Working Paper: Structural Data Needs for Mobility Research

Knowledge Hub

15-minute City

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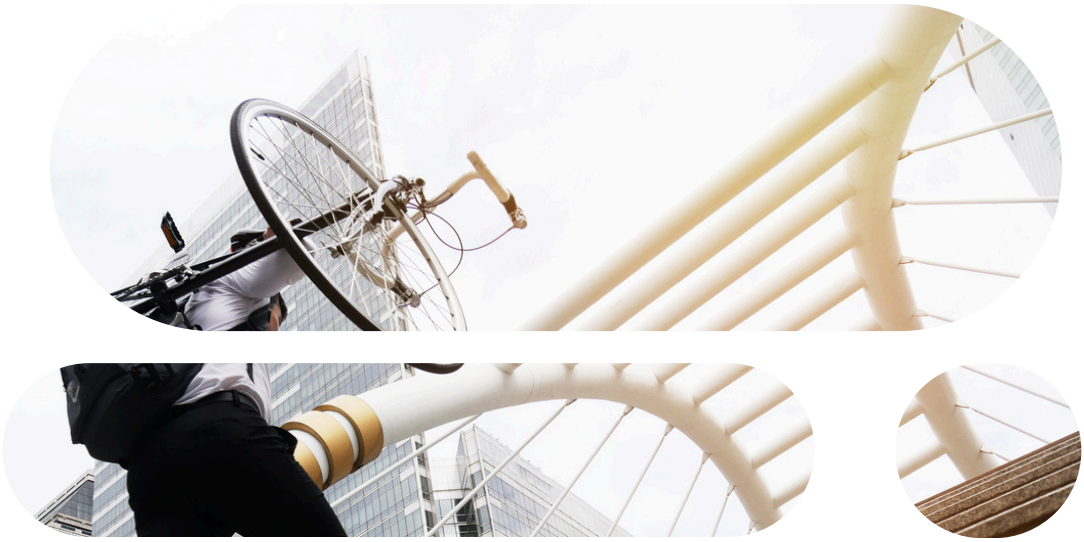

AUTHORS

DATA ON MACRO-LEVEL: Jonathan Fetka, TU Wien | Marian Schlott, University of Wuppertal | Evripidis Magkos, University of Aegean | Bingyu Zhao | Ilyas Oulbacha, TU Wien | Mazdak Sadeghpour, ENTPE

DATA ON MICRO-LEVEL: Jan Riel, Karlsruhe University of Applied Sciences | Veera Helle-Custer, Eastern Switzerland University of Applied Sciences | Lory Michelle Bresciani Miristice, Sapienza University of Rome | Sevket Oguz Kagan Capkin, Sapienza University of Rome

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Summary

This working paper presents key factors and indicators, collectively identified by a working group within the DUT Knowledge Hub focused on data issues at both macro and micro levels, that are relevant to mobility-related modelling and spatial analysis in the European context. National and international statistical offices, related governmental institutions and policymakers and researchers are the target audience for this publication.

Key messages

Data-driven mobility research needs national statistical offices to provide reliable, comparable and available data. In a transnational context, this means data (in this context statistical input data with spatial resolution) needs not only to be available, but also consistent in resolution and quality across borders. Yet between European countries, availability and quality vary enormously. This hampers the transferability of tools, models, and research findings.

This document outlines the key data needs of mobility researchers at both macro and micro levels, focusing on data provided by national statistical offices required for evidence-based planning tools. It aims to provide a shared basis for the ongoing debate on harmonisation of data availability across Europe.

Data availability needs to improve hand in hand with Europe-wide standardisation of how, when, and in what form data is collected. Governance and private actors need to collaborate not only on data provision, but also on ensuring its usability for research and planning practice.

When data needs are clear and pathways for harmonising data availability and quality within Europe are developed, research findings don't stay locked in their project context. Urban and rural communities across Europe can then benefit from mobility research that was never meant to stay local but to drive transnational learning.

Introduction

The need for data harmonisation

Access to reliable datasets is a fundamental requirement for mobility research. Harmonised data enables comparisons across neighbourhoods, cities, and countries, and allows surveyed behaviour to be cross-checked across different spatial contexts in Europe. Developing a common set of relevant data needs can thus ultimately help deepen our understanding of how spatial, demographic, and socio-economic factors shape human mobility.

Four Driving Urban Transitions (DUT) projects within the 15-Minute City (15minC) Transition Pathway (MobinFact, PERSEUS, POTUS and SmartUrbanity) identified a recurring need for greater data harmonisation across national and regional boundaries. This need for data harmonisation was explored in depth during the first DUT Knowledge Hub Subgroup meetings from 2025 to 2026, where the transnationally unequal availability of (statistical) input data with spatial resolution emerged as a central challenge.

Exploring and compiling 41 micro-level and 34 macro-level indicators in this publication, the authors intend to show the complexity of data needs for transferable mobility research in Europe, as well as to highlight the fragmented data provision situation of today. Transport and spatial planning methods often rely on official data as key inputs, for example in transport demand models, yet such data is often limited in availability. In trans-European research projects that aim to apply a unified methodological framework, data accessibility and availability can vary significantly, adding further complexity. This list therefore compiles indicators that can only (or almost only) be retrieved from official data sources.

The compiled lists of indicators in this publication can be used by researchers as a basis for reference in own data challenges and as a basis for further improving the data standards within Europe. For colleagues working towards better data availability in public statistical institutions, the list below can be a basis for discussions the transnational harmonisation of data availability and to deduct the need for prioritisation of indicators.

Data on Macro-level

The macro level of data refers to the spatially aggregated data or statistics which can inform the supply, demand, and interactions of the people, settlement, and transport infrastructures at an urban, regional, or national scale. Data at this level captures key dimensions that shape or characterise the human settlement and mobility contexts, from population distribution and socioeconomic composition to land use configurations, building stock characteristics, and transport infrastructure provision. These variables are essential for evaluating the conditions for 15-minute city (15mC) accessibility at scale, enabling comparisons across neighbourhoods, cities, and countries. Also, data on this level is needed for modelling mobility behaviour (of people and goods), thus leading towards more targeted instruments in (urban) planning.

Currently, this data is mostly not harmonised between different countries, hindering the transferability of models and instruments, limiting the potentials of knowledge-based strategic planning. It allows for a spatial analysis and transferability of behavioural data, fostering a better understanding of contextual socio-economic and environmental factors ultimately shaping our mobility system.

Identifying macro-indicators: about the methodical approach

Data needs at the macro level are defined by three requirements:

1) Available as geographic information: information that can be digitally processed and referenced as vector or raster data;

2) Available at national scale: even though the data may have different resolutions from building blocks to regions, authors specifically asked for data that are available for a whole country (of the survey respondent). Authors instructed responders to exclude datasets that are only available locally despite high resolution, as they do not support transferable analysis.

3) Freely available: data sourced exclusively from private or paid providers are excluded due to barriers to acquisition, as well as variables generally covered (yet acknowledging its limitations) by open sources such as OpenStreetMap (OSM).

To deduct relevant data categories and indicators, a two stage survey was conducted within the DUT-Knowledgehub on Data, incorporating transnational and somewhat transdisciplinary (within a broader mobility/urban planning context) perspectives on relevant data in the researchers daily work. The feedback was then filtered and prioritised for assessing the availability.

Through several rounds of internal iterations, pilots as well as presentations to fellow DUT Knowledge Hub members in the indicator subgroup, five macro-level indicator categories and 29 specific indicators are selected for further analysis: Demographic variables,

Socioeconomic variables, Housing and building variables, Land use variables, Infrastructure variables.

In order to investigate the availability of data in different countries, a questionnaire was shared within mobility researchers across Europe within the DUT-networks as well as beyond. A slightly adapted questionnaire was later sent to national statistic offices, for addressing the current status of availability rather than the "felt" availability and importance stated by the researchers.

In the survey, authors inquired mobility researchers across Europe regarding the availability of such data at their country and the resolution that it is available (e.g., city-level, district-level, or finer). Authors further inquired the respondents regarding the importance of the availability of such data. Based on these information, key outputs of further analysis include:

1) Availability: variable availability list

2) Spatial Resolution: the available and required ones

3) Importance: rank of variables by importance, cross-tabulated with the availability results, so as to map out the gap of important data that are not available.

Together, these categories provide the foundational data layer for assessing whether urban environments structurally support accessible, equitable, and sustainable mobility for all residents and can act as a baseline for modelling behavioural data beyond the surveyed context.

1. Demographic variables

Demographic variables refer to the differences in mobility-related behaviour due to age, gender, income etc. They are relevant to deduce mobility-relevant differences in attitude with effects for mode-choice, routing, purpose etc.

- Number of Population: Total population of each spatial unit, providing the baseline measure of demand for mobility infrastructure and services.
- Household size: Average number of persons per household, influencing trip generation rates and mode choice patterns.
- Age: Number of people in each age group of each spatial unit, capturing the varied socio-economic status, mobility needs, capabilities, and preferences across life stages.
- Gender: Gender contribution of the population, relevant for potential differences in travel behaviour, perceived safety, and mode preferences.
- Number of children per household: average number of children in households, influencing trip chaining, mode choice, and demand for safe walking and cycling infrastructure.

- Household composition: Ratio of households with different status (single, couple, family, etc.), shaping daily travel patterns and destination needs.
- Employment status categories: Distribution of employment statuses (e.g., full-time, part-time, unemployed, student, retired), reflecting variability in travel demand, timing, and purpose.
- Income: Number/Ratio of households in each income level bin, influencing transport mode availability, car ownership, and access to services.
- Health / Mobility restrictions: Number/Ratio of population with health conditions or physical limitations affecting independent mobility and the need for barrier-free infrastructure.
- Education level: Educational attainment of the population in each category (e.g., diploma, undergraduate degree, postgraduate degree, ...), used as a socioeconomic proxy relevant to travel behaviour and residential location patterns.
- Car ownership: Rate of car ownership per household or population unit, reflecting private motorisation levels and their influence on mode choice.

2. Socio-economic variables

Socioeconomic variables refer to the economic and structural conditions of urban areas that shape land use dynamics, employment distribution, housing affordability, and the spatial organisation of daily activity. They influence the feasibility and attractiveness of active and sustainable mobility.

- Rent levels/housing price indicators: Average housing costs of the spatial unit, reflecting affordability levels and their influence on residential location and commuting distances.
- Establishments/firms locations per economic category (e.g. NACE): Addresses/Locations of economic establishments and their respective sector, indicating the concentration and accessibility of employment and services.
- Employees per zone/grid per economic category (e.g. NACE): Number of employees by sector and spatial unit, providing a measure of employment density and trip attraction potential.
- Commuter data: Origin-destination flows of commuters by trip purpose (work, education, leisure, ...), capturing actual mobility patterns and demand for connections between zones.
- Vacancy rates: Share of unoccupied dwellings and commercial units per area, indicating neighbourhood vitality and its effect on local destination availability and perceived safety.

3. Housing and building variables

Housing and building variables refer to the physical and typological characteristics of the built stock, which shape residential density, neighbourhood morphology, and the spatial preconditions for walkable and transit-accessible urban environments.

- Building type: Locations and classification of buildings by type (e.g., single-family, collective, high-rise, social housing), influencing residential density and the urban form supporting active mobility.
- Building age: Construction period of individual buildings, or the ratios of buildings per spatial unit built in different periods. Used as a proxy for the likelihood of barrier-free design compliance.
- Average dwelling area / floor area: Average size of dwellings or total floor area of residential units in the zone, reflecting residential density and land use intensity.
- Number of dwellings per building: Average number of residential units per building in each zone, indicating building density and its relationship to local population concentration.

4. Land use variables

Land use variables refer to the spatial organisation of activities, environmental conditions, and destinations across urban areas, shaping the proximity, diversity, and accessibility of daily needs that underpin walkable and cycling-friendly neighbourhoods.

- Land-use zoning: Formal classification of land uses (residential, commercial, mixed-use, logistics, etc.) per zone, structuring the spatial distribution of activities and the potential for proximity-based mobility.
- Noise exposure: Spatial distribution of noise levels (e.g., noise maps), particularly from traffic, affecting the comfort and attractiveness of walking and cycling routes.
- Heat exposure: Distribution of urban heat across the city, influencing thermal comfort and the viability of active mobility under varying climatic conditions.
- Pollution exposure: Spatial patterns of air pollution concentrations (e.g., PM2.5) relevant to health impacts along walking and cycling routes.
- Traffic Volume: Volume of motorised traffic per road segment or at counting stations, reflecting the intensity of traffic pressure on active mobility infrastructure and public space.
- Accident data: Spatial distribution of recorded traffic accidents, identifying safety hotspots and informing risk assessment for pedestrians and cyclists.

- Data on POIs (other than OSM): Location and categorisation of points of interest from non-OSM sources, supplementing destination data for accessibility and land use mix analysis.
- PT stop density (GTFS-Data): Location or density of public transport stops derived from GTFS feeds or similar sources, indicating the spatial coverage and accessibility of the public transport network.
- PT frequency density (GTFS-Data): Service frequency of public transport per stop or zone derived from GTFS data or similar sources, reflecting the effective usability and attractiveness of public transport as a mobility option.
- PT service hour density (GTFS-Data): Temporal span of public transport services per stop or zone derived from GTFS data or similar sources, capturing the availability of public transport across different times of day.

5. Infrastructure variables

Infrastructure variables refer to the physical provision, quality, and spatial characteristics of transport networks for all modes, forming the structural backbone that enables or constrains active, micro, and motorised mobility across urban areas.

- Car Infrastructure (Width, Velocity, ...): Physical characteristics of road infrastructure for motorised vehicles, including lane widths, speed limits, and more, shaping traffic conditions adjacent to active mobility routes.
- Cycling Infrastructure (Width, Condition...): Provision and physical quality of cycling infrastructure (bike track or marked lanes), including the type, width, surface condition, etc., determining the safety and comfort of cycling.
- Pedestrian Infrastructure (Width, Condition...): Provision and physical quality of pedestrian infrastructure (e.g., footpaths and pedestrianised areas), including the type, width, surface condition, etc., influencing the walkability and accessibility of the network.
- Street Elements (Loading areas, parking areas, greenery, furniture, technical elements...): Maps of street furniture, greenery, parking, and other street-level elements affecting the usability, safety, and attractiveness of public space for active mobility users.

Data on Micro-level

The micro level of data refers to the fine spatial scale of urban environments, capturing the physical qualities of individual streets, paths, intersections, their immediate surroundings, and public spaces. The data of infrastructural factors describing the quality of pedestrian paths, bike routes, etc., are important for forming an image of the accessibility, comfort and safety of active and micro mobility. This level of analysis is essential for understanding the actual usability of urban infrastructure, since even a well-connected network can fail users if individual segments are inaccessible, uncomfortable, unsafe, or uninviting. At this scale, data captures not only the objective physical properties of the built environment but also the perceived and experiential dimensions that shape whether people choose to walk, cycle, or use micro-mobility devices at all.

This list is a collection of factors, that increase walkability or bikeability. Data needs at the micro level are defined by the specific factors that determine whether a route or space functions well for active and micro-mobility users. These needs are typically structured around several thematic dimensions.

In the case of pedestrians and walkability, many factors and their impact on the mode and route choice are subjective, context and time dependent. However, there are factors that have an objectively positive impact on walkability or on different target groups (mobility impaired, children, women etc.). Especially these datasets would be valuable assets for researchers and planners. Standardised micro-level datasets available across Europe would allow researchers to conduct meaningful cross-city and cross-national comparisons of walking and cycling conditions, and support for example tool development across the continent.

Identifying micro-indicators: About the methodical approach

Based on literature and the author's previous research, authors have collected a list of factors that impact both walkability and bikeability. The original list contained 57 factors. We conducted a survey among the DUT Knowledge Hub peers in order to collect insight on the importance of the individual walkability and bikeability factors (on a scale from 1 – very low to 5 – very high), which target group the factor foremost impacts (women, elderly, children, mobility impaired etc.) and if some factors could be merged. Also, the participants could add a note regarding data availability of a specific factor.

Two rounds of survey feedback brought the list of factors down to 41 items, organised into six functional categories: 1) Inclusive accessibility, 2) Network and directness, 3) Opportunity and destinations, 4) Physical comfort and health, 5) Public space feel, 6) Traffic safety and stress, and 7) Environmental conditions.

The results of the survey can be found here: Survey Report App and the detailed survey report can be obtained from the authors.

In our respective DUT projects, MobInFact and SmartUrbanity, we are conducting further research work in order to quantify walkability and bikeability as measurable indexes.

1. Inclusive accessibility

Inclusive accessibility refers to infrastructure features that enable safe, barrier-free, and independent mobility for users with diverse physical, sensory, and cognitive abilities, ensuring equitable access to urban environments and transport systems.

- Tactile guidance: Presence of tactile guidance systems supporting visually impaired users and improving independent navigation.
- PT stop accessibility: Barrier-free and safe public transport stops, including ramps, lifts, safe crossings, and comfortable waiting environments.
- Barrier-free design: Infrastructure design enabling mobility-impaired users through ramps, smooth surfaces, curb cuts, and accessible layouts, also relevant for strollers, bicycles, and temporary mobility constraints.

2.Network and directness

Network and directness refers to the structure, connectivity, and continuity of the walking and cycling network, influencing route flexibility, efficiency, and intuitive navigation.

- Intersection density: Density of intersections as a proxy for route choice flexibility and directness; effects may vary depending on design and traffic conditions.
- Path density: Density of pedestrian and cycling links per area as a proxy for network connectivity, permeability, and route availability.
- Route directness: Directness of routes measured as network distance compared to Euclidean distance to key destinations.
- Network continuity: Continuity and completeness of pedestrian and cycling infrastructure, including gaps, discontinuities, and temporary obstacles such as construction or illegal parking.
- Wayfinding: Clarity and legibility of signage, landmarks, and route guidance, including detours and temporary changes.

3.Opportunity and destinations

Opportunity and destinations refers to the availability, diversity, and proximity of daily services, facilities, and destinations accessible along or near walking and cycling routes.

- PT catchment: Walking or cycling catchment to public transport stops within distance or time thresholds, representing intermodality and integration with public transport.
- Green spaces: Presence of parks and green areas along or near routes contributing to accessibility, environmental quality, and route attractiveness.
- Local supply reachable: Availability of essential daily destinations within walking or cycling distance.
- Supply diversity: Variety of daily destinations within walking or cycling distance supporting flexibility and accessibility.
- Land-use mix: Mix of residential, jobs, services, and leisure uses influencing local supply and presence of people across the day; useful as a proxy where POI data coverage is limited.

4.Physical comfort and health

Physical comfort and health refers to environmental and infrastructural conditions affecting physical effort, thermal comfort, environmental exposure, and health during travel.

- Width: Width of sidewalks or bike lanes relative to user needs and interactions with other users.
- Slope: Gradient and physical effort required along routes, particularly relevant for users with reduced mobility.
- Surface quality: Quality and smoothness of pavement surfaces influencing comfort, safety, and usability.
- Condition / upkeep: Maintenance condition of infrastructure, including seasonal variability, drainage quality, and surface deterioration.
- Weather (context): Weather conditions influencing route comfort as a contextual and time-dependent factor, including wind, rain, and seasonal variability.
- Shelter: Availability of sheltered or covered route segments protecting users from weather exposure.
- Microclimate: Local microclimatic conditions influenced by trees, urban form, and materials affecting thermal comfort.
- Shade and coolness: Presence of street trees or structures providing shade and improving thermal comfort.
- Blue infrastructure: Presence of water-related infrastructure such as rivers, canals, or waterfronts influencing environmental quality and comfort.
- Noise exposure: Exposure to traffic-related noise along walking and cycling routes.
- Air pollution exposure: Exposure to air pollution along routes, varying by location, time, and environmental conditions.

5.Public space feel

Public space feel refers to experiential and perceptual qualities of the urban environment influencing comfort, attractiveness, and perceived liveability.

- Cleanliness: Cleanliness of public space including litter, odours, graffiti, and maintenance conditions.
- Crowding: Level of crowding along routes, varying by time of day and urban context.
- Bottlenecks: Presence of narrow or constrained segments reducing effective route usability.
- Aesthetics: Overall visual quality of public space, architecture, and greenery.
- Human scale: Street proportions and spatial enclosure contributing to a comfortable human-scale environment.
- Active ground floors: Presence of active uses and engaging frontages such as shops, cafés, and entrances.
- Social presence: Presence of other people influencing perceived vibrancy and safety.
- Perceived calm: Calmness derived from low traffic levels and pleasant environments.
- Natural surveillance: Presence of "eyes on the street" (people) enhancing perceived safety through passive surveillance.

6.Traffic safety and stress

Traffic safety and stress refers to traffic conditions and infrastructure characteristics affecting perceived and objective safety for walking and cycling.

- Traffic volume: Volume of motorised traffic adjacent to walking or cycling infrastructure.
- Traffic speed: Speed of motorised traffic affecting perceived and objective safety.
- Crossing safety: Safety features at crossings including crossing infrastructure, visibility, sight lines, and clearance from obstacles.
- Separation: Physical separation from motorised traffic or other modes.
- Other modes behaviour: Behaviour of other road users affecting perceived safety, including yielding behaviour and aggressive driving.
- No parking (door zone): Absence of on-street parking reducing door-zone risks for cyclists.
- Traffic legibility: Clarity of traffic rules, priorities, and road layout.
- Lighting quality: Quality of lighting influencing perceived safety, particularly during nighttime conditions.

Conclusion

This working paper presented a structured overview of macro- and micro-level indicators necessary to understand mobility (and to better model behaviour) in urban environments, particularly in the European context. The 41 micro-level and 34 macro-level indicators compiled here reflect the breadth and complexity of data needs for transferable mobility research and simultaneously highlight the fragmented data provision situation of today.

The availability of urban and mobility data has evolved rapidly, with initiatives such as open data, the expansion of GTFS adoption, remote sensing-based data extraction from imagery, LiDAR, and other sensor data. However, improved data availability needs to be accompanied by harmonised definitions, collection methods, spatial resolutions, and update cycles to support meaningful cross-city and cross-national comparison and transferable applications.

Also, and most importantly, still a practical need for comparable structural data (e.g. demography; see the indicators mentioned in this report) remains. This data should be provided and cared for by public authorities/national statistical institutions. Looking at transnational research, also the alignment of data accessibility (in terms of spatial resolution, update cycles, collection methods, harmonised definitions) for research purposes, needs to continue at a faster rate. Otherwise, a lot of potential for evidence-based planning remains untapped, as instruments transferability to other countries is hindered by different data standards.

Looking ahead, a natural next step is a structured mapping of existing data harmonisation initiatives and compiled indicator frameworks, including tools such as the SUMP guidelines and related European monitoring frameworks, to identify where standards already exist, where definitions conflict, and where critical gaps remain. This would allow the research community to build on existing efforts rather than duplicate them, and could form the basis for a shared, community-validated data framework for mobility research across Europe.

We invite researchers, urban planners, and data providers to engage with and critically reflect on the indicator framework presented here. Feedback on indicator relevance, availability across different national contexts, and suggestions for missing variables are especially welcome as collaborative input will be essential to translating this framework into a practical resource for both research and planning practice.

ABOUT THE DU KNOWLEDGE HUB

This working paper is an output from the Knowledge Hub. The Knowledge Hub is DUT's instrument to gather a knowledge community, capitalise on project results and facilitate the transfer of the project results to practitioners.

The projects involved in the discussions leading to this working paper were MobinFact, PERSEUS, POTUS, PROMISE, SmartUrbanity, Multignation and TuneTo15.

CONTACT DETAILS

Group 1

Structural Geospatial Data of Transport and Settlement / Macro-Level: Jonathan Fetka, TU Wien, jonathan.fetka@tuwien.ac.at

Group 2

Walkability and Bikeability Indicators / Micro-Level: Veera Helle-Custer, Eastern Switzerland University of Applied Sciences (OST), veera.helle@ost.ch

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DUT Coordinator: Florian Kressler, AustriaTech

Layout: Ana Calvo, IQ Samhällsbyggnad

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