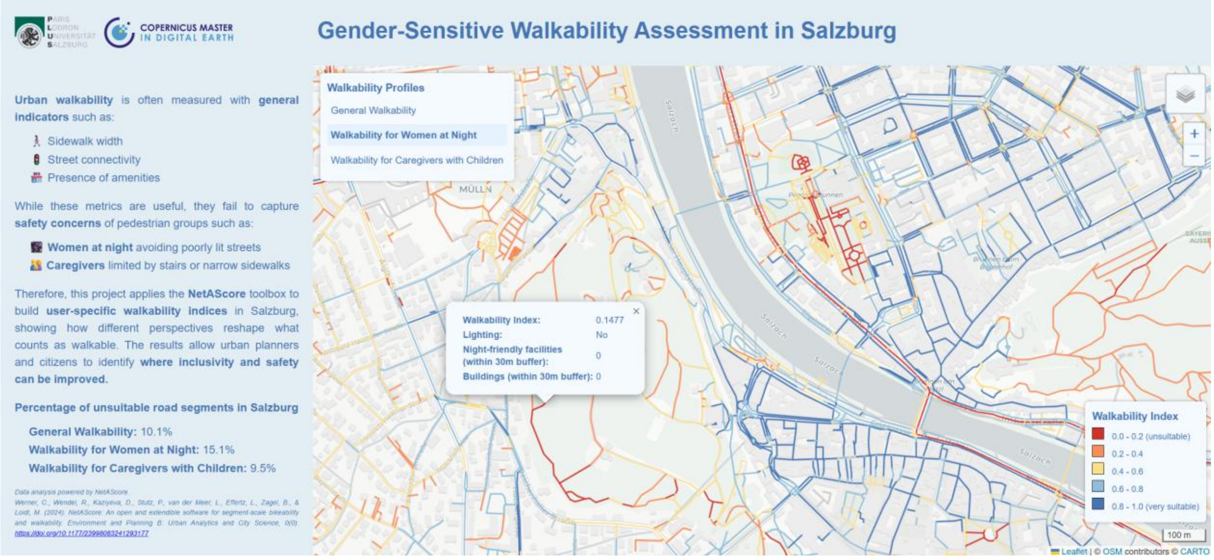

Figure 2. Walkability profile of women walking at night showcasing areas that are not lit.

Similarly, the walkability profile for caregivers with children also shows many differences from general walkability. In this context, it should be noted that this accessibility profile generally showed slightly fewer unsuitable road sections than general accessibility. Especially in the vicinity of Salzburg, the roads were often rated better, while the true value of this walking profile becomes apparent in the city center. Here, areas with less traffic, more green spaces and many child-friendly facilities such as Mirabellgarten become very suitable road segments for walkability. On the other hand, an interesting feature was the contribution of the *stairs* indicator. Since it was assumed that stairs would be a limitation for caretakers with strollers, the results show that areas with stairs, such as the example on Kapuzinerberg, receive a lower rating compared to general walkability. In this context, the importance of the individual pop-ups becomes clear, as they can provide specific user groups with additional information tailored to their needs, such as the presence of stairs.

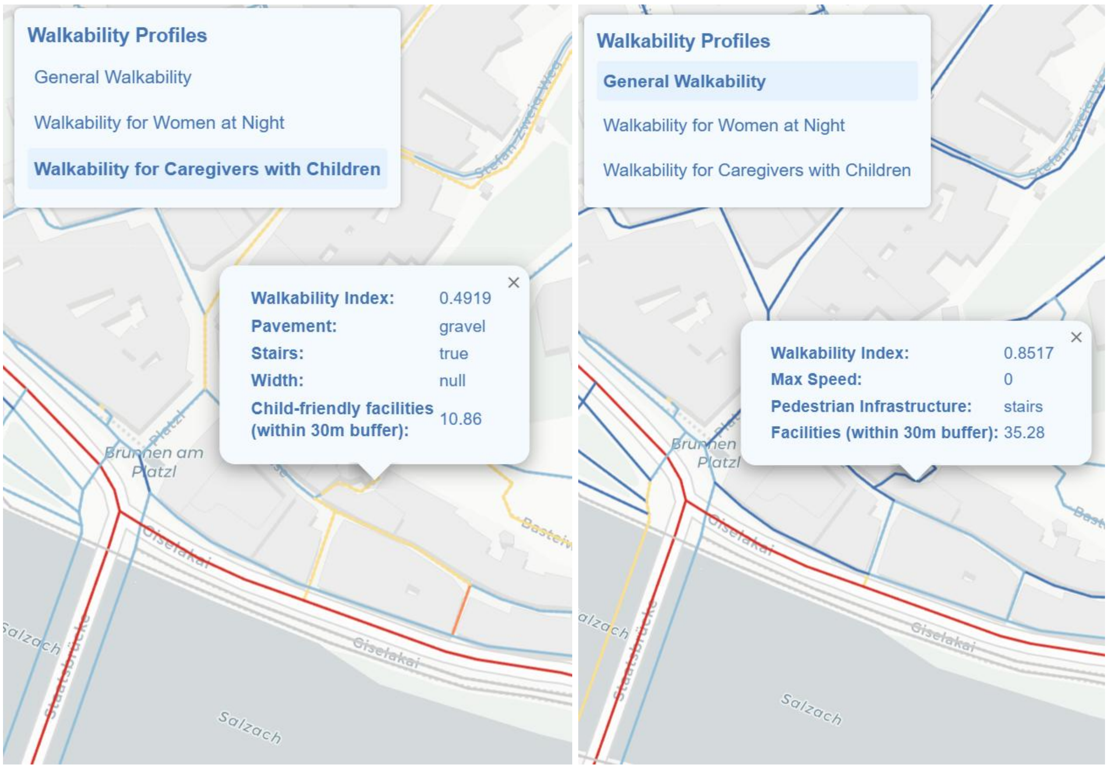

Figure 3. Comparison of the WI for general walkability and walkability for caregivers with children.

Conclusion

This project has impressively demonstrated how important it is to consider accessibility not only from a general perspective, but also to consider the specific perceptions and needs of certain user groups. The integration of additional indicators such as user-specific facilities and the display of lit areas into the NetAScore toolbox helped to efficiently create individual walkability indices. In this context, the results clearly show areas where women may feel unsafe due to poor lighting or where caregivers may have accessibility issues due to elevation or stairs. At the same time, the WebGIS is an important step toward transparency and accessibility for urban planners and citizens.

Although the results are already very informative, it should be noted that the user-defined walkability indices are currently only examples and can only be considered a first step toward a truly inclusive walkability assessment. In this context, some problems occurred in computing the walkability indices, particularly in the walkability profile for caregivers, where areas outside of the city center were often rated higher. Here, it might be useful to add additional indicators that could further improve the results. At the same time, it is proposed that user-related surveys be conducted to better understand the needs and perceptions of women regarding walkability. These surveys could provide insight into how the walkability indicators can be used. Here, it might be useful to expand the WebGIS and add online surveys in combination with the web map. For this, the already implemented Django project could serve as a basis and be further developed into an interactive web application in which citizens and urban planners can understand the concept of gender-specific walkability while also addressing their own concerns, drawing on their local knowledge and specific perceptions. This project thus demonstrates a scalable approach with high potential for creating more sustainable, resilient, and inclusive cities.

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Note on the Use of AI and Language Tools

For this project, next to the documentation of NetAScore, ChatGPT was used to better understand the structure and functionality of NetAScore, including its database schema and various file formats. Using the existing NetAScore repository, the code was adapted to implement the newly defined user profiles. The prompts consisted of questions about how specific NetAScore functions work and how to modify profiles. Furthermore, ChatGPT used for the development of an interactive web map using Django, helping to understand how to integrate NetAScore outputs into the web application. The produced code blocks were reviewed and manually adjusted to fit the specific project requirements. In addition, DeepL was applied to enhance the language quality of the report by correcting grammatical errors.