# ATGreen(GO): A multi-dimensional framework to measure accessibility and promote exposure to urban green

*Keywords: accessibility, nature connectedness, routing, sustainable mobility, street networks*

## Extended Abstract

Recent research underscores the pivotal role of urban greening and nature-based solutions in promoting sustainable urban development. These initiatives have become increasingly prominent on the political agenda of many cities and are widely recognized as effective strategies to mitigate extreme climate conditions and reduce the environmental footprint of urban areas[1]. The benefits of urban greenery extend beyond environmental improvements, directly enhancing residents' well-being by improving health outcomes[2] and fostering social cohesion[3]. With more than two-thirds of the global population projected to live in cities by 2050, the development of reliable spatial indicators to assess the availability of urban green spaces—and to measure the impact of their scarcity—has become a critical research priority. While many researchers and practitioners have focused on measuring individual green accessibility indicators in specific geographic areas, the concept of green accessibility is inherently multi-dimensional. Policy bodies and public health authorities have established multi-level targets and provided recommendations, demonstrating that a single metric cannot fully capture the complex relationship between urban residents and their access to nature.

In this work, we propose and rigorously evaluate a framework that measures and compares multiple indicators of green accessibility within a multi-dimensional context[4]. Specifically, we have developed a flexible pipeline that integrates publicly available datasets to characterize three families of accessibility metrics—minimum distance, exposure, and per-person—under various parameterizations, such as greenery type, minimum green area size, and time budget. We investigate the degree of interchangeability among several indicators within and across families by analyzing the stability of population and area rankings induced by any two indicators. Our findings reveal that subgroups of a city's population who are disadvantaged according to one accessibility indicator may perform well according to others. Importantly, we demonstrate that spatial indicators used to evaluate green accessibility are highly sensitive to the underlying parameterization. From a policy perspective, this highlights the necessity of considering a range of indicators within a multi-dimensional framework to properly assess the adequacy of green provision in a city. Finally, we introduce **ATGreen**, an interactive web platform designed to provide easy access to all data and algorithms produced in this study. The platform's functionalities extend beyond data exploration, enabling users to create and test ad-hoc indicators and assess the impact of urban greenification. Leveraging open-source data and software, ATGreen covers over 1,000 cities in 145 countries, making it adaptable to any city, subject to data quality evaluation. Its goal is to assist policymakers in developing data-driven policies for comprehensive evaluation of green accessibility.

With ATGreen, our initial focus was on mapping the structural elements of green accessibility. As a natural progression, we expanded our efforts to develop tools that enhance urban residents' exposure to nature in their daily routines. In this direction, we implemented **ATGreenGO**, a routing engine and interactive web application that recommends nature-enriching routes with minimal detours compared to the shortest path. The use of routing engines has surged in recent decades due to the widespread availability of internet access on mobile devices. While routing engines offer various functionalities, their primary purpose is to compute optimal routes between two points. This computation can be customized based on several parameters, including mode of transport (walking, cycling, driving, public transport, or multimodal options), arrival and departure times, traffic conditions, emissions, and more. Most commonly, routing engines define route optimality based on the time required to complete the journey. However, there is growing interest in designing algorithms that recommend urban routes based on alternative definitions of optimality. Recent examples include the perceived pleasantness of the route[5], its popularity[6], or air quality[7].

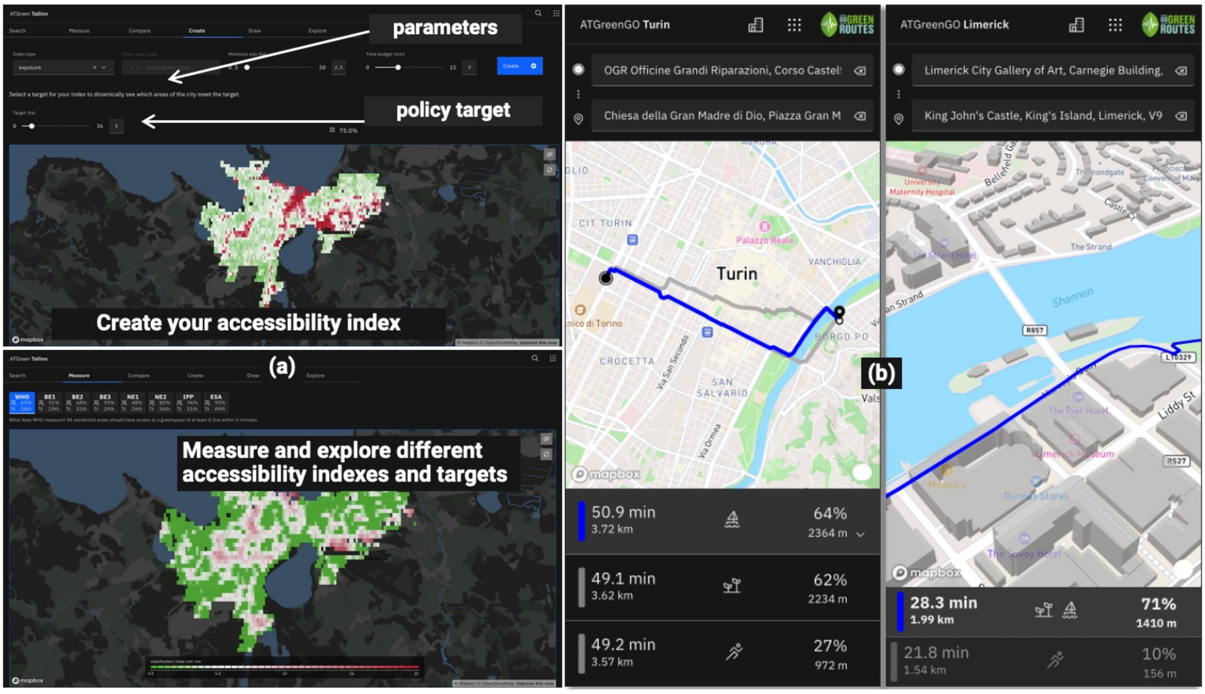


Figure 1: (a) Example interaction with ATGreen: At the top, users can create a custom accessibility index by selecting the type of green, the minimum size of the green feature, and the time budget. At the bottom, users can measure and explore the spatial configuration of several established accessibility indexes and targets. (b) Example of the greenest, bluest, and shortest routes computed with ATGreenGO for two European cities, Turin and Limerick.

The theoretical contributions of ATGreenGO are twofold: (1) the design of a nature-enriching algorithm capable of characterizing a city's street network with spatial features related to the presence of nearby natural elements, such as public green areas or blue bodies; (2) the definition of a routing optimization problem whose solution maximizes green exposure while balancing the detour from the shortest route.

Overall, the system's validation suggested that AtGreenGO can recommend nature-rich alternatives to the shortest path that, limiting the extent of the detour, can be integrated into the users' daily routines.

## References

[1] Emanuele Massaro et al. "Spatially-optimized urban greening for reduction of population exposure to land surface temperature extremes". In: *Nature Communications* 14.1 (2023), p. 2903.

[2] WHO. *Urban green space interventions and health: A review of impacts and effectiveness*. 2017.

[3] WHO. Regional Office for Europe. *Urban green spaces: a brief for action*. 2017.

[4] A. Battiston and R. Schifanella. "On the need for a multi-dimensional framework to measure accessibility to urban green". In: *npj Urban Sustainability* 4.1 (2024), pp. 1–11.

[5] R Schifanella D. Quercia and L. M. Aiello. "The shortest path to happiness: Recommending beautiful, quiet, and happy routes in the city". In: *ACM conference on Hypertext and social media*. 2014, pp. 116–125.

[6] X. Xie Y. Zheng L. Zhang and W. Ma. "Mining interesting locations and travel sequences from GPS trajectories". In: *International conference on World Wide Web*. 2009, pp. 791–800.

[7] A. EC. Redondi A. Pimpinella and M. Cesana. "Walk this way! An IoT-based urban routing system for smart cities". In: *Computer Networks* 162 (2019), p. 106857.