

Global geographical access to urban green spaces

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Global geographical access to urban green spaces

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Abstract

Access to urban green space (UGS) supports health and well-being, yet inconsistent definitions and accessibility measures limit cross-city comparisons. We present a reusable, scalable framework combining pedestrian accessibility and landscape configuration of UGS across 11,422 cities in 191 countries and territories. Using 20-m least-cost path modelling, we estimate access for populations aged <65 and ≥65 years under three walking-speed scenarios and two complementary UGS definitions: a conservative, use-oriented one and a broader, ecologically oriented one. Globally, 60.1% of people aged <65 and 55.4% aged ≥65 can reach UGS within 15 minutes under the conservative definition; within five minutes, these shares fall to 25.4% and 19.8%. Accessibility was lowest in Sub-Saharan Africa and South Asia. City-level accessibility varied by up to 68 percentage points among megacities between UGS definitions. Green-space quantity alone did not determine access: accessibility also depended strongly on its spatial distribution. Our framework provides a harmonised, age-disaggregated basis for monitoring SDG 11.7.

Introduction

Today, 45% of the world's population lives in cities, which are projected to account for two-thirds of global population growth between now and 2050 (United Nations, 2025). This trend is particularly important as built-up areas are expanding faster than urban populations (United Nations, 2025), leaving a growing share of urban land covered by concrete, asphalt, and other heat-absorbing materials. These surfaces absorb heat during the day and release most of it at night, intensifying the urban heat island (UHI) effect (Rizwan et al., 2008) and exposing more people to elevated temperatures and related health risks (McDonald et al., 2026; Y. Wu et al., 2025).

Urban green spaces (UGS) are essential for addressing this challenge. Recent studies show that existing urban tree cover already offsets about half of potential UHI intensity worldwide (McDonald et al., 2026), while a 20% increase in urban greenery could prevent around 1.02 million heat-related deaths globally (Y. Wu et al., 2025). Beyond regulating temperatures, green spaces promote physical activity and social interaction, while supporting mental health and overall wellbeing (Araújo et al., 2024; Hunter et al., 2023; Kwon et al., 2021; Reyes-Riveros et al., 2021; Sugiyama et al., 2018; WHO, 2016; J. Xu et al., 2023). As such, UGS are vital to creating liveable, resilient urban environments.

The breadth and strength of this evidence are reflected in global policy commitments. In 2016, the New Urban Agenda was adopted at the United Nations Conference on Habitat III (United Nations, 2017), and target 11.7 of the United Nations Sustainable Development Goal (SDG) 11 explicitly calls for "*universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities*" by 2030 (United Nations, 2015). Yet access to green spaces remains deeply unequal despite this ambition. Vulnerable population groups bear a disproportionate burden of inaccessibility, with access to green space concentrated among higher socio-economic classes (Achebak, Masselot, et al., 2026; Achebak, Paniello-Castillo, et al., 2026; Kuang et al., 2026; Leng et al., 2023). These inequities, together with the need for UGS, raise an urgent question: how can progress towards SDG 11 be meaningfully measured and monitored at a global scale (Giuliani et al., 2026) to enable targeted improvements?

Answering this question requires looking beyond simple proximity or density metrics. While measures such as green space per person or the percentage of residents within a straight-line distance of a park reflect spatial availability, they do not indicate how people actually access green spaces (Battiston & Schifanella, 2024). Physical barriers and enablers such as roads, railways, and topography influence whether green spaces are reachable, and walking capacity

varies greatly across age groups (Victor et al., 2015; Chênes et al., 2021; Giuliani et al., 2026). For older adults and others with limited mobility, access to UGS may be far more limited than proximity measures suggest (Giannoulaki & Christoforou, 2024; Victor et al., 2015; Willberg et al., 2023). This is an important equity consideration, as He et al. (2026) demonstrate that dispersed green spaces reduce heat-related mortality more effectively than a small number of large parks, largely because they are accessible to a broader share of the population, including individuals with limited walking mobility.

Over the past decade, measures of UGS exposure and accessibility have evolved alongside a growing understanding of the health benefits of contact with nature. Early measures focused mainly on proximity, with WHO's review of UGS and health recommending that residents live within 300 metres of a green space covering at least 0.5 hectares (WHO, 2016). The 3-30-300 rule expanded this approach by incorporating green visibility and canopy cover, recommending that residents should be able to see at least three trees from home, neighbourhoods should have at least 30% tree canopy cover, and residents should live within 300 metres of a public green space (Konijnendijk, 2022). More recently, the 15-15 rule (Wang et al., 2026) has shifted the emphasis from proximity towards actual use, defining green space as accessible when residents can reach it within a 15-minute walk and it is sufficiently large to support at least 15 minutes of meaningful exposure, a duration associated with health benefits in recent studies (Jin et al., 2024; Y. Li et al., 2025).

Geospatial accessibility modelling helps assess whether distance- and time-based thresholds are met and supports planning concepts such as the 15-minute city. This concept envisions urban environments where residents can reach essential amenities, including green space, within 15 minutes on foot or by bicycle (Allam et al., 2022). The way travel time or distance is measured matters. Simple buffer-based approaches draw a straight-line radius around a green space and are widely used, but they can overestimate access by ignoring physical barriers, the street network, and variations in travel speed. More detailed approaches account for these features to represent movement through urban space more realistically (Battiston & Schifanella, 2024). Here, we use a least-cost travel-time approach that accounts for barriers and age-specific walking speeds. This provides a more realistic representation of pedestrian accessibility while remaining computationally feasible for application across thousands of cities (Giuliani et al., 2026).

Over the years, geospatial accessibility research on UGS has progressed from city- and national-scale GIS models (Chênes et al., 2021; Zhang et al., 2011) to multi-city and multi-country comparisons (Kaufmann et al., 2025; Kifayatullah et al., 2025; L. Wu & Kim, 2021), and more

recently to two global assessments. Richards et al. (2025) use a ~1 km friction surface (Weiss et al., 2018) and vary walking speed by age and sex, while Battiston and Schifanella (2024) cover over 1,000 cities with distance, exposure, and per-capita metrics, and provide a customizable definition of green space. Green space itself still lacks a harmonised definition, and how it is mapped varies by region and culture, including in OpenStreetMap tagging (Ludwig & Zipf, 2019).

More fundamentally, no universally agreed methodology exists for measuring and reporting access to UGS, and countries do not monitor it consistently (UN-Habitat, 2021). The SDG 11.7 indicator is classified as Tier 2, meaning that its methodology is conceptually established, but data are not produced regularly and typically do not capture accessibility, use, or safety (Pafi et al., 2016; Poelman, 2016; UN-Habitat, 2021). At the European level, a comparable indicator measures the proportion of urban residents without access to green areas in their immediate neighbourhood (Poelman, 2016; Chênes et al., 2021).

Our approach builds on an open, reproducible accessibility framework (Giuliani et al., 2026) to provide a global assessment and a standardised, scalable method for monitoring SDG 11.7 within and across countries. We examine green space using two complementary definitions, with a conservative definition restricted to publicly accessible areas such as parks and recreation grounds, and a broader definition that additionally captures ecologically green land that may not be publicly accessible, including meadows, gardens, scrub, and forests. Using AccessMod, an open-source cost-distance modelling tool, we estimate walking access at 20 m resolution across urban centres worldwide (Ray et al., 2022), separately for populations under 65 and aged 65 years and older and across multiple walking-speed scenarios to capture uncertainty in mobility. We further characterise the spatial configuration of green space within each city using landscape metrics capturing its extent and fragmentation, characteristics that recent studies have associated with health outcomes such as heat-related mortality beyond proximity alone (He et al., 2026; Yao et al., 2026).

Methods

Study area and city delineation

We estimate walking travel times to public green spaces in 11,422 cities worldwide. Defining cities consistently at the global scale remains challenging, as urban areas can be delineated using administrative boundaries, built-up extents, or functional metropolitan regions, resulting in substantially different geographic extents (L. Dijkstra et al., 2021; UN-Habitat, 2020). A city's spatial extent can also vary substantially depending on the definition used (UN-Habitat, 2020).

To ensure global comparability, we delineate cities using the Global Human Settlement Layer Urban Centre Database 2025 (GHS-UCDB, version R2024A V1.1) (Melchiorri et al., 2024). Following the Degree of Urbanisation methodology, urban centres are defined as contiguous clusters of 1-km² grid cells with a population density of at least 1,500 inhabitants per km², a total population of at least 50,000, and at least four connected cells. The resulting dataset comprises 11,422 urban centres worldwide (Melchiorri et al., 2024).

Spatial datasets

To model pedestrian movement and quantify population access to UGS, we compile spatial datasets describing topography, land cover, transport infrastructure, movement barriers, population distribution, and UGS (Table 1).

Table 1. Overview of geospatial datasets and respective sources.

Dataset	Data type	Source year/version	Source resolution	Reference	Hyperlink
Urban-centre boundaries	Vector polygons	2025; GHS-UCDB R2024A v1.1	Vector boundaries delineated from a 1 km source grid	(Melchiorri et al., 2024)	GHS Urban Centre Database R2024A
Elevation / digital elevation model	Continuous raster	Mixed source years; AWS Terrain Tiles v1.1 produced in 2017, with SRTM acquired in 2000 used across much of the global land area.	Approximately 38 meters at the equator	(Hollister et al., 2025); Mapzen/AWS Terrain Tiles	AWS Terrain Tiles; elevatr (R package)
Land cover	Categorical raster	2021	10 m	(Zanaga et al., 2022)	ESA WorldCover 2021 v20Q
Age- and sex-disaggregated population counts	Population-count rasters	Global 2 WorldPop 2025 population estimates; R2025A v1 release	Approximately 100m at the equator	(Bondarenko et al., 2025)	WorldPop R2025A v1
Roads	Vector lines; Overture transportation segments, distributed as GeoParquet	Overture release 2026-06-17.0; other releases used for a subset of cities due to the extended processing period	-	(Overture Maps Foundation, 2026); (OpenStreetMap contributors, 2026)	Overture release 2026-06-17.0; OpenStreetMap attribution
Movement barriers: rivers, canals, streams, lakes and other water bodies	Vector lines and polygons; Overture base water features, distributed as GeoParquet	Overture release 2026-06-17.0; other releases used for a subset of cities due to the extended processing period	-	(Overture Maps Foundation, 2026); (OpenStreetMap contributors, 2026)	Overture release 2026-06-17.0; Overture base theme
Movement barriers: railways, airport infrastructure and military areas	Vector lines and polygons; Overture transportation and base features, distributed as GeoParquet	Overture release 2026-06-17.0; other releases used for a subset of cities due to the extended processing period	-	(Overture Maps Foundation, 2026); (OpenStreetMap contributors, 2026)	Overture release 2026-06-17.0; OpenStreetMap attribution
Urban green-space polygons	Vector polygons; Overture base land use and land features, distributed as GeoParquet	Overture release 2026-06-17.0; other releases used for a subset of cities due to the extended processing period	-	(Overture Maps Foundation, 2026); (OpenStreetMap contributors, 2026)	Overture release 2026-06-17.0; Overture attribution and licensing

Terrain characteristics, roads and barriers

Elevation data, originally available at approximately 38 m resolution, are used to account for slope-dependent walking speeds (Hollister et al., 2025). Land-cover information is obtained from the ESA WorldCover dataset at 10 m resolution (Zanaga et al., 2022). Road networks and barriers to movement are derived from OpenStreetMap (OSM) data (OpenStreetMap contributors, 2026) distributed through the Overture Maps Foundation (Overture Maps Foundation, 2026). We primarily use Overture release 2026-06-17.0; however, because the analysis spanned an extended period, we processed a small proportion of cities using other releases available at the time of analysis. Barriers include rivers and lakes without bridge crossings, railway infrastructure, military areas, and airport facilities (Figure 1a).

Population data

Age- and sex-disaggregated population distribution data for 2025 are obtained from WorldPop and aggregated into two age groups (<65 years and ≥65 years) (Bondarenko et al., 2025). The population aged ≥65 years is calculated by summing the WorldPop age classes 65–69, 70–74, 75–79, 80–84, 85–89, and ≥90 years, while the population aged <65 years is derived by subtracting the population aged ≥65 years from the total population. Population counts, originally available at 100 m resolution, are downscaled to a 20 m grid by distributing the population of each 100 m cell equally among its constituent 20 m cells, thereby preserving the original population totals. Further details are provided in the *Data preparation* section.

Urban green spaces

UGS are delineated using two definitions that reflect different interpretations of what constitutes urban green space. The *conservative*, use-oriented definition aims to identify spaces that can reasonably serve as destinations for everyday recreation, physical activity, or mental wellbeing. It includes predominantly vegetated parks and recreational spaces of at least 0.5 ha that are designated as such in OSM and not explicitly marked as private or inaccessible. As information on entrance conditions and fees is rarely available in OSM (Ludwig et al., 2021; Ludwig & Zipf, 2019), these spaces are assumed to be generally accessible to the public at no cost. This conservative definition underpins our primary estimates of access to UGS.

The *wide*, ecologically oriented definition captures the city's broader vegetated structure. These areas can support ecological functions such as habitat provision, urban cooling, and landscape connectivity, while also providing recreational opportunities in some cases. However, they are not necessarily publicly accessible, easy to enter, or suitable for regular recreational use. Accessibility estimates under this definition therefore represent potential access to the broader mapped urban green network and provide an upper-bound estimate relative to the conservative

definition. The wide definition is not intended as an exhaustive inventory of all vegetated or ecologically valuable land within a city.

Both definitions include only green-space polygons measuring at least 0.5 ha (5,000 m²). This threshold aligns with the European Common Indicator cited in the WHO review of urban green space and health, which defines accessible public green space as an area of at least 0.5 ha within 300 m of residents (WHO, 2016). It has also been used in comparative assessments of UGS accessibility (Battiston & Schifanella, 2024). The threshold is also broadly consistent with the 3–30–300 rule (Konijnendijk, 2022). Limiting the analysis to spaces of this size focuses the assessment on areas more likely to provide meaningful recreational or ecological functions, while reducing the inclusion of small, vegetated fragments such as traffic islands and narrow roadside strips.

Green-space polygons are extracted from OSM (OpenStreetMap contributors, 2026) via Overture Maps (Overture Maps Foundation, 2026), using the same releases described above. The conservative definition includes features classified as parks, recreation grounds, dog parks, playgrounds, or village greens. Parks are the most consistently mapped feature type and are most reliably associated with public recreational use across global regions. Recreation grounds and playgrounds also generally have relatively little ambiguity about their intended use (Ludwig et al., 2021). To focus the analysis on vegetated spaces, features with predominantly hard surfaces, such as asphalt, concrete, paving stones, cobblestone, or sand, are excluded (Supplementary Table 1).

The wide definition includes all spaces in the conservative definition and additionally retains gardens, forests and woodlands, grass, meadows, grasslands, scrub, and shrubbery, broadly following Battiston and Schifanella (2024). These categories capture vegetation and land cover rather than recreational use, broadening ecological coverage while introducing greater uncertainty about public accessibility and recreational suitability (Supplementary Table 1).

Nature reserves, cemeteries, allotments, and heathland are excluded from both definitions. Although these categories can represent important green spaces and may be publicly accessible, their vegetation, recreational function, and accessibility vary substantially across geographic and cultural contexts. For example, cemeteries may be highly vegetated and used as public green spaces in some regions but not in others, illustrating the limitations of interpreting OSM tags consistently across settings (Ludwig & Zipf, 2019). We therefore exclude these context-dependent categories to improve comparability across cities, while recognising that the wide definition does not represent a complete inventory of urban vegetation.

Data preparation

All raster and vector datasets are projected to the appropriate Universal Transverse Mercator (UTM) zone for each city and harmonised to a common 20 m spatial resolution. This resolution limits inflation of narrow linear features, such as roads and rivers, during rasterisation while retaining the street-level detail relevant to within-city accessibility. To minimise edge effects in travel-time calculations, such as access to a park immediately outside the city boundary, all spatial layers are processed within a 3 km buffer around each city, with final outputs clipped to the city boundary for the calculation of zonal statistics and accessibility metrics.

Land cover is resampled to 20 m using nearest-neighbour interpolation and used as the common alignment template. Elevation is resampled to this template using bilinear interpolation. Population data, originally available at 100 m resolution, are disaggregated to 20 m by distributing counts equally among the constituent cells while preserving population totals. Roads and movement barriers are rasterised directly onto the 20 m template. Green space polygons are rasterised at the same resolution for the calculation of landscape metrics and subsequently converted to cell-centroid points for the accessibility analysis (Figure 1b).

Accessibility modelling

We estimate walking travel time to UGS with a cost-distance algorithm implemented in AccessMod (Ray et al., 2022; University of Geneva, GeoHealth Group, 2025; WHO, 2026). AccessMod is a geospatial accessibility modelling framework widely used to estimate travel times to health services (Ouma et al., 2018; Curtis et al., 2021; Macharia, Joseph, et al., 2022; Hierink et al., 2023), UGS (Chênes et al., 2021; Giuliani et al., 2021), and educational facilities (Jaramillo-Araujo & Hall, 2026; Macharia, Ray, et al., 2022). The model uses a friction surface, assigning each traversable grid cell a movement cost based on local terrain conditions. As a result, travel speeds vary with land-cover classes, road types, and topography.

To construct the friction surface, land-cover, road, and barrier datasets are combined into a single land-cover raster. UGS polygons are rasterised and converted into points at the friction surface's 20 m resolution because the accessibility analysis requires discrete destinations rather than polygon features. To limit the number of destinations and reduce computational demand, we retain only points along each UGS boundary, assuming pedestrians can enter a green space anywhere along its boundary. After calculating travel times, we use the original green-space polygons as a mask to assign a travel time of 0 minutes to all cells within each UGS. This approach does not account for fences, walls, or designated entrances, as the OSM data lack this level of detail.

Travel scenarios for different population groups

Accessibility modelling also requires assumptions about transport modes and speeds to the UGS, which here are represented by walking speeds for the two age groups. We parameterise walking speeds using the meta-analysis of outdoor walking speeds reported by Murtagh et al. (2021). Because globally consistent age-specific walking-speed estimates are unavailable, we assign the "usual" walking pace reported by Murtagh et al. (2021) to the population younger than 65 years, and the "slow" walking pace to the population aged 65 years or older. To account for uncertainty in walking speeds, we derive lower- and upper-bound travel scenarios from the corresponding 95% confidence intervals reported in the meta-analysis (Murtagh et al., 2021). This results in six travel scenarios in total: three walking-speed assumptions (lower, mean, and upper) for each of the two population groups (Supplementary Table 2).

Because the walking speeds reported by Murtagh et al. (2021) were measured on smooth surfaces, we adjust them to account for off-road movement. Following Gast et al. (2019), who found that walking speeds on rough natural terrain are approximately 14% lower than on smooth surfaces, we apply a 14% reduction to all non-road land-cover classes.

Slope correction

AccessMod calculates pedestrian travel times using a least-cost path approach based on Dijkstra's algorithm (E. W. Dijkstra, 1959). The cost of travelling between neighbouring cells is adjusted for slope using Tobler's hiking function (Tobler, 1993), which accounts for both slope steepness and direction of travel. This makes movement anisotropic, so traversing the same slope uphill and downhill results in different travel-time costs, with uphill movement toward a green space generally assigned a higher cost than downhill movement. Dijkstra's algorithm then identifies the route to the nearest UGS with the lowest accumulated travel time based on these direction-specific costs (Ray et al., 2022).

We then calculate travel times from every grid cell in the city to the nearest UGS destination using two green space definitions, conservative and wide, resulting in 12 scenarios per city: three walking-speed scenarios across two age groups (under 65 and 65 and older) for each definition. We generate accessibility surfaces separately for each age group, walking-speed scenario, and green space definition.

Urban green-space structure

Recent evidence suggests that the public-health benefits of UGS depend not only on their overall quantity but also on their spatial configuration (He et al., 2026). For example, cities with higher

green-space coverage, more dispersed green-space distributions, and more regular patch boundaries show lower heatwave-related mortality risks, whereas simply increasing the number of green-space patches or the size of the largest patch does not necessarily result in additional health benefits (He et al., 2026). Based on these findings, we quantify multiple dimensions of UGS configuration to characterise not only the travel time to UGS within cities but also its spatial arrangement, fragmentation, connectivity, and morphology.

To this end, we calculate a suite of landscape metrics from the rasterised green-space layers using the *landscapemetrics* package in R (Hesselbarth et al., 2018). All these landscape metrics are calculated for both our conservative and wide definitions of UGS. Green-space presence is quantified using the percentage of landscape occupied by UGS (PLAND). We characterise fragmentation and spatial dispersion using patch density (PD), number of patches (NP), largest patch index (LPI), and splitting index (SPLIT). Aggregation and connectivity are assessed using the aggregation index (AI), clumpiness index (CLUMPY), patch cohesion index (COHESION), and mean Euclidean nearest-neighbour distance (ENN-MN). Patch-size variability is quantified using the mean (AREA-MN) and standard deviation (AREA-SD) of patch area. We characterise shape complexity and boundary regularity using the landscape shape index (LSI), mean shape index (SHAPE-MN), edge density (ED), and total edge length (TE).

Data analysis: population access and green space configuration

We subsequently analyse accessibility and landscape characteristics at the city level to examine how the quantity and spatial configuration of UGS relate to population access. Using the resulting travel-time surfaces and age-specific population distributions (Bondarenko et al., 2025), we calculate the number and proportion of residents able to reach a UGS within successive one-minute walking-time intervals. We aggregate accessibility estimates to the city level and summarise them by age group, UGS definition, and travel scenario.

We further characterise UGS within each city using landscape metrics describing green-space coverage, fragmentation, connectivity, and spatial configuration, and examine their relationships with city-level accessibility. Summary statistics are reported globally and across population groups, UGS definitions, and travel scenarios.

For each city, we express accessibility as the share of the population in each age group that can reach a UGS within a given travel time (for example 5 or 15 minutes), and T80 as the travel time at which 80% of that population is reached. The total population of a city is the largest cumulative population in its travel-time output, which is the number of residents who can reach a UGS at

any travel time. Residents inside the city boundary who are cut off by barriers such as rivers or railways never reach a UGS in the model. We do not count them in the city population, because we consider this an artefact of incomplete or incorrect road networks and landscape representations rather than a true lack of access. In 36 cities, the model reached no residents under at least one definition, mostly because the only UGS lay in the 3 km buffer, and these cities could not be estimated. We include all other cities with at least one UGS within the city or its 3 km buffer, and we exclude no city based on its accessibility values.

Global, regional, income group and city size estimates are population-weighted. We sum the residents who can reach a UGS within the threshold across all cities in a group and divide by the total population of that group, so that each city contributes in proportion to its size. Regions and income groups follow the World Bank classification (World Bank, 2026), and five territories without a World Bank region (Kosovo, Puerto Rico, Western Sahara, Réunion and Mayotte) are assigned on geographic grounds. Megacities are cities of 10 million inhabitants or more. For the age gap, we subtract for each city the 15-minute share of residents aged 65 and older from that of residents under 65. The global and regional age gaps average these differences, with each city weighted by its total population (both age groups combined). The median age gap and the median T80 are the middle values across cities, without population weighting. Confidence intervals repeat each calculation with the lower and upper walking-speed scenarios, which correspond to the 95% confidence limits of the meta-analytic mean walking speed (Murtagh et al., 2021), and therefore reflect uncertainty in walking speed only.

Software

All data acquisition, preprocessing, spatial analyses, and statistical analyses are conducted using R version 4.4.3 (R Core Team, 2025). Walking accessibility is modelled in AccessMod version 5.8 (University of Geneva, GeoHealth Group, 2025). Because modelling accessibility across 11,422 cities worldwide at a 20 m spatial resolution is computationally demanding, we run all analyses in a high-performance computing (HPC) environment hosted by the University of Geneva (UNIGE, 2026). Generative AI tools, mainly Claude (Anthropic), ChatGPT (OpenAI) and Grammarly, were used to improve the language of the manuscript and to support the development of the analysis code. The authors reviewed, tested and verified all AI-assisted text and code, and take full responsibility for the content of this work.

Data availability

All city-level outputs derived from the zonal statistics are available on Zenodo, stratified by age group, walking-speed scenario and green-space definition (DOI to be provided upon publication,

with a temporary [Dropbox link for reviewers](#)). We do not archive the underlying travel-time rasters because urban expansion, changes in the built environment and updates to transport infrastructure may quickly make these surfaces outdated. They can be regenerated with the code described below. All input datasets are openly available from the sources listed in Table 1.

Code availability

The data input pipeline used to download and prepare the input layers, and the R scripts used to compute the accessibility statistics, landscape metrics, figures and tables, will be made publicly available on GitHub and archived on Zenodo upon publication (DOI to be provided, with a temporary [Dropbox link for reviewers](#)). Accessibility analyses were run with AccessMod version 5.8 (University of Geneva, GeoHealth Group, 2025), which is open source and available at <https://github.com/unige-geohealth/accessmod>, together with [AMRemote](#). To keep accessibility estimates up to date, we encourage users to rerun the pipeline with current input data rather than reuse archived travel-time surfaces.

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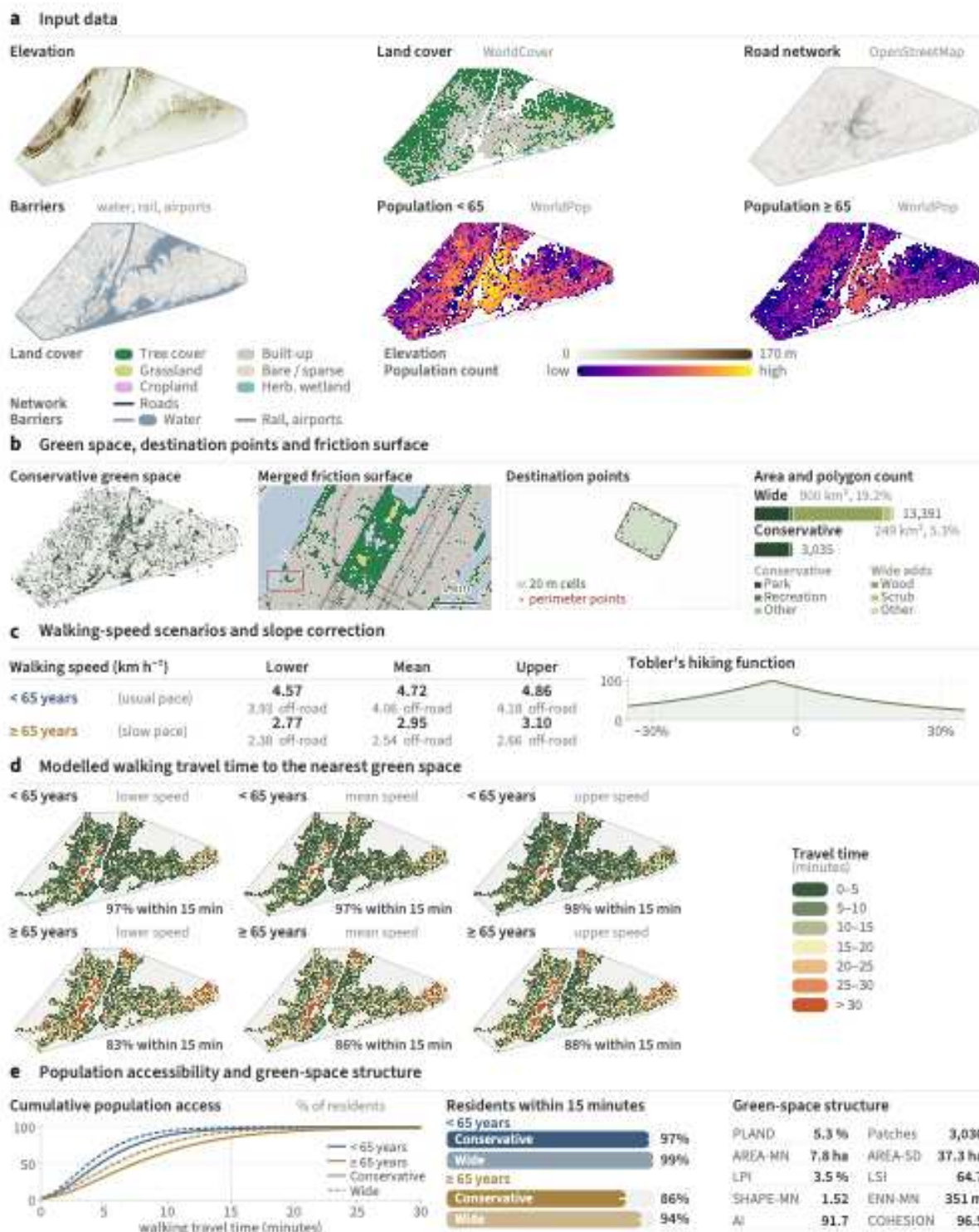


Figure 1. Overview of the analysis pipeline illustrated as an example for New York City. (a) Input layers, harmonised to a 20 m grid within a 3 km buffer around the city boundary. (b) Green spaces, here depicted only under the conservative UGS definition, the merged friction surface (detail over midtown Manhattan; red box locates the adjacent panel), conversion of rasterised green space into perimeter destination points, and green-space area by feature type under both definitions. (c) Walking speeds by age group and the walking slope correction. (d) Travel time to the nearest green space under the conservative UGS definition, for two age groups and three walking-speed scenarios. (e) Cumulative population access (shaded bands show the 95% confidence interval from the lower and upper walking-speed scenarios), proportion of residents within 15 min, and landscape metrics of green-space structure. See Methods for full detail.

Results

Coverage of the analysis

Of the 11,422 cities in the database, 9,438 (82.6%) had UGS under the wide definition within the city or its 3 km buffer. Of these, 7,715 (67.5% of all cities) also had UGS under the conservative definition and could therefore be assessed under both definitions, while 1,723 had UGS only under the wide definition. The remaining 1,984 cities (17.4%) had no UGS under either definition, including within the buffer. Cities assessable under both definitions were distributed across Asia (n = 4,386), the Americas (n = 1,435), Europe (n = 1,161), Africa (n = 674), and Oceania (n = 59).

Each of the 1,723 cities with UGS only under the wide definition contributed six accessibility analyses (two age groups × three walking-speed scenarios), resulting in 10,338 model runs. The 7,715 cities assessable under both definitions contributed twelve analyses each (two age groups × three walking-speed scenarios × two UGS definitions), resulting in a further 92,580 runs. In total, we conducted 102,918 accessibility analyses, of which 102,678 yielded travel-time estimates across 191 countries and territories. The remaining 240 analyses, corresponding to 36 cities, reached no residents within the city boundary, primarily because the only identified UGS were located within the surrounding 3 km buffer.

Global and regional patterns

Under the conservative definition and the mean walking-speed scenario, 60.1% (95% confidence interval (CI) 59.1–61.0%) of the global urban population under 65 lived within a 15-minute walk of a UGS. For residents aged 65 and older, the corresponding percentage was 55.4% (95% CI 53.0–57.1%). Against the stricter WHO benchmark of a 5-minute (roughly 300 m) walk, these shares fell to 25.4% (95% CI 24.6–26.2%) and 19.8% (95% CI 18.4–20.8%), respectively. Using the wide UGS definition raised the global figures to 68.9% (95% CI 68.0–69.8%) and 65.9% (95% CI 63.9–67.5%), confirming that the definition of green space is an important factor in measuring access to UGS.

Accessibility varied strongly between regions (Figures 2 and 3; Supplementary Table 3). Under the conservative definition, access was highest in North America, where 92.7% (95% CI 92.0–93.3%) of the population under 65 and 76.2% (95% CI 73.5–78.1%) of those aged 65 and older could reach a UGS within 15 minutes. It was lowest in South Asia (under 65: 42.1%, 95% CI 41.1–43.1%; 65 and older: 27.3%, 95% CI 25.6–28.6%) and Sub-Saharan Africa (under 65: 21.0%, 95% CI 20.3–21.7%; 65 and older: 15.3%, 95% CI 14.2–16.1%). The regional ranking was the same for both age groups (Figure 3a).

Cities with the lowest accessibility

Under the conservative definition and mean scenario, 964 cities had fewer than 20% of their under-65 population living within a 15-minute walk of green space. For residents aged 65 and older, the number rose to 1,936 cities. Low accessibility was not limited to small settlements. Among the 28 megacities (population of 10 million or more), the lowest shares of residents under 65 within a 15-minute walk were recorded in Lagos, Nigeria (4.6%, 95% CI 4.4–4.8%; 65 and older: 2.5%, 95% CI 2.3–2.7%) and Dhaka, Bangladesh (22.6%, 95% CI 21.9–23.2%; 65 and older: 10.6%, 95% CI 9.8–11.1%). In Lagos, reaching 80% population coverage under the conservative definition required 169 minutes of travel. Under the wide definition, the 15-minute share increased to 72.4% (95% CI 70.9–73.9%), and the time required for 80% coverage fell to 18 minutes. This increase of 67.8 percentage points (pp) was the largest difference between the two definitions among all megacities. Dhaka required 142 minutes to reach 80% coverage.

Averaged across all 28 megacities, the population-weighted under-65 share within 15 minutes was 66.0%, above the global mean of 60.1%, while the 65-and-older share was 62.7%, against a global mean of 55.4%. Megacity status therefore does not, in itself, imply poor access; New York City (97.4%), Tehran (96.5%) and Seoul (95.5%) recorded the highest values among megacities.

The twenty largest urban centres

The twenty largest urban centres by total WorldPop population varied widely in accessibility (Table 2). Under the conservative definition and the mean walking-speed scenario, the share of the population under 65 within a 15-minute walk ranged from 22.6% (95% CI 21.9–23.2%) in Dhaka to 97.4% (95% CI 97.0–97.7%) in New York City; for residents aged 65 and older the range was 10.6% to 86.1%. Cairo (31.1%), Jakarta (35.1%) and Bangkok (40.2%) also fell in the lower part of this distribution, while Seoul (95.5%), Beijing (94.9%), Buenos Aires (94.7%) and Tokyo (93.9%) clustered near the top (95% CIs in Table 2).

Using the wide UGS definition increased estimated accessibility across all twenty cities, although the magnitude varied considerably. The largest differences were in Jakarta (+32.8 pp), Manila (+29.0 pp), Bangkok (+26.5 pp), and São Paulo (+18.4 pp), indicating high sensitivity to including ecologically green areas beyond those captured by the conservative definition. In contrast, estimates were relatively stable in Buenos Aires (+1.0 pp), Kolkata (+1.7 pp), New York City (+1.9 pp), and Dhaka (+2.6 pp).

Residents aged 65 and older had lower accessibility than those under 65 in all twenty cities and under both definitions. Under the conservative definition, the largest within-city difference was

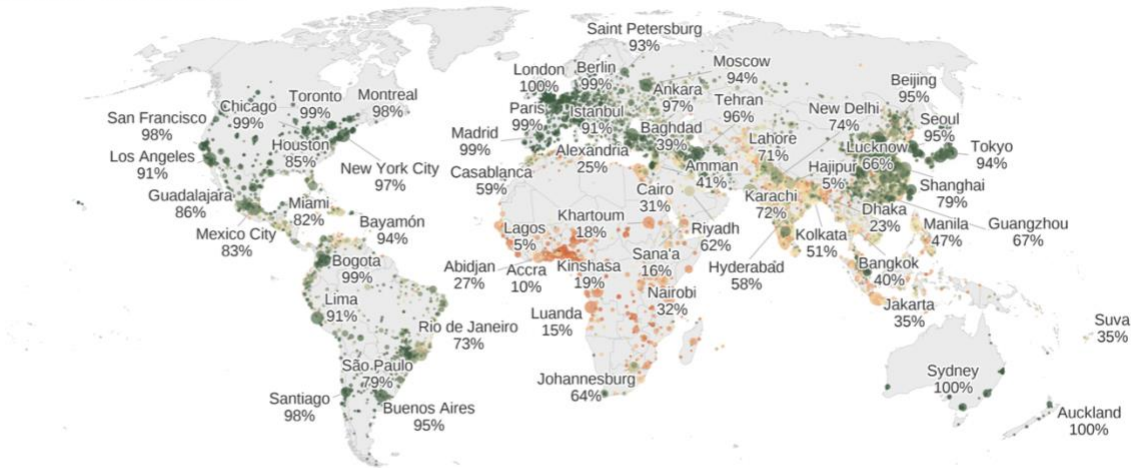
in Los Angeles (24.0 pp), followed by Manila (20.4 pp) and Tokyo (19.5 pp). Globally, older residents' access was on average 15.2 pp lower than that of younger residents in the same city (median 17.5 pp). Scenario ranges were consistently wider for the older population (mean range 4.4 pp versus 1.8 pp for the under-65 group), reflecting greater sensitivity to assumptions about walking speed.

Table 2. Green-space accessibility in the world's 20 largest cities. Cities are ranked by total WorldPop population (under 65 and 65 and older combined) within the GHS Urban Centre Database boundary. Values are the share of each age group within a 15-minute walk of an urban green space under the conservative and wide definitions, using the mean walking-speed scenario. Values in parentheses are 95% confidence intervals from the lower and upper walking-speed scenarios (the 95% confidence limits of the meta-analytic mean walking speed).

City	Country	Total pop. in millions (WorldPop)	Conservative UGS definition		Wide UGS definition	
			Under 65 (95% CI)	65 and older (95% CI)	Under 65 (95% CI)	65 and older (95% CI)
Guangzhou	China	51.7	67.3% (66.1–68.5%)	49.7% (47.1–51.7%)	81.2% (80.2–82.0%)	63.7% (61.0–65.8%)
Jakarta	Indonesia	34.3	35.1% (33.9–36.3%)	21.7% (20.0–23.1%)	67.9% (66.7–69.1%)	49.9% (47.2–51.9%)
Tokyo	Japan	32.6	93.9% (93.1–94.5%)	74.4% (71.1–76.9%)	98.2% (97.9–98.5%)	88.1% (85.8–89.6%)
New Delhi	India	31.6	74.2% (73.3–75.0%)	59.7% (57.7–61.1%)	79.1% (78.4–79.9%)	65.1% (63.1–66.6%)
Dhaka	Bangladesh	26.6	22.6% (21.9–23.2%)	10.6% (9.8–11.1%)	25.2% (24.5–25.8%)	12.3% (11.5–13.0%)
Manila	Philippines	25.8	47.5% (45.9–49.0%)	27.1% (24.9–28.8%)	76.5% (75.1–77.8%)	53.8% (50.7–56.1%)
Cairo	Egypt	24.6	31.1% (30.1–32.0%)	28.7% (26.9–30.2%)	36.1% (35.0–37.2%)	31.6% (29.6–33.2%)
Seoul	South Korea	21.3	95.5% (95.0–95.8%)	83.2% (80.8–84.9%)	99.7% (99.6–99.8%)	95.2% (93.9–96.1%)
Shanghai	China	21.3	79.1% (78.0–80.0%)	63.9% (60.7–66.2%)	83.9% (83.0–84.8%)	69.8% (66.7–71.9%)
Mexico City	Mexico	20.0	83.5% (82.5–84.4%)	67.4% (64.4–69.6%)	92.0% (91.2–92.7%)	77.5% (74.6–79.6%)
São Paulo	Brazil	19.4	78.9% (77.7–79.9%)	61.1% (57.8–63.6%)	97.3% (96.9–97.7%)	82.9% (80.0–85.0%)
Karachi	Pakistan	18.1	71.9% (70.7–73.0%)	54.7% (51.9–56.8%)	79.3% (78.2–80.3%)	61.4% (58.5–63.5%)
Bangkok	Thailand	18.0	40.2% (38.7–41.6%)	22.6% (20.7–24.2%)	66.7% (65.3–68.0%)	46.9% (44.1–49.0%)
Kolkata	India	17.6	51.0% (49.9–52.1%)	34.5% (32.5–36.1%)	52.7% (51.6–53.8%)	35.8% (33.8–37.4%)
Istanbul	Turkey	15.5	91.4% (90.7–92.0%)	76.9% (73.9–79.0%)	98.7% (98.5–98.9%)	89.8% (87.4–91.4%)
Beijing	China	15.0	94.9% (94.4–95.3%)	82.7% (80.1–84.6%)	98.8% (98.6–99.0%)	90.5% (88.4–91.9%)
New York City	United States	14.6	97.4% (97.0–97.7%)	86.1% (83.5–87.9%)	99.3% (99.1–99.4%)	93.6% (91.9–94.7%)
Moscow	Russia	14.2	93.8% (93.3–94.3%)	81.4% (79.1–83.1%)	99.9% (99.9–99.9%)	97.8% (97.1–98.3%)
Buenos Aires	Argentina	14.0	94.7% (93.9–95.4%)	77.0% (73.5–79.5%)	95.7% (95.0–96.4%)	79.0% (75.6–81.4%)
Los Angeles	United States	14.0	90.5% (89.4–91.5%)	66.5% (62.8–69.3%)	93.4% (92.5–94.3%)	72.3% (68.7–75.0%)

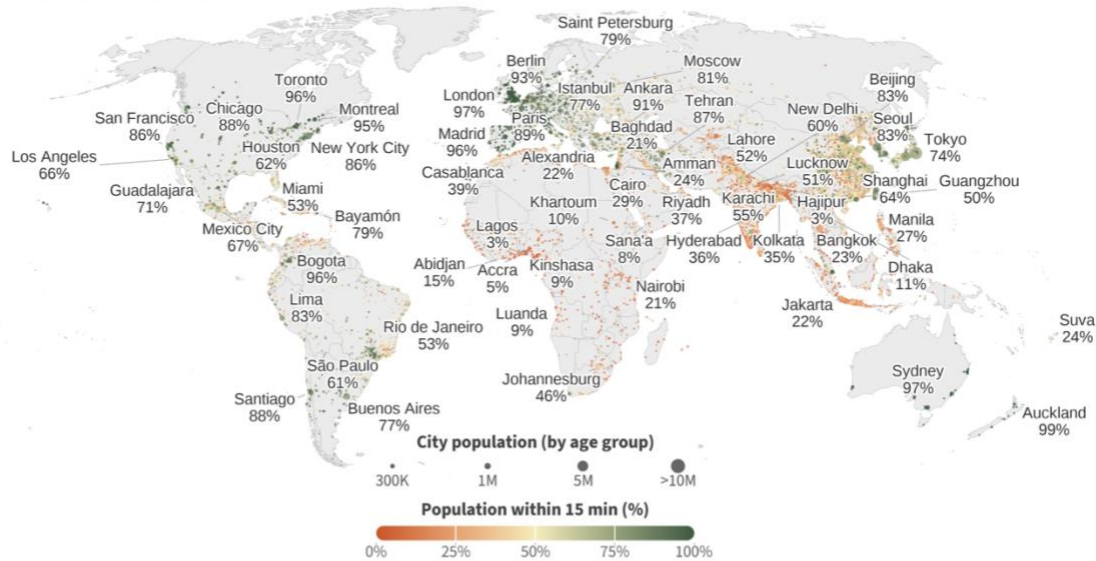
a Under 65

Mean scenario - Conservative definition



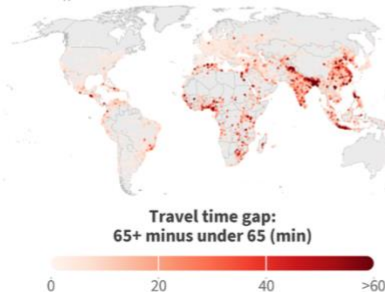
b 65 and older

Mean scenario - Conservative definition



c Age gap in green space accessibility

Difference in median travel time to 50% coverage (65+ minus under 65), in minutes



d Regional mean travel time

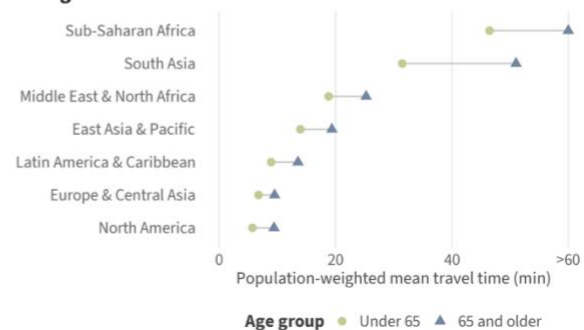


Figure 2. Green space accessibility by age group across cities. (a) & (b) Share of the urban population residing within a 15-minute walk of a green space under the conservative definition for adults under 65 (a) and adults aged 65 and older (b), using the mean walking-speed scenario. Each dot represents one city; dot size is proportional to the age-group population. Selected cities are labelled with name and coverage share. (c) Age gap in green space accessibility, defined as the difference in median travel time to reach 50% green space coverage (65+ minus under 65, in minutes). (d) Population-weighted mean travel time to the nearest green space, by World Bank region and age group, under the mean scenario and for the conservative definition. Horizontal lines connect the two age groups within each region.

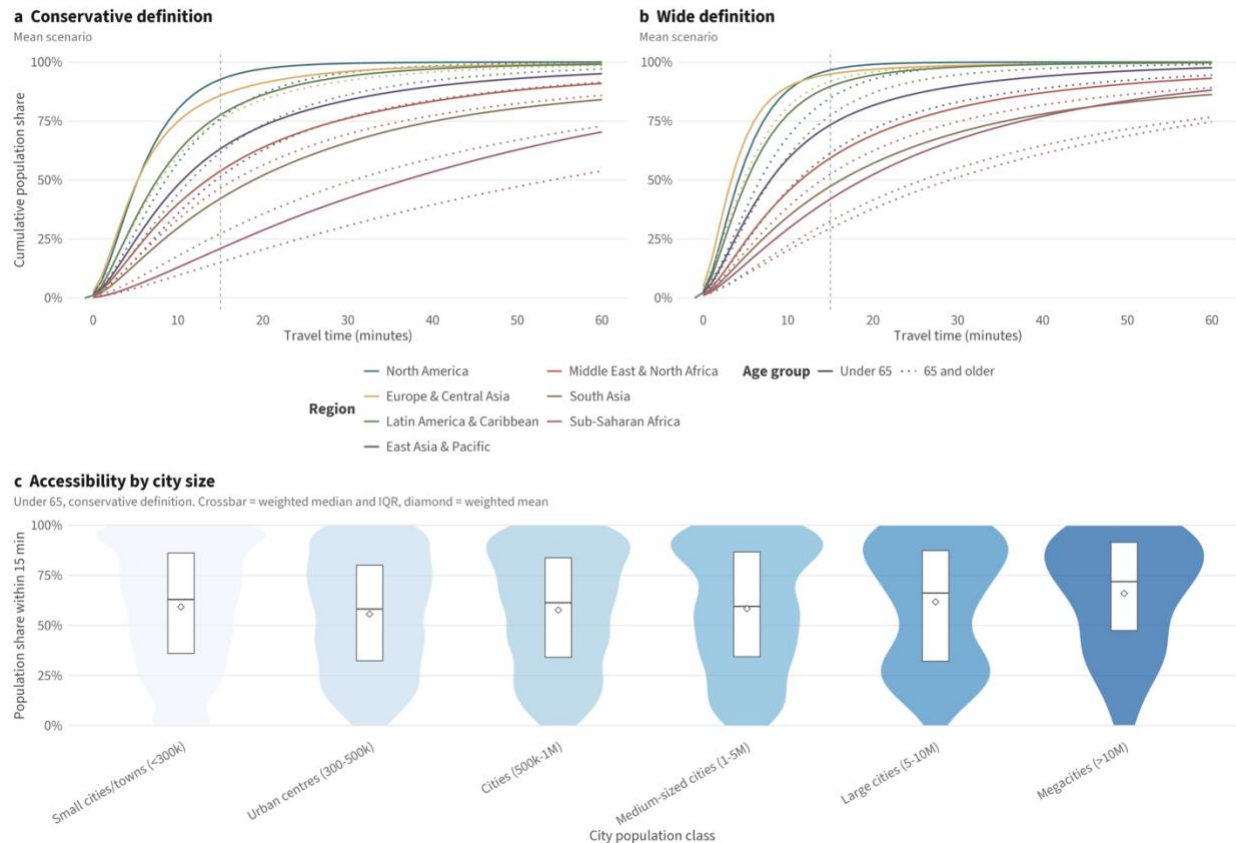


Figure 3. Global green space accessibility curves and regional disparities. (a) & (b) Cumulative share of the urban population that can reach green space within a given travel time, by World Bank region, shown for both age groups under the mean walking scenario and (a) conservative UGS definition & (b) wide UGS definition. (c) Distribution across cities of the share of residents under 65 within a 15-minute walk of a UGS, by city size, under the conservative definition and the mean walking-speed scenario; crossbars show the population-weighted median and interquartile range, diamonds the population-weighted mean.

Age and income equity

Globally, adults aged 65 years and older consistently have lower access to UGS than those under 65. People 65 years and older are less likely to be able to reach a green space within a 15-minute walk, and under the conservative definition, older residents' access is on average 15.2 percentage points (pp) lower than that of residents under 65 living in the same city (median gap across cities: 17.5 pp). The disparity is largest in East Asia and the Pacific (+17.5 pp), followed closely by Latin America and the Caribbean (+17.1 pp) and North America (+16.2 pp). It is smallest in Europe and Central Asia (+12.9 pp) and Sub-Saharan Africa (+8.8 pp). The relatively small gap in Sub-Saharan Africa should not be read as equitable UGS provision, since access there is low for both age groups.

The largest city-level difference under the conservative definition was observed in Arjona (Colombia), where 80.6% of the population under 65 could reach a UGS within 15 minutes under

the mean walking scenario, compared with 34.8% of adults aged 65 and older, a gap of 45.8 pp. A similar pattern was found in Coari (Brazil), where accessibility was 72.9% for the population under 65 but 28.6% for those aged 65 and older, a gap of 44.3 pp, and in Paungde (Myanmar), with 76.6% and 33.4%, respectively. Under the wide definition, these gaps are even wider, reaching 57.9 pp in Taba (Nigeria) (under 65: 87.4%; 65 and older: 29.5%).

Access to green space was also strongly stratified by national income classification (Table 3). Under the conservative definition, cities in high-income countries had the highest population-weighted mean access among residents under 65 (89.1%), compared with 65.0% in upper-middle-income, 36.2% in lower-middle-income, and 28.9% in low-income settings—a spread of about 60 pp. This gradient held for both age groups; among residents aged 65 and older, the corresponding figures ranged from 76.7% to 21.1%.

Table 3. Green-space accessibility and travel time by World Bank income group of the country in which each city is located.

Income groups follow the World Bank classification. Values indicate the proportion of the population within a 15-minute walk of an urban green space under the mean walking-speed scenario; values in parentheses are 95% confidence intervals, derived from the lower and upper walking-speed scenarios. Median T80 is the median across cities, without population weighting, of the travel time in minutes at which 80% of a city's population can reach a UGS.

Country income group	Conservative UGS definition				Wide UGS definition			
	Within a 15-minute walk		Median T80 (min)		Within a 15-minute walk		Median T80 (min)	
	Under 65	65 and older	Under 65	65 and older	Under 65	65 and older	Under 65	65 and older
High income	89.1% (88.4–89.7%)	76.7% (74.2–78.4%)	11	17	95.4% (95.1–95.7%)	90.2% (88.6–91.3%)	6	10
Upper middle income	65.0% (63.9–66.1%)	48.5% (46.0–50.4%)	21	33	75.9% (74.9–76.8%)	59.3% (56.8–61.2%)	16	26
Lower middle income	36.2% (35.2–37.1%)	25.7% (24.1–26.9%)	35	56	45.7% (44.6–46.7%)	32.5% (30.7–33.9%)	30	48
Low income	28.9% (28.0–29.8%)	21.1% (19.7–22.2%)	36	57	45.8% (44.6–46.9%)	34.1% (32.2–35.6%)	25	41

Green space configuration and accessibility

How green space is distributed across a city can be as important for pedestrian access as how much green space there is (Figure 4). Nairobi and Bengaluru, for example, have similarly low green-space cover under the conservative definition (0.7% and 0.8% of urban land, respectively), but very different levels of access. Only 32% of Nairobi's population under 65 lives within a 15-minute walk of a UGS, compared with 87% in Bengaluru. Nairobi has just 87 relatively widely separated green spaces, whereas Bengaluru has more than 1,100 smaller spaces distributed more closely across the city. This difference is also reflected in the time needed to reach 80% of the population, which is 61 minutes in Nairobi compared with 11 minutes in Bengaluru.

More green space did not necessarily translate into better access. Taiyuan has almost twice the green-space cover of Bogotá (4.5% versus 2.7%), yet substantially lower 15-minute accessibility (71% versus 99% among residents under 65). Almost half of Taiyuan's green area is contained in a single site, and its green space is distributed across only 90 sites, compared with more than 1,200 across Bogotá. These examples illustrate that cities with similar, or even greater, amounts of green space can provide very different levels of access depending on how that green space is distributed.

This pattern was also apparent when broadening the definition of UGS. In Taiyuan, the wide definition more than tripled green-space cover, from 4.5% to 15.9%, but added relatively few new sites (90 to 102), and 15-minute accessibility increased only from 71% to 75%. In Bengaluru, by contrast, green-space cover increased from 0.8% to 8.4%, while the number of sites increased from 1,144 to 3,415 and their mean separation fell from 276 to 138 m. Accessibility increased accordingly, from 87% to 97%. The contrast was even stronger in Lagos, where the number of identified green spaces increased from 24 to 513 and their mean separation fell from 2,474 to 252 m, alongside an increase in 15-minute accessibility from 5% to 72%. In Lima, where broadening the definition changed the existing green-space network relatively little, accessibility remained almost unchanged (91% to 92%).

However, a more dispersed green-space network does not necessarily mean that green space is accessible to where people live. In Onitsha, the wide definition increased the number of identified green spaces from one to 132 and substantially reduced the distance between them, yet 15-minute accessibility increased only from 1% to 5%. Landscape metrics describe how green spaces are arranged relative to one another, but not how they are distributed relative to the population. Accessibility therefore depends not only on the amount and configuration of green space, but also on where green spaces are located in relation to where people live.

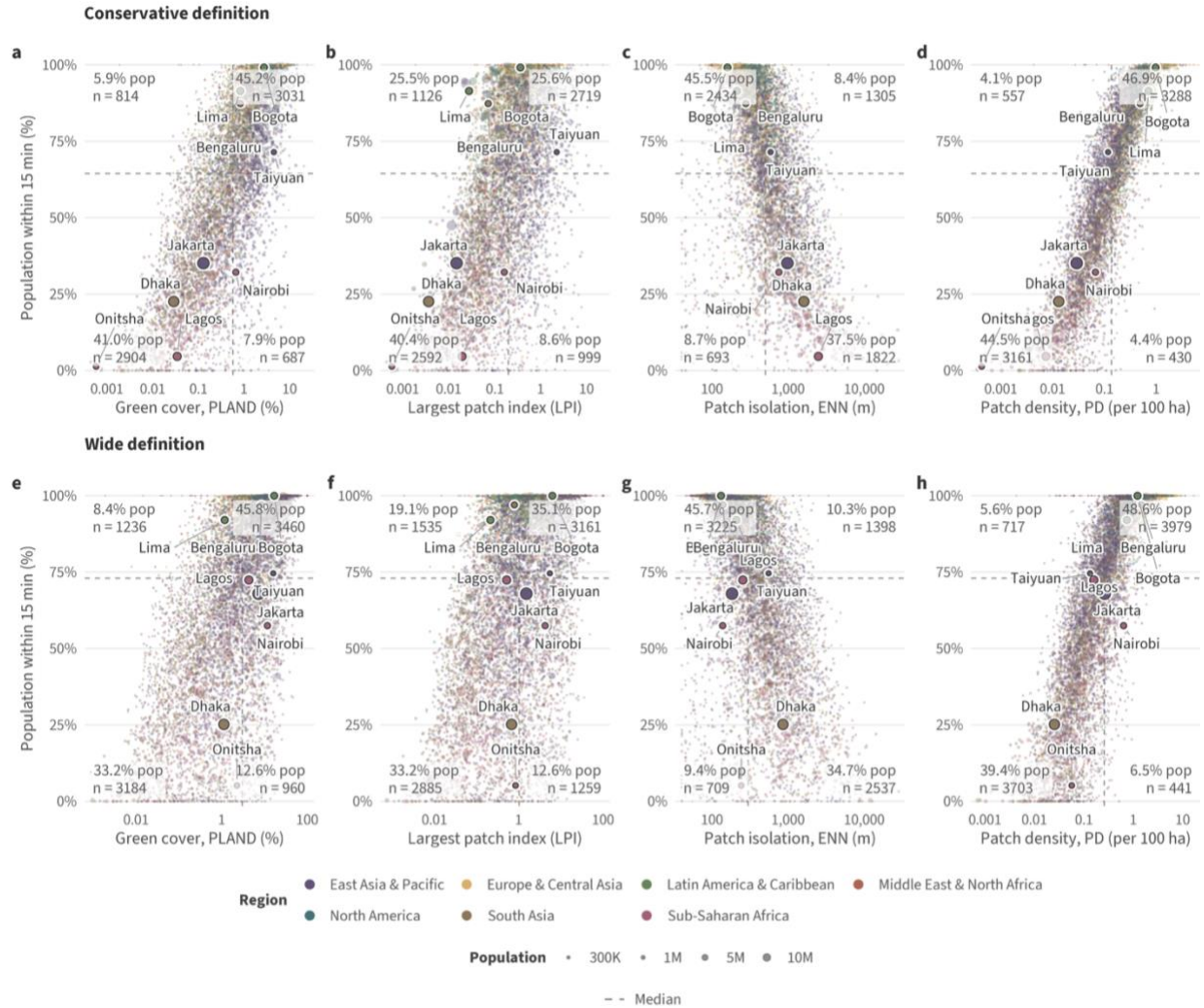


Figure 4. Landscape configuration and green space accessibility.

Share of the population under 65 within 15 min of green space (y) against four landscape metrics (x, log scale). Panels a to d use the conservative green-space definition, e to h the wide definition. Point size = city population; colour = World Bank region. Dashed lines are the median accessibility and the median metric value, computed separately for each definition. Shaded quadrants are the two in which accessibility and the metric agree; labelled points are the largest cities in each. Corner annotations give each quadrant's share of the panel's population and its city count. PLAND, proportion of city land under green space; LPI, share of the landscape in the largest patch; ENN, mean nearest-neighbour distance between patches; PD, patches per 100 ha.

Discussion

Our findings show that pedestrian access to urban green space remains limited globally and cannot be understood from the amount of green space alone. Under the conservative definition and mean walking-speed scenario, 60.1% of residents under 65 and 55.4% of those aged 65 and older live within a 15-minute walk of a UGS, leaving 39.9% and 44.6%, respectively, beyond this threshold. At approximately five minutes of walking, corresponding roughly to the 300 m proximity standard commonly used in public health guidance (WHO, 2016), accessibility falls to 25.4% and 19.8%. Thus, around three-quarters of the urban population included in our analysis lives beyond this widely used proximity standard. At the same time, our analysis demonstrates that pedestrian accessibility can be assessed consistently and reproducibly across cities, population groups, walking-speed scenarios, and alternative definitions of UGS, providing a scalable framework for monitoring access beyond simple measures of green-space availability.

Compared with Richards et al. (2025), who assessed walking access to urban ecosystems at approximately 1 km resolution, our estimates indicate lower overall accessibility. They report that more than half of 4.7 billion urban residents live within a 5-minute walk of an urban ecosystem, whereas we estimate 34.1% of residents under 65 under the wide definition and 25.4% under the conservative definition. Several methodological differences may explain this contrast. First, Richards et al. include any mapped vegetation as a potential destination, whereas our conservative definition is restricted to designated parks and recreation grounds of at least 0.5 ha. In our analysis alone, broadening the UGS definition increases 5-minute accessibility by nearly 9 percentage points. Second, spatial resolution affects how barriers to pedestrian movement are represented. At 20 m resolution, our friction surface captures roads, railways, and watercourses in considerably greater detail than is possible at approximately 1 km resolution. The friction surface used by Richards et al. (2025), based on Weiss et al. (2018), also permits movement across water bodies at a low walking speed, whereas we treat water bodies without mapped crossings as barriers.

Urban green space definition

How green space is defined has a substantial effect on our estimates. Moving from the conservative to the wide definition increases the global 15-minute share by 8.8 pp, but the impact is much larger in some cities. Among megacities, Lagos shows the biggest difference: its share rises by 67.8 pp, from 4.6% to 72.4%, while the time required for 80% of residents to reach a green space drops from 169 to 18 minutes (Supplementary Figure 1). This is mainly because the wide definition adds many sites across the city, increasing the number of green spaces in Lagos from 24 to 513. Large increases are also seen in Jakarta (32.8 pp), Manila (29.0 pp) and

Bangkok (26.5 pp), while in Buenos Aires, Kolkata, New York City and Dhaka, the difference between the two definitions is less than 3 pp.

Both definitions also carry uncertainty that we cannot quantify. Areas mapped as green space that are not used for recreation inflate access, while green spaces missing from the data lead to underestimates. The first problem matters most for the wide definition in tropical regions, where large areas are tagged as forest, scrub or grassland but may not function as accessible recreational space. Previous research has shown that the meaning of OSM green-space tags differs between regions, which likely affects our estimates as well (Ludwig & Zipf, 2019; Ludwig et al., 2021).

More fundamentally, no comprehensive global inventory of public UGS currently exists, and the openly available data that could be used are unevenly complete across regions. For instance, OpenStreetMap building completeness, a common proxy for overall mapping effort, exceeds 80% in only 1,848 of 13,189 urban agglomerations and remains below 20% in 9,163, which are home to 48% of the global urban population (Herfort et al., 2023). This gap is most pronounced in the regions where our estimates are lowest and likely contributes to the regional differences we observe. Together with the absence of an agreed systematic methodology for measuring and reporting access to UGS, this means that methodological choices, such as city definitions, travel speeds for population groups and UGS definitions, can produce different global estimates of UGS access at the same travel-time threshold. We therefore report two definitions of UGS and three walking-speed scenarios alongside each estimate, so that the sensitivity of the results to these choices remains visible.

Defining city boundaries

Another factor that strongly shapes estimates of access to UGS is how a city is defined and its spatial boundaries are delineated. Cimini et al. (2024) assessed access in 14 Italian metropolitan cities and found that approximately 28% of residents could reach a public UGS within 300 m along the road network, increasing to approximately 40% within 400 m. For the same 14 cities, our population-weighted 5-minute share under the conservative definition was 54.1% for residents under 65 and 37.5% for those aged 65 and older. Because the mean walking speed assigned to the younger group covers roughly 340 to 390 m in five minutes, their 400 m estimate is the closer comparator, leaving a difference of approximately 14 pp. Both assessments include OpenStreetMap green spaces of at least 0.5 ha, so this difference mainly reflects two other choices. The first is the spatial unit. Cimini et al. (2024) delineate urban areas according to DEURBA, combining urban centres with dense urban clusters of at least 5,000 inhabitants (EUROSTAT, 2021); their population base therefore includes numerous smaller settlements spatially separate from the main urban core. By contrast, GHS-UCDB urban centres (Melchiorri

et al., 2024) are limited to contiguous, densely built-up areas, and visual comparison confirms that this extent is generally smaller for European cities than EUROSTAT delineations of cities and functional urban areas (Supplementary Figure 2). The second choice is the movement model: their distances follow the road network, whereas our anisotropic cost-distance approach allows pedestrians to cross any traversable land cover, shortening the modelled route to a green space. Since both city boundaries (UN-Habitat, 2020; L. Dijkstra et al., 2021) and routing assumptions vary substantially across studies, accessibility estimates are not directly comparable unless these choices are aligned. This underscores the need for a harmonised city definition in global monitoring.

Age and walking speed equity in green space access

Residents aged 65 and older had lower accessibility than younger residents in 96.5% of cities. In most of the remaining cities ($n = 256$), accessibility was the same for both age groups, usually because neither group had access within the specified threshold. Because both age groups are distributed similarly within cities (Pezzulo et al., 2017; Bondarenko et al., 2025) and move across the same friction surface, the observed age gap is driven primarily by differences in walking speed. Slower walking speeds reduce the area that can be reached within a given time, particularly where green spaces are farther away or routes are constrained by physical barriers. City-level differences reach 45.8 pp in Arjona, Colombia, and 24.0 pp in Los Angeles. Our estimates are likely to be conservative as we model all residents aged 65 and older with one slower walking pace and corresponding confidence intervals, whereas comfortable gait speed continues to decline across later decades (Andrews et al., 2023), averaging 0.58 m/s beyond age 90 (Colcord et al., 2023). Even though we applied confidence intervals around the assumed walking speeds, our figures may understate the disadvantage faced by the oldest residents, who are also the most heat vulnerable. The same reasoning applies to the reduced-mobility population that SDG target 11.7 names alongside older persons. Willberg et al. (2023) show that combining age, seasonal and diurnal variation reduces older adults' 15-minute walking access to the nearest grocery from 93% to 34% in the Helsinki region, indicating that accessibility measured for an average pedestrian systematically overstates what older residents can reach.

Urban heat, access and green space configuration

Most global evidence linking urban green space to heat focuses on vegetation cover rather than access. A 20% increase in greenness could reduce the heat-attributable fraction of deaths by 0.80 percentage points across 11,534 urban areas (Y. Wu et al., 2025), while current urban tree cover already offsets 41–49% of the potential urban heat island intensity (McDonald et al., 2026). Our results add a complementary perspective: whether residents can reach green space as a

potential refuge during extreme heat, assuming that trees are large enough to provide shade. Proximity is particularly relevant in this context, as the journey itself entails heat exposure. Yet within five minutes, only 25.4% of residents aged under 65 and 19.8% of those aged 65 and older can reach a green space under the conservative definition.

Similar levels of green-space cover can correspond to very different levels of access. Nairobi and Bengaluru have similarly low green-space cover (0.7% and 0.8%), yet 15-minute accessibility is 32% in Nairobi and 87% in Bengaluru, a difference that indicators based on vegetation cover alone would not reveal. These differences are especially relevant for older populations, who bear a disproportionate burden of heat-related mortality and whose 15-minute accessibility in our analysis was on average 15.2 percentage points lower than that of younger residents in the same city.

[Linking results to global targets and initiatives](#)

These results also provide a scalable approach to monitoring progress towards SDG target 11.7, which calls for universal access to safe, inclusive, and accessible green and public spaces, particularly for women and children, older persons, and persons with disabilities (UN-Habitat, 2021). The associated indicator, SDG 11.7.1, currently measures the average share of built-up area that is open space for public use (UN-Habitat, 2021). As an area-based metric, however, it does not capture whether residents can access green space or how access differs across population groups. Our framework provides a potential basis for a more population-centred and accessibility-oriented assessment of urban green-space provision. Although comparable approaches are already used at the city level, for example, the ParkScore index in the United States (Trust for Public Land, 2026), no equivalent global framework currently enables cities across different settings to be assessed using a common methodology.

Our approach may also support broader urban climate-resilience applications. For example, the Global Heat Resilience Service, established under the Group on Earth Observations in response to the United Nations Secretary-General's Call to Action on Extreme Heat (Group on Earth Observations, 2026), aims to develop standardised Earth-observation-based approaches to urban heat-risk assessment. While our framework does not directly measure heat risk, its population-disaggregated estimates of access to green space could complement such assessments by identifying neighbourhoods and population groups with limited access to a potentially important heat-mitigation strategy.

Limitations

Several limitations should be considered when interpreting the estimates presented here. First, results are sensitive to the population dataset used: previous analyses have shown that the choice of dataset can substantially affect accessibility estimates at sub-national scales (Hierink et al., 2022). This also affects how we define and weight cities. The GHS-UCDB, which we used to define city boundaries (Melchiorri et al., 2024), applies a population threshold of 50,000 residents based on GHS-POP. However, when we summed WorldPop Global 2 population estimates (Bondarenko et al., 2025) within those same boundaries, 1,639 of the 9,407 cities had estimated populations below 50,000. This discrepancy points to substantial differences between the two population datasets at the city level and creates uncertainty in both city inclusion and population-weighted accessibility estimates. Second, OSM green-space data completeness varies considerably across regions (Ludwig & Zipf, 2019), and the data are not comprehensive in many parts of the world. Where parks and recreation grounds are unmapped, our estimates understate access. This is most likely in regions with the least mapping activity, which are also the regions where our estimates are lowest (Herfort et al., 2023). Third, our estimates measure potential spatial access rather than actual use. Reaching a green space does not mean that people will visit it or stay long enough to experience potential health benefits (Saxon, 2021; S. Xu et al., 2024; Jin et al., 2024; X. Li et al., 2025). Recent research also suggests that green-space size matters for achieving sufficient exposure, including the opportunity to remain in a space for around 15 minutes (Wang et al., 2026). Although our analysis includes only green spaces of at least 0.5 ha, it does not assess whether each space is large enough to support a visit of that duration. Future work could apply size thresholds linked to exposure duration, as proposed in the 15-15 rule, or consider size and accessibility jointly (Wang et al., 2026). Finally, we model pedestrian access only. This provides a consistent metric across cities and reflects the role of proximity in urban green-space planning, but may not capture how people access green spaces in cities where walking is less common because of climate, urban form, or transport patterns. In these settings, access by public or private transport may matter more, and extending the framework to other transport modes could usefully complement the pedestrian estimates. These limitations underscore that the estimates are best interpreted as a standardised measure of potential pedestrian access, rather than as a direct measure of green-space use or exposure.

Conclusion

Urban greenness and access to UGS are related, but they are not the same. How green space is defined and distributed across a city determines whether it provides meaningful pedestrian access, especially when accounting for differences in UGS definitions and walking capacity across

age and population groups. A city may be green without being accessible, and distinguishing between the two is essential to understanding who benefits from urban green-space provision. Beyond these findings, our analysis shows that detailed, population-based accessibility can be assessed consistently across more than 11,000 cities worldwide. The framework is reproducible and scalable across geographic levels, enabling the same approach to support global monitoring as well as national and local assessments, where green-space planning and policy decisions are typically made. This large-scale application therefore offers both a global baseline and a proof of concept for more targeted monitoring of urban green-space access. Shifting from measures of how green cities are to measures of who can actually reach green space can help translate global targets such as SDG 11.7 into locally relevant planning evidence.

Author contribution

All authors contributed to the study's conceptualisation and the design of the analytical framework. PT and FH developed and prepared the modelling code. PT ran the models and validated the outputs together with FH. FH analysed the model outputs, produced the figures, and wrote the original draft of the manuscript. PT, YG, NR and GG reviewed the manuscript and provided feedback over several rounds of revision. All authors read and approved the final manuscript.

Competing interest

The authors declare no competing interests.

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