International Transport Forum

Benchmarking Accessibility in Cities

Measuring the Impact of Proximity and Transport Performance

Case-Specific Policy Analysis

European Commission

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The International Transport Forum

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Reader’s guide

This report uses terms and notions that have multiple meanings in everyday and academic use. The following definitions apply to terms used in describing the modelling undertaken:

Accessibility: In this report, accessibility refers to the ability to reach destinations using a given transport mode.

The EC/ITF/OECD urban access framework (UAF): These terms refer to the framework developed as a result of the joint work for this project. It is based upon a previous version of the UAF of the ITF.

Functional urban area (FUA) or Metropolitan Area: These terms refer to the entire urban continuum that includes the city and the commuting zone, as per the EU-OECD definition.

City: One or more local administrative unit that have the majority of their population in an urban centre, which is a cluster of contiguous cells each with a density of at least 1,500 inhabitants and a total population of 50,000.

Commuting zone: The local administrative units surrounding a city that have at least 15% of their employed residents commuting to the city.

Cell: For computational purposes, Functional urban areas (FUAs) are split in 500 metre-sided square grids. Every cell in the grid is associated with the sum of population and destinations located within the cell. Accessibility is measured between cells.

Destination: A location of interest, where the trip ends. Destinations are aggregated at the cell level. The end point of every trip is the absolute geographical centre of the cell. Once a cell is “reached”, everything encompassed in the cell is also reached.

Origin: Place where a trip starts. The starting point of the trip is the centre of the cell weighted by the distribution of population within the cell.

Travel time: The travel time between cells is the average time a person needs to go from an origin to a destination with a given mode. That travel time is always considered door-to-door, following certain mode-specific assumptions.

Indicator/metric: These two terms are used interchangeably and characterise the accessibility indicators developed.

Executive summary

What we did

This report presents a new urban accessibility framework. It identifies which destinations can be reached on foot, by bicycle, public transport or car within a certain time (accessibility). It then measures how many destinations are close by (proximity). The comparison between accessible destinations and nearby destinations shows how well each transport mode performs (transport performance). These three indicators are calculated for destinations such as schools, hospitals, food shops, restaurants, people, recreational opportunities and green spaces in 121 cities in 30 European countries.

This report differs from previous accessibility studies in five important ways. First, it captures transport performance independent of city size. In standard accessibility indicators, city size often heavily influences the results. Secondly, it uses a harmonised definition of a city developed by the European Union and the OECD. This defines a "functional urban area" as a city and its surrounding commuting zone. Thirdly, it includes significantly more cities and a large number of countries. Fourth, its indicators cover a broader range of typical urban destinations. Finally, four different transport modes are captured, namely walking, cycling, public transport and the car.

The report will be accompanied by an interactive online visualisation tool that allows easy comparisons between the cities, destinations, transport modes, geographies and travel times based on the approximately 30 000 data points calculated for this report. The tool also allows users to specify which destinations they consider more important in terms of their accessibility to create their own ranking of cities. This new urban accessibility framework was developed by the European Commission, the International Transport Forum and the OECD.

What we found

Cities consistently offer higher accessibility than their surrounding commuting zones for cycling, public transport and cars. In commuting zones, however, accessibility is lower and transport performance is worse for public transport, due to fewer stops and lower frequencies, and for cycling, due to a less dense road network with fewer intersections. Transport performance for the car, however, is significantly higher in commuting zones thanks to less congestion and higher speeds limits. Despite the higher transport performance by car, accessibility by motor vehicle remains lower in the commuting zone than in the city because destinations are more dispersed.

In general, the car provides better accessibility than public transport or cycling, especially for longer travel times and in commuting zones. For trips of 15 minutes, however, the bicycle performs better in most cities. Public transport performs well within a city, but in a commuting zone someone travelling by car can reach ten times more people than by public transport.

People can access more destinations in dense cities despite higher levels of congestion. In dense cities, trips are shorter because people live close to many destinations. Although congestion reduces transport performance, dense cities are still able to reach high levels of accessibility because so many destinations are nearby. This underlines that accessibility can be increased not only by policies that improve transport performance, but also via policies that bring people closer to their destinations.

Walking in cities can be hampered by multiple obstacles, such as railway lines, highways and rivers without regular pedestrian crossing points such as bridges or tunnels. In addition, the road network in some neighbourhoods consists of large built-up areas (blocks) and few intersections. The framework applied here goes beyond relying on information about infrastructure, it also considers the spatial distribution of population and destinations. This makes it possible to show how many people are affected and where they live.

What we recommend

Use the new urban accessibility framework to compare and benchmark cities

The framework underpinning this study has already been applied to Mexico City, Bogotá, Santiago de Chile and Montevideo in the context of a project on developing accessibility indicators for Latin American cities. Another project is in preparation to apply the framework to cities in the Association of South-East Asian Nations (ASEAN). The tool thus has the potential to become a global standard for comparing and benchmarking urban accessibility. We encourage more cities, countries and International Organisations to use this new framework.

Improve accessibility by reducing trip lengths and enhancing transport performance

Accessibility depends not only on how fast you can travel, but also how far you need to travel to reach your destination. To boost accessibility in their city, policy makers can use the new urban access framework to identify whether a city needs to improve the performance of a particular transport mode or to bring population and (certain) destinations closer together.

Learn from similar cities with higher accessibility scores

Policy makers can learn how to improve their city by comparing it to others of similar size and income level that provide better accessibility. Residents often oppose new or denser development. Yet real-life examples of a city and neighbourhoods that provide better accessibility can help to overcome some of this resistance and ultimately support low-carbon mobility.

Collect more and better urban mobility data, notably on walking and cycling

Data on the availability and the quality of infrastructure for pedestrian and cyclists is rudimentary or even absent and should be improved. Better data is also needed on the time to find a parking space in different parts of the city during peak and off-peak hours. Congestion data should be collected for more cities and more roads, using transparent methods. Such data could be integrated into the new urban access framework and further improve its usefulness. New forms of urban mobility such a car sharing, bicycle sharing, e-bikes and e-scooters could also be added to the framework.

Introduction

Improving accessibility to destinations is increasingly recognised as the ultimate goal of transport policies. It is an intuitive concept that influences decisions about where to live, where to set up an office or build a factory and whether to drive or use public transport. But accessibility metrics are rarely used in decision-making (ITF, 2019). Their limited use in urban transport policy decision can be linked to three distinct problems. First, there is no consensus on which of the many different accessibility metrics to use. Second, accessibility metrics tend to be determined more by the size of a city than its transport performance. Third, accessibility metrics are very sensitive to where the boundary around a city is drawn, which undermines the reliability of comparisons of cities based on different (national) definitions.

To overcome these three problems, the International Transport Forum together with the European Commission and the OECD have developed a new Urban Access Framework (UAF). It aims to create a global consensus on a limited set of simple accessibility indicators. It addresses the city size bias by distinguishing how the performance of the transport system and proximity to destinations can boost accessibility. To compare cities to their commuting zones in a harmonised manner between countries, it relies on the EU-OECD functional urban area (FUA) definition, which is an emerging global-standard and has been estimated for more than 10 000 cities in the world.

This new framework makes it easier to compare urban accessibility across the globe. The metrics are easy to understand and to communicate. They can also be integrated into standard assessments.

The first section of this report describes this new urban access framework (UAF). The second shows the results of this framework as applied to 121 cities and their commuting zones in 30 countries for four modes of transport, seven destinations and three travel times (section 2). The final section discusses insights for developing transport policy based on findings gained from the use of the accessibility indictors in five specific cases.

Challenges and solutions for an integrated transport accessibility framework

Accessibility provided by transport varies greatly when reviewing urban areas globally. Road congestion problems are known to be more prevalent in large cities of the developing world, while transit system development is extremely uneven across cities. Yet intuition can easily be misleading as cities have densities, scales and transport network structures that are hard to fathom with simple observations. Accurate and meaningful comparisons require uniform and comparable metrics. This is the objective of the urban access framework (UAF). The following section documents the methodological results retained from the framework.

Why does a common definition of a city matter?

Without a common understanding of what makes a city, meaningful comparisons are impossible. In administrative terms, the City of Paris in France, for example, covers only a small part of the contiguous and densely populated neighbourhoods at the core of the metropolis. This is in stark contrast to the City of Rome in Italy, where the administrative city covers both the densely populated area and large areas that are dedicated to farming, with low-density settlement patterns. Only the commuting zone lies outside of the boundaries of the city. A comparison of, for example, access to public transport within the city therefore means something very different in Paris than it does in Rome.

The challenge is that the administrative boundaries of European cities have often been determined by history rather than by modern daily realities that people experience today. Successful cities attract people and grow in terms of population and spatially. The result is that the central city or municipality often only accounts for a fraction of the total population that lives in a metropolitan area. One-third of OECD metropolitan areas consist of 60 or more municipalities or local administrative units (OECD, 2016b).

To allow for meaningful comparisons, the OECD and the European Commission have developed a harmonised definition of functional urban areas (FUA) – cities and their commuting zones – that is based on functional connections between localities. This FUA consists of municipalities or local units that form a densely and contiguously-inhabited urban centre – city of at least 50 000 inhabitants and its less-densely populated commuting zone from which at least 15% of the local workforce commute to the city (OECD, 2012a). The largest among the FUAs, i.e. those with 500 000 or more inhabitants, are referred to as metropolitan areas. The EU-OECD definition of FUAs does not aim to replace national definitions of urban or metropolitan areas that are used for different purposes but is extremely useful for international comparisons.

There are two important features of the EU-OECD definition of FUAs for the analysis of transport performance and for transport planning. The first is that it allows the distinction between the dense inner city and the commuting zone and therefore separate analysis of the transport system in the two parts of the FUA. The city offers greater opportunities for active mobility and “critical mass” for high-frequency public transport, whereas the commuting zone tends to be dominated by smaller settlements with more pronounced reliance on private car use. At the same time, the two parts of the FUA can be jointly assessed. Car-reliant commute or transit-oriented development is not just the result of random chance, but outcomes of explicit or implicit policy choices (OECD, 2015b). This relates to the second important feature of FUAs, the ability to consider the administrative fragmentation within the urban or metropolitan area. Fragmented governance arrangements can hinder transport development (e.g. OECD, 2012b) and even adversely affect productivity in cities (Ahrend et al., 2017).

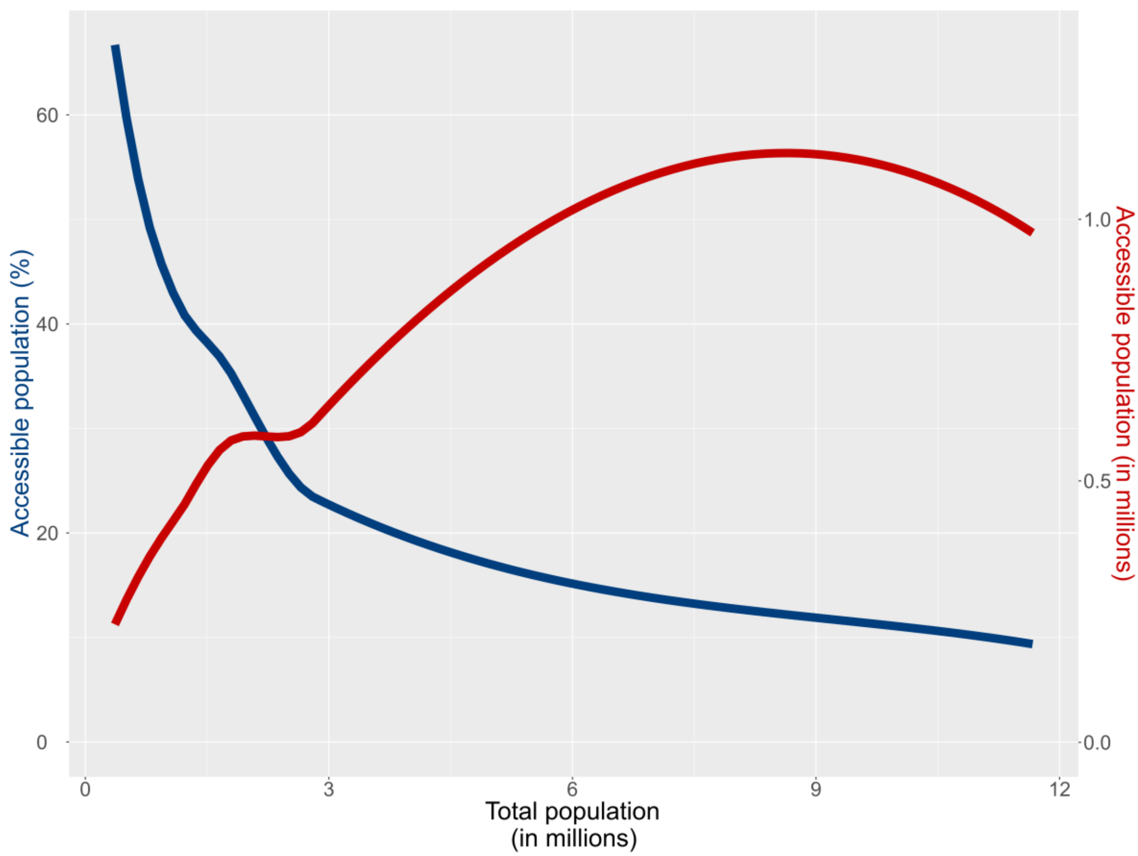
Existing indicators suffer from either small or big city bias

Benchmarking accessibility to destinations across cities using traditional indicators of accessibility is impossible. Indicators are inherently biased to show either excellent performance in small or in large cities, depending on how they are set up. Accessibility in absolute terms, (i.e. the total number of opportunities that people are connected to) increases with city size. Not because the transport system performs better, but because shops, restaurants, jobs and leisure facilities are simply more abundant. Conversely, if the relative accessibility is considered, i.e. the share of the opportunities that a city provides that can be reached within, e.g. 30 minutes of driving, small cities will always perform better than large ones.

Figure 1 illustrates how the two indicators lead to opposing conclusions on the performance of the transport network in cities. The two lines represent a locally-weighted smoothing for the two accessibility indicators over all metropolitan areas in Europe. The horizontal axis is the total population of a city and the vertical axes the accessible population by percentage (left y-axis) and in absolute numbers (right y-axis). The red line is accessibility to people in absolute numbers, while the blue line is accessibility in relative numbers. The share of the total population accessible to an average inhabitant within 30 minutes of driving is, on average, 50% for European metropolitan areas with 1 million inhabitants. For those with 6 million inhabitants, it is just 15%. Clearly, road transport in smaller cities performs better than in larger ones. The opposite conclusion arises when the total number of residents that can be reached within 30 minutes of driving by the average inhabitant is considered. The 50% of population that can be reached in the smaller of the two metropolitan areas translates to reaching 500 000 people within 30 minutes of driving, whereas the 15% in the larger metro area means a driver can reach 900 000 people within the same time.

The example illustrates the small- or big-city-bias. In this context, the size and distribution of a city's population is considered more important than the performance of the transport system itself. The performance of the transport system is an important element of accessibility that existing indicators (e.g. travel speed) have failed to capture completely.

Figure 1. Traditional measure of access and city-size bias



Accessibility depends on the performance of the transport network, urban development patterns and geographical constraints

Measurement of the efficiency of the transport system need to account for the way land is used in cities. Mixed-use environments and transit-oriented development promote density around corridors allow more people to be connected to opportunities more quickly, compared to sprawling suburban developments with economic activity concentrated in a single central business district. The shape of cities plays an important role as well. A metropolitan area like Barcelona in Spain is constrained by the sea on one side and mountains on the other. Hence, geography will not allow for the radial connections that cities without such constraints can develop.

For policy to use the right levers to improve accessibility, understanding what drives performance – transport or land use – is crucial. The metropolitan areas of Vienna in Austria and the West Midlands around the city of Birmingham in the United Kingdom, are of similar size and perform similarly in terms of accessibility in absolute numbers – the average person can access around 750 000 inhabitants in 30 minutes by car. The drivers of performance, however, differ. Vienna is a monocentric FUA whereas West Midlands is composed from multiple cities. As a result, Vienna is denser, with a population density of around 10 000 inhabitants per km^2, double that of the West Midlands metro area. The longer high-capacity road network In the West Midlands metro area attenuates the lower density, especially in the city centre. The West Midlands metro area has around 1 000 km of high capacity roads, compared with 265 km in Vienna. As a result, the average legal driving speed in West Midlands is 5 km/h higher than in Vienna. This comparison demonstrates how the structure of the city, the performance of its transport network and the distribution of destinations all affect the accessibility indicator.

Benchmarking is essential to identify gaps and investment opportunities

Benchmarking is an essential exercise to identify gaps and efficient investment opportunities. Transport infrastructure remains one of the largest items in the investment portfolios of national and subnational governments. The European Union’s project to develop core interregional transport corridors through the Trans-European Transport Network (TEN-T) alone are estimated to require a total investment of EUR 607 billion by the end of 2030 (EU, 2017). Public transport investment in major cities requires equally large sums. In France, the Grand Paris Express that aims to add 200 km of rail-based public transport to the wider Paris area is expected to cost more than EUR 30 billion based on latest estimates (CdC, 2017). The Crossrail project in the United Kingdom that introduces a new East-West corridor and better connection from Heathrow airport to the inner city is budgeted at over EUR 18.5 billion (Crossrail, 2019) and the extension of the metro line A in Prague in the Czech Republic is estimated to cost more than EUR 800 million in current prices (OECD, forthcoming).

Some of the resources required for major infrastructure investments come from local funds, but regional and central governments typically contribute a significant share of the total budget. For many European countries, EU funds are often an important catalyst for investment. For the 12 EU countries that joined the European Union in 2004 and 2007, European Regional Development Funds (ERDF) and Cohesion Funds accounted for over 40% of total government capital expenditure on transport during the 2007–13 period (EU, 2017).

Given the large sums involved and the lasting effect that transport infrastructure investment has on regional and urban development, the decisions concerning which infrastructure and where to construct it needs to be carefully considered. Existing tools help policy makers to take economically viable decisions once a set of projects has been chosen, but not to identify potential project sites to begin with. A common appraisal tool is cost-benefit analysis; it is an indispensable, widely used and continuously evolving tool to compare the gains from investment against its cost (ITF, 2011; OECD, 2016a). All 20 OECD countries that responded to an OECD survey on cost-benefit analysis used this tool in some form. In nearly half of the countries, the use of cost-benefit analysis is a legal requirement nationwide. In the remaining countries, the tool is either applied without being a requirement or required before investing in transport projects at state, regional or local government level (OECD, 2015a). Although proven to be effective assessments are focused on individual projects and only rarely used to guide the initial investment decision.

Beyond investment decisions, benchmarking is also crucial to help policy makers and the public assess progress towards ambitious global agendas that address the needs of citizens. The Sustainable Development Goal 11 on Sustainable Cities and Communities sets an explicit target for providing access to safe, affordable, accessible and sustainable transport systems for all by 2030 (Target 11.2). But monitoring for this target is less ambitious than the target itself. The key indicator to assess progress is the proportion of population that has “convenient access to public transport”, broken down by gender, age and monitored for persons with disabilities (UN, 2019). Whilst important, this indicator does not capture what access to public transport actually provides for people, i.e. what opportunities they can reach, e.g. employment, health and wellbeing services, recreational areas etc. It also fails to capture the access to opportunities that active modes of mobility can provide, e.g. walking and cycling.

The Framework: Developing harmonised indicators for benchmarking

The methodology presented in this report proposes a new flexible framework to develop informative indicators that control for city size, take different modes of transport into account and consider the "points of interest" that people want to reach. The framework acknowledges that accessibility is the product of the proximity of valued destinations (the result of land-use policies and private investments) and of the performance of the transport system (the result of transport policies and investments in infrastructure). The accessibility indicators developed in this report are based on a quantification of each of these components.

Six advantages of the framework

1. *Independence from city size.* The framework finds a middle-ground between absolute and relative accessibility by comparing the absolute number of opportunities that can be reached within a given time with the potential number of opportunities within a fixed distance from the point of origin. This fixed area of reference addresses the small- and big-city-bias.
2. *Multi-modal accessibility.* The framework covers active modes of mobility (walking and cycling) in addition to accessibility by car. Where data is available the framework also includes public transport.
3. *Access to destinations.* The typical view is that transport flows from everywhere to everywhere (e.g. Cervero and Hall, 1989). But the points where the journey originates from and the places where people want to go are not evenly distributed within the city. The framework considers a detailed population density grid to weigh the origins of traffic flows and uses a range of "points of interest" to capture the different uses of the city as destinations for the transport flows.
4. *Comparable cities.* To allow for benchmarking within and across countries, the framework adopts a harmonised definition of cities, underpinned by the FUA concept developed by the European Commission and the OECD.
5. *Flexibility and adaptability.* The framework has been developed to allow for international comparability but can be adapted to accommodate country-specific needs or preferences and allows for further refinements as data improves.
6. *Visualisation.* The framework can be combined with new data visualisation techniques and thereby help reach a greater audience and enrich the social dialogue on transport policies (see Box 2).

Deriving policy-relevant indicators: accessibility in terms of proximity and transport performance

Accessibility indicators are appealing because they combine the impact of transport systems with the spatial distribution of destinations. But when comparing cities and metropolitan areas, it is difficult to know if accessibility to desired points of interest is high because the transport system is superior or because the urban form of a city facilitates access as origins and destinations are more concentrated.

The framework therefore builds on the following three components, summarised in Table 1:

- Absolute accessibility is the total number of destinations that can be reached by driving, cycling, walking or taking public transport. It captures all the opportunities that are available to a resident and are determined both by the size and density of the city and the neighbourhood where someone lives, as well as the transport network that connects the area to the rest of the city.

- Proximity captures the spatial concentration of trip origins and potential destinations. It is defined as the total number of services within a given distance, typically 8 km. It measures the number of destinations in "close" proximity to the origin regardless of the travel time required to access them. Proximity in the context of the framework is not considered through mode choice but on the geographical characteristics, transport planning, policy and investment decisions that ultimately affect the distance between origin and destination for travellers.
- Transport performance for each mode, controlling for the spatial distribution of destinations. This compares the total number of destinations accessible (by car, public transport or bike) with the number of destinations nearby (within a set radius). Transport performance is computed as the ratio between the absolute accessibility for a given mode and proximity to potential destinations. A ratio of one or more means the mode performs well, a ratio close to zero means the mode performs poorly, even in providing access to nearby destinations. Although this ratio is more abstract than total or relative accessibility, it avoids the biases based on city size. It summarises many aspects of the effectiveness of the mode in providing access to destinations. For example, in the case of public transport, it captures the frequency of services, the in-vehicle speed, the number of transfers and the distance to the nearest bus stop or station.

Table 1. Accessibility indicator types in the urban access framework

Accessibility indicator	Description
Absolute Accessibility	Number of destinations reachable within fixed amount of time with a given mode, i.e. accessible destinations.
Proximity	Total number of destinations within a certain distance, i.e. nearby destinations.
Transport performance	Ratio of accessible destinations to nearby destinations.

An important feature of this set of three indicators is that the product of proximity and transport performance equals accessibility. This means that proximity and transport performance effectively identify the effect that respective contribution of land use patterns and transport have on accessibility. The urban access framework is an evolution of prior work by the International Transport Forum, first developed for a global comparison of point-to-point access within cities (ITF, 2017a).

To capture the experience of the average resident, each of the three indicators is aggregated, using a population-weighted average, for the city, commuting zone and functional urban area.

Figure 2. How transport performance for car travel is computed
(Strasbourg, France)

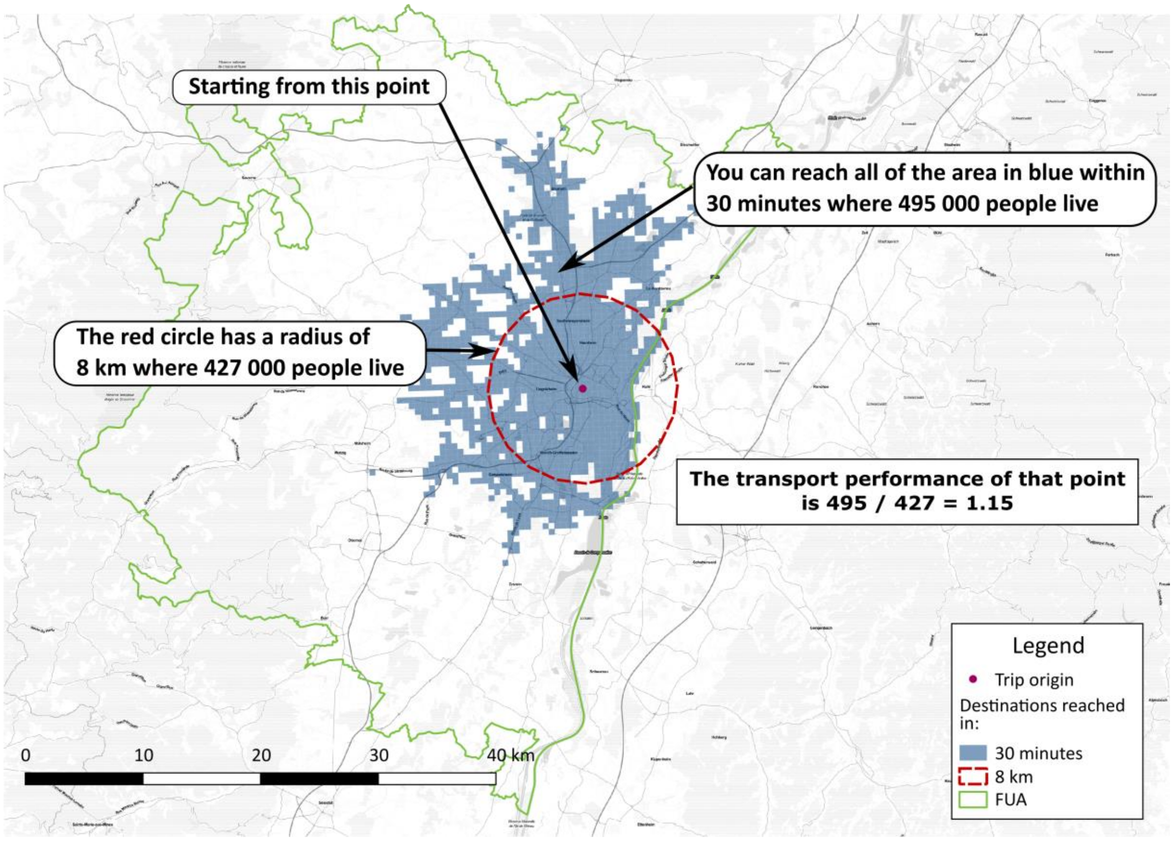
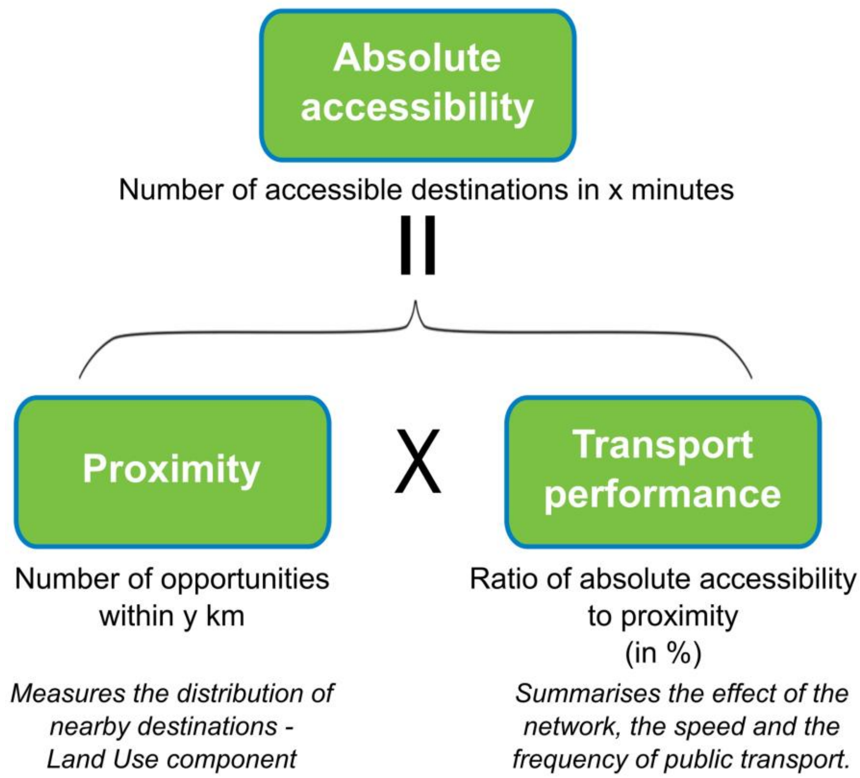


Figure 3. Breaking down absolute accessibility



Standardised data underpins the harmonised framework

Developing urban accessibility metrics that can be used at a global scale requires uniform data and consistent methodologies. To date, comparisons have been limited to a small set of cities or limited by reliance on infrastructure-based indicators that are only distant proxies of urban accessibility. However, the increasing availability of standardised data and growing capabilities of computation are rapidly changing the scene and offering new possibilities.

Traditional indicators tended to focus on an in-depth assessment for a small number of places, while the new Framework allows for a comparison across a large number of cities. Numerous accessibility studies have been produced in case-study format, focusing on a single city or comparisons across a very small set. For instance CEREMA (2015) listed 21 accessibility studies conducted in France in recent decades, excluding academic work. Most of them were conducted using slightly different methodologies and datasets compromising comparability. Detailed local assessments are essential for decision making at different scales, but the limited spatial scope and poor comparability of such assessments constrains large-scale benchmarking.

Comparative studies are often focused on the concept of proximity. For example, the European Commission measured accessibility to public transport in European cities (Poelman and Dijkstra, 2015). The study combines calculations on the share of the population with access to public transport services within walking distance from their home with the quality of the service provided at their stops, measured in terms of frequency of service. The advantage of such proximity-based metrics is that they are relatively easy to calculate and allow for clear policy conclusions (ITF, 2017b). However, the policy implications might be limited as only the origins of trips and not the destinations are taken into account (Peralta, 2015).

The arrival of new standardised sources and tools for computation make it possible to broaden the scope of availability indicators. A series of reports undertaken in the United States calculate the potential accessibility to jobs in more than 40 US metropolitan areas by car, public transport and walking for 1990, 2000 and 2010 (Owen and Levinson, 2014, 2015; Levinson, 2013). Similar work has been implemented in other OECD countries, e.g. in Australia (Kelly et al., 2012). These studies combine census population data, job locations and detailed information of the urban transport network to assess the number of jobs a resident can reach for different travel times. They add both origin and destination of trips into the calculation but fail to resolve the city-size bias inherent in absolute and relative accessibility measures.

What it takes to build the framework

This section describes the different data and methodological steps that were taken in order to compute the indicators and discusses the assumptions that were made. One of the big advantages of this Framework is that it is adaptable. Different data sources can be used and added as they become available, e.g. job data, more detailed congestion assumptions, bike lane or sidewalk information etc.

The building blocks

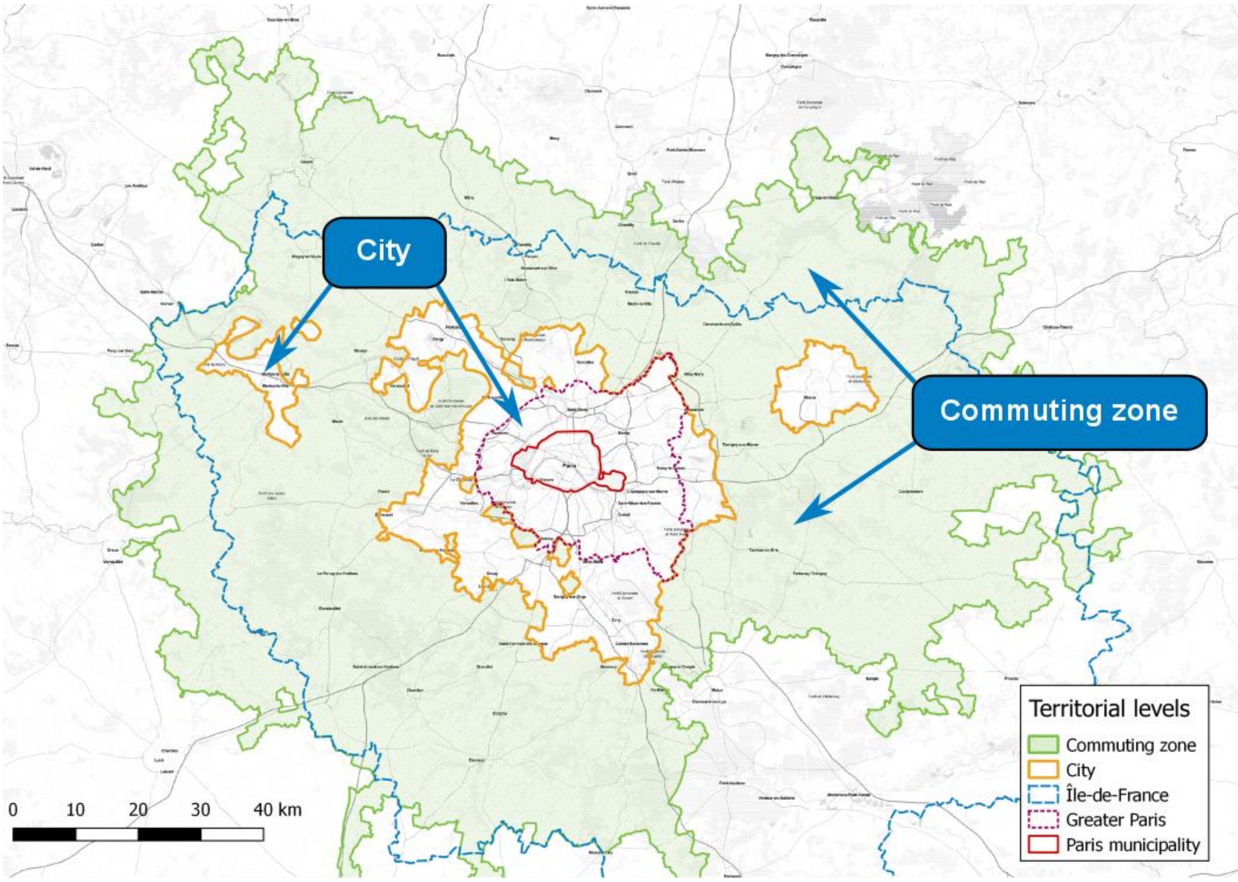
Several building blocks are needed before the actual computation and aggregation processes.

The territorial scale – scope of the analysis

A common definition of an urban area is a prerequisite for meaningful comparisons between countries. Even within the European Union, different administrative boundaries and definitions of urban and metropolitan areas are limiting factors for cross country benchmarking and evaluation. To overcome this issue, this study makes use of the harmonised definition of urban areas as functional economic units as mentioned previously. The *Functional Urban Area (FUA)* concept was jointly developed by the OECD and the EU and FUAs have been defined in all European and most OECD countries.

Figure 4 below illustrates the FUA definition of Paris, France compared to its administrative boundaries. The City is bound by the orange perimeter, and contains both the municipality of Paris and greater Paris. The commuting zone is coloured in green and has similar geographical coverage to the region, Ile-de-France. The sum of both is the FUA. Destinations outside the FUA are not taken into account.

Figure 4. The Functional Urban Area of Paris



The level of analysis is important in order to create accurate results. FUAs cover large territories where people and activities are concentrated. Choosing a wrong level can create many issues. If the level of analysis is too broad, differences between places get lost in the aggregation process. An overly detailed analysis, on the other hand, makes the computational task impossible. The right territorial level of analysis can produce meaningful results, capture changes at the neighbourhood level while making the computation possible. In addition, using a uniform zoning system is preferable to administrative units. Finally, for measuring accessibility by walking, the size of each zone needs to be small enough– so that a person can reasonably walk across zones; otherwise it becomes meaningless if a walking trip can only happen within the same zone.

In this project, a grid system of cells with 500 m squared sides is used. The grid was created from the INSPIRE 100 m population grid originally developed by the Joint Research Centre (JRC) of the EC (JRC, 2016). Each 500 m grid cell represents the sum of the population, services and other amenities that are located within it. There are approximately 1 580 000 cells in the 121 FUAs, 918 000 of which are populated. All accessibility indicators are computed at this level.

Data

As with most quantitative models or estimations, the quality of results is often heavily dependent on the quality of the input data. For this project, homogenised and standardised data sources that exist at a global or European level have been collected, taking its pan-European scope into account. The work presented in this report makes use of multiple datasets to compute the accessibility indicators. The main categories of data required to compute the accessibility indicators are:

Population distribution; the population of each grid cell is aggregated from the INSPIRE 100 m population grid that is used to create the overall grid.

Location of destination; a standardised process was developed to determine the number of destinations of interest in each grid cell. In total, seven distinct destination categories were used (Table 2).

Table 2. Categorisation of destinations

Destination	Further description	Purpose	Main source
Other people		Proxy for opportunities	INSPIRE population grid -JRC
Schools	All pre-university education, primary and secondary	Education, daily trips	TomTom
Hospitals		Health care, emergencies	TomTom
Food shops	Super market, groceries, bakeries, butchers, specialty stores, etc.	Daily needs, economic activity	TomTom
Restaurants	All type of restaurants	Social interactions, economic activity	TomTom
Recreation	Theatres, museums, cinemas, stadiums, tourist and cultural attractions	Social interactions, hobbies, culture	TomTom
Green spaces	All green urban areas (parks) and forests.	Active lifestyle, quality of life	Copernicus Urban Atlas 2012 land cover/land use database

Road network: the road network is extracted from OpenStreetMaps (OSM). The road network contains the geography of the roads, intersections, type of road and legal speed limits on each road segment. To represent travel speeds on the road network, two congestion coefficients are used: a higher coefficient for roads in the city and on high capacity roads in the commuting zone; and a lower one for other types of roads in the periphery. The data coefficients are derived from the TomTom congestion index and INRIX data on observed travel speeds. Each FUA has its own set of coefficients.

Public Transport network: the public transport network is recreated using schedule data under General Transit Feed Specification (GTFS) standards. GTFS is a standard for publication of public transport schedule data and is accepted as the norm throughout the world. It contains information about public transport stops, routes, frequencies and stop times. Out of the 121 FUAs, GTFS information exists for 82. Some of the remaining 39 FUAs might have public transport services, but their schedules are not publicly available in GTFS format. In the 82 FUAs where public transport services are available there could also be some public transport services for which GTFS is not available, and as such the analysis does not consider these services. The indicators for the mode of public transport are computed only for cities where such information is available. A full list of the FUAs with public transport, and a detailed list of all the data used can be found in the Annex.

Box 1. Transforming general transit feed specification data to travel times

The General Transit Feed Specification (GTFS) defines a common format for public transportation schedules and associated geographic information. GTFS files have the following mandatory files: agency, routes, trips, stops, stop times and calendar. It is possible to recreate the entire scheduled public transport activity of an area by combining these files.

For this analysis, peak hour travel times of a random weekday are estimated. For this specific time frame, the average travel time between any two stops of the same public transport line is computed. The waiting and transfer time at any part of the journey are set equal to half of the headway of two consecutive services. A transfer is considered possible when two public transport stops are located within 200 metres of each other. In the case that multiple GTFS files exist for the same FUA (different modes, different operators), these files are merged and the system is considered as an integrated public transport network. Through these steps, travel time between any two public transport stops in a FUA can be estimated.

Travel time; for a given FUA, the grid cells of the zoning system serve both as origins and destinations. Travel time is computed between an origin and a destination cell using a Dijkstra fastest path algorithm. This means that all possible paths between the two points are examined and the one with the shortest travel time is chosen. The travel time is computed door-to-door.

Door-to-door travel time includes elements such as:

- Delays from congestion and time spent looking for parking when using a car;
- Access time, waiting time, and transfer time when using public transport;
- The effect of road gradients when using bike.

Indicator parameters; each of the three indicators developed have multiple dimensions. As mentioned earlier, they are computed for seven different destination categories and for four different modes. In addition, they are computed for three time intervals or distance thresholds. This leads to a total of 3x7x4x3=252 indicators for each of the 918 000 inhabited cells, leading to a total of 231 million data points.

The thresholds are listed in Table 3. To determine the number of destinations of interest in proximity to each cell the model assigns fixed average straight line speeds to each mode based on typical average speeds in European cities, 16 km/h for cars, public transport and cycling, 4 km/h for walking. This information is then aggregated at the cell level to three geographical scales: city, commuting zone and functional urban area. This helps to make the information easier to digest, but still means a total of 756 data points. To make this more readily accessible and visible, a visual and interactive tool was developed (Box 2) where the user can easily switch between different destinations, time thresholds and geographic levels.

Box 2. Visualisation Tool for the Urban Access Framework

Accessibility is multi-dimensional by nature. It might depend on the mode and the destination considered for example. Even with simple indicators, measuring it requires making some assumptions and setting some parameters, such as time-thresholds. Extracting a single story from this complex picture can be challenging. One approach is to use a composite indicator, an aggregation of individual indicators (*dimensions*) compiled into a single value. Most aggregation techniques require choosing a weight for each dimension that represents its importance relative to the others. A well-documented drawback of this method is that there is no objective way to select a weight.

The ITF has developed an online tool that can be used to explore the Framework indicators. A key feature of the tool is that users are able to build their own customised indicator of overall accessibility, by rating the importance of different destinations and specifying additional parameters. Users can then see how cities rank in terms of overall accessibility, based on their own view of the weight to attach to each dimension. This tool is inspired by the OECD "Better Life Index", (http://www.oecdbetterlifeindex.org) and will become available publically in 2019 on the ITF website: (https://www.itf-oecd.org/accessibility-and-safety-european-cities).

Figure 5. The ITF Urban Access Framework Visualisation Tool

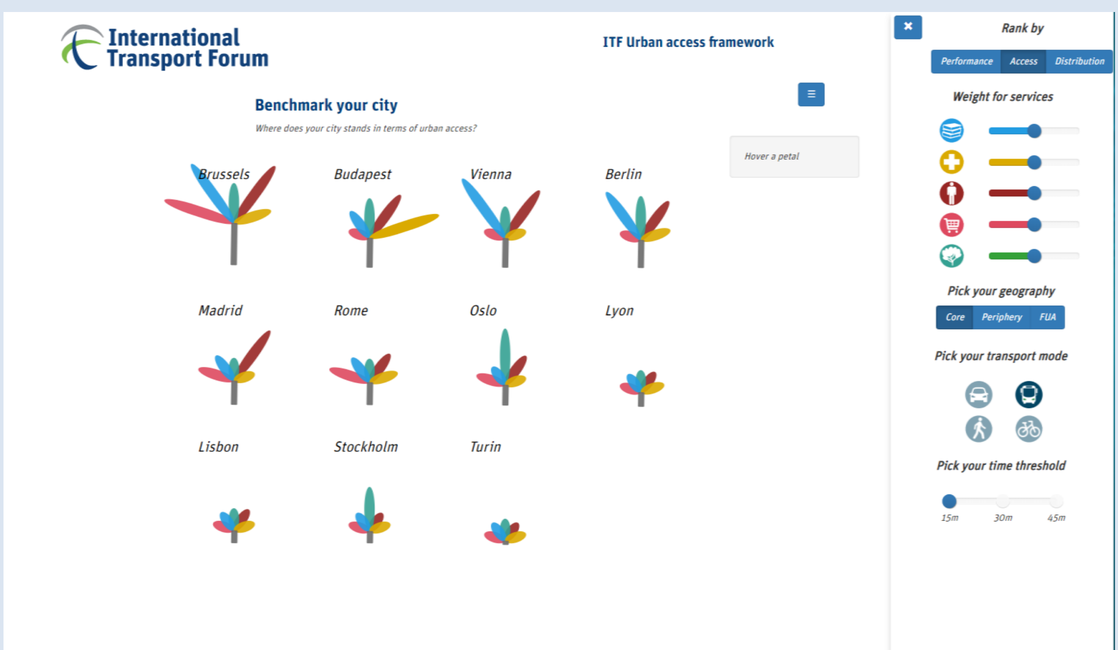


Table 3. Indicator parameters

Indicator parameters	Possible values	
Modes	Car, public transport, cycling	Walking
Threshold and associated distance	15 min (4 km), 30 min (8 km), 45 min (12 km)	15 min (1 km), 30 min (2 km), 45 min (3 km)
Destinations	People, schools, hospitals, food shops, restaurants, recreation, green spaces	

Computing the indicators step-by-step

The accessibility indicators are computed using a multi-step approach.

Step one: Travel time is computed from one origin to all possible destinations within the FUA for the given city. At this step, having travel time to all destinations, one can estimate how many grid cells are reachable within a certain time threshold. As mentioned earlier, the assumption is that when a person reaches a destination cell, they reach every activity, amenity, and service that is located there. The total number of destinations reached is the absolute accessibility of that origin. Figure 6 illustrates this in Poznan, Poland. From the origin point (in green), a person can reach 45 000 inhabitants in 15 minutes by car (dark blue), and 700 000 in 30 minutes (light blue). When measuring accessibility from a single origin, the distribution of destinations is all that matters. If many destinations (people, schools, shops, etc.) are located near the trip origin, that grid cell will have a high absolute accessibility score.

Step two: Accessibility is measured from all origin points of a city. Step one is repeated for every destination cell. This results in an absolute accessibility score for every cell of the FUA. Figure 7 presents the resulting map for Poznan, Poland. The origin point in Figure 6 is one of the many grid cells with a high absolute accessibility score. In order to get an aggregate accessibility value for a city (or any other territorial level), these individual accessibility scores need to be averaged.

Step three: The average absolute accessibility by car in 15 min for the FUA of Poznan is 19 100 inhabitants. This would be the result if every grid cell had an equal weight. However, not every grid cell is the same. There are cells with as many as 7 000 inhabitants and those with as few as five. The cell with 7 000 should have a higher weight on the average value. Therefore to compute aggregated indicators, a population-weighted average is used. As such, the aggregated indicators represent the accessibility that the average inhabitant of that area has. In the FUA of Poznan, using a population-weighted average, the average absolute accessibility to people in 15 minutes by car is 37 000.

Figure 6. Isochrones from a point of origin in Poznan, Poland

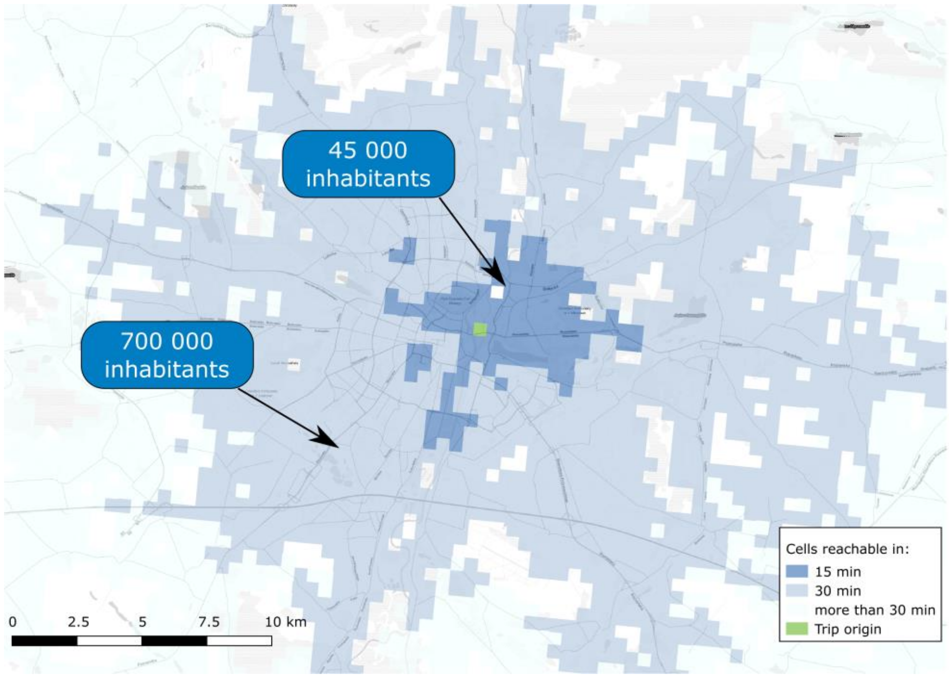


Figure 7. Absolute accessibility by car in Poznan, Poland

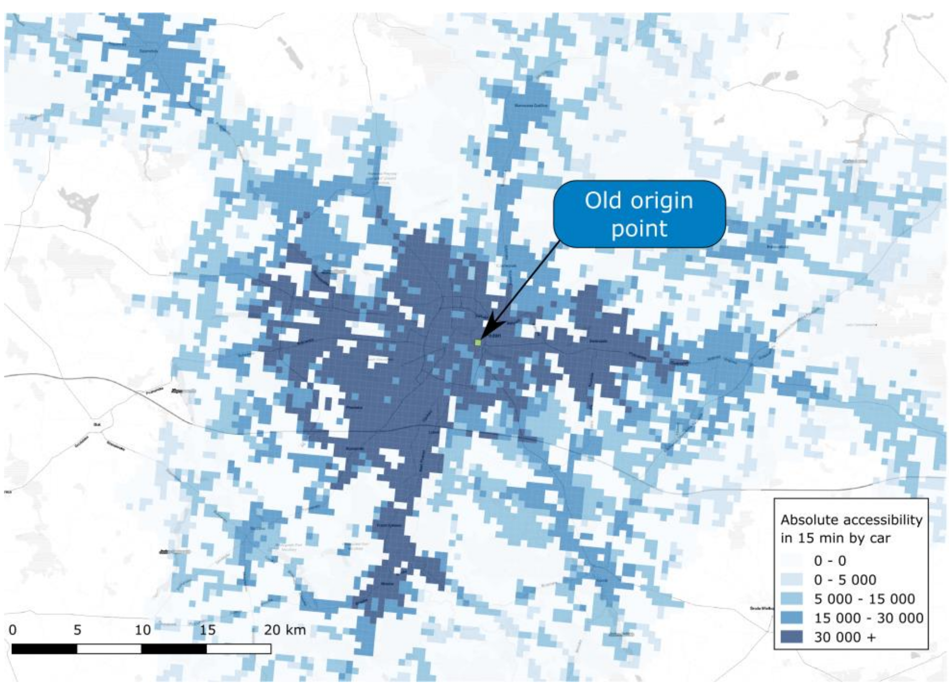
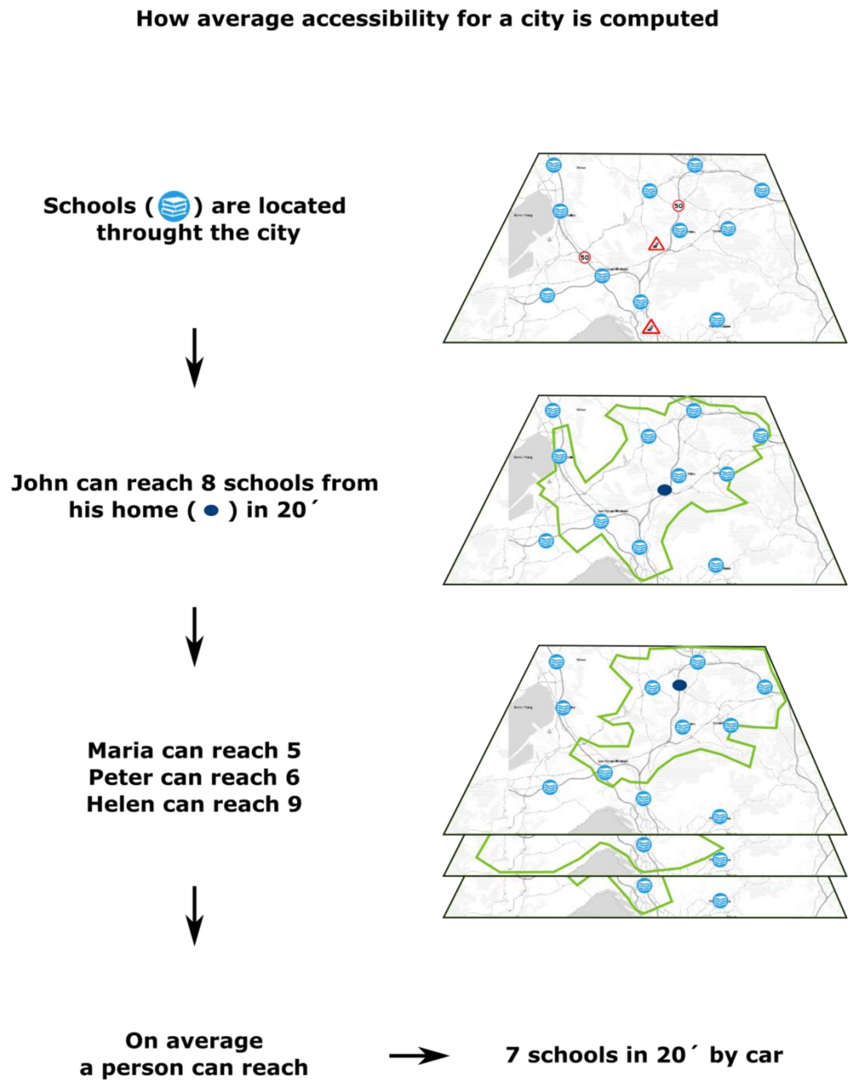


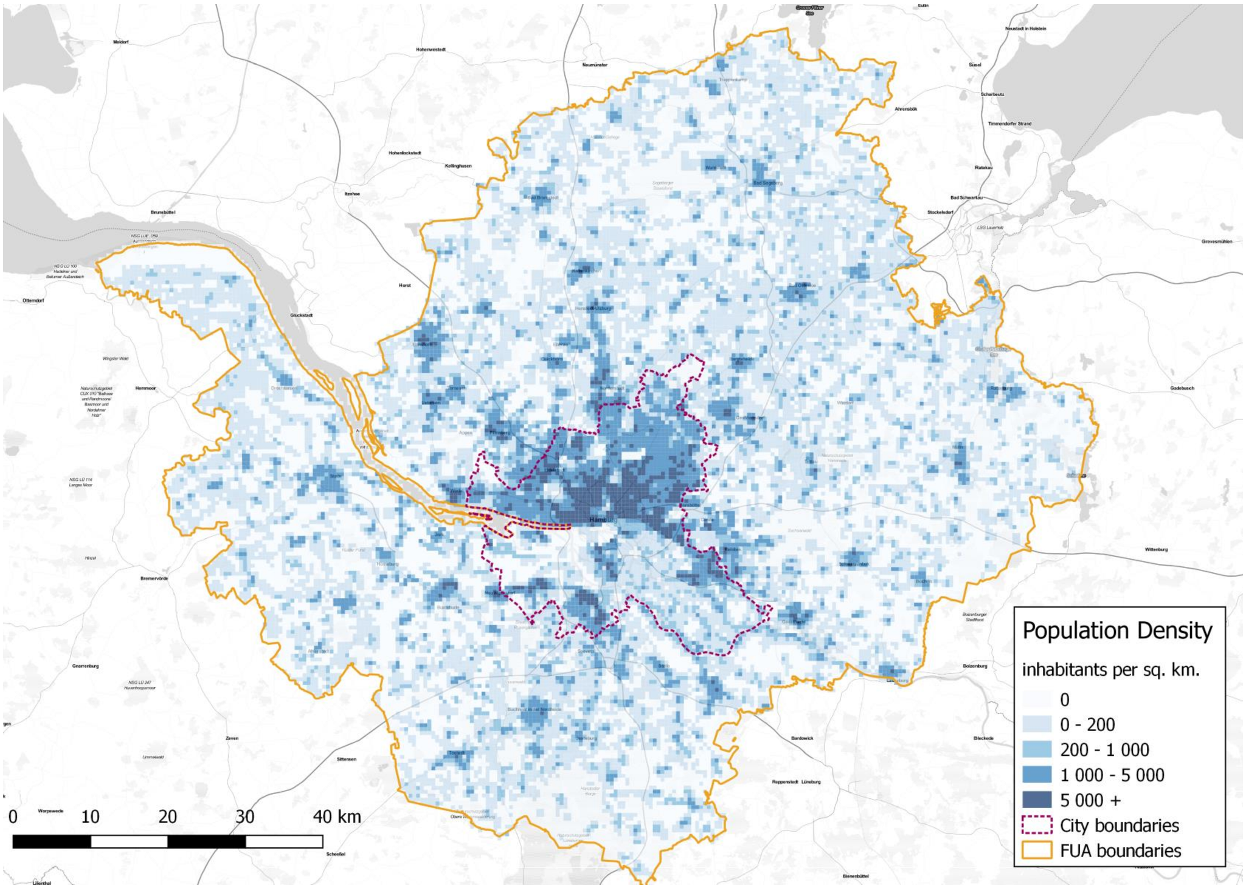
Figure 8. Computing and aggregating accessibility indicators



Indicator demonstration in a single urban area

To better understand the concept of the indicators, this section will present them in a single FUA, that of Hamburg, Germany, focusing on the modes of car and public transport. Hamburg is the third biggest metropolitan area in Germany after Ruhrgebiet (a conglomeration of multiple cities in the area of Ruhr) and Berlin. The FUA of Hamburg has a total of 3.1 million inhabitants. The majority of the people, 1.8 million, live within the city of Hamburg, while the remaining 1.3 million live in the commuting zone (Figure 9). Since the city is much smaller in size than the commuting zone, the population density is also much higher. In the city centre, the population density is over 5 000 inhabitants per square kilometre. The population of the commuting zone on the other hand is mostly grouped in small towns or villages, with the bigger ones being close to the city boundary.

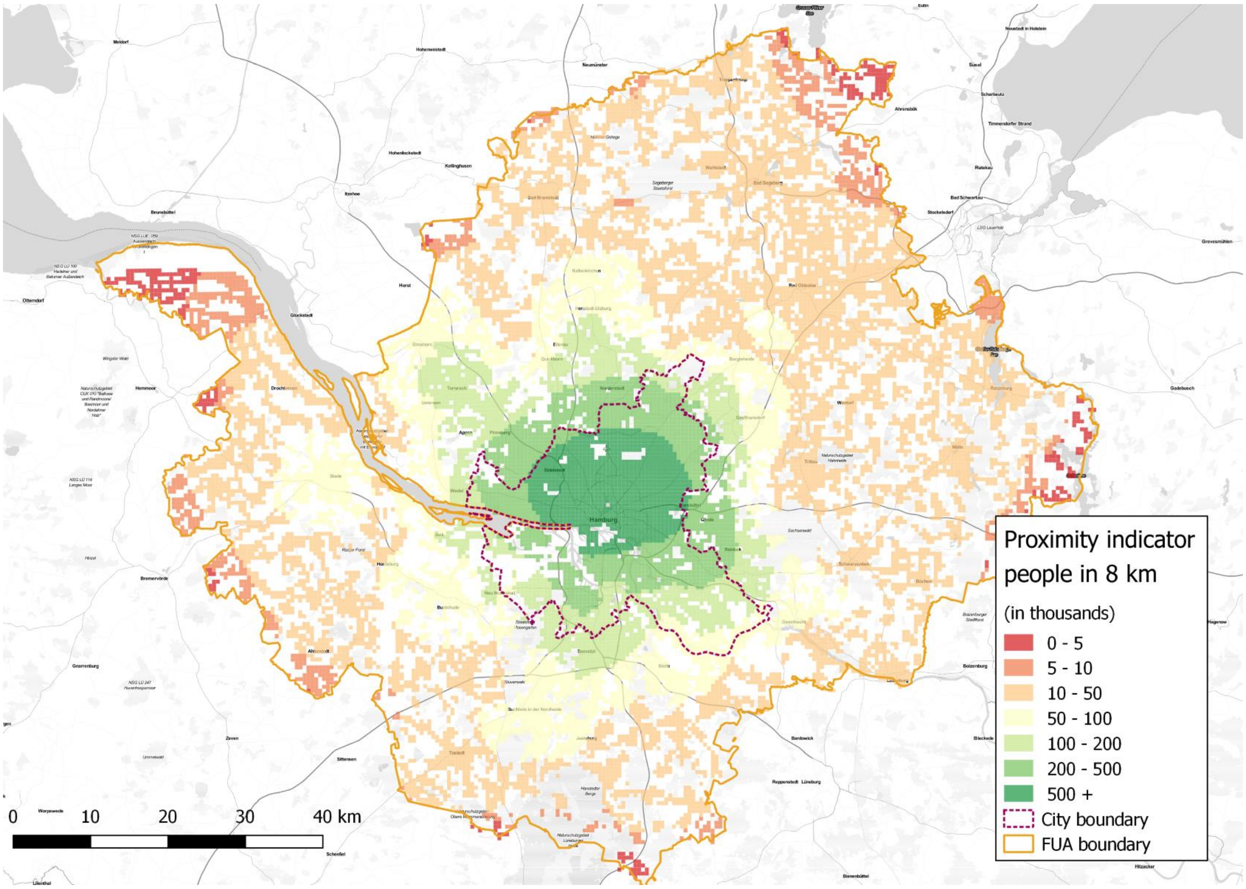
Figure 9. Population Density in Hamburg, Germany



As the proximity indicator reflects the spatial distribution and concentration of destinations, there are much higher values within the city boundaries. This indicator measures the number of destinations within a certain distance threshold, in this case people. Therefore, it is expected that the denser city centre will have higher proximity values. Indeed, there are some areas in Hamburg where there are almost 1 million people in an 8 km radius (Figure 10). Areas near the limits of the city have lower proximity scores, but people living there still have more than 200 000 people nearby. The population weighted average proximity value for the city of Hamburg is 595 000 people.

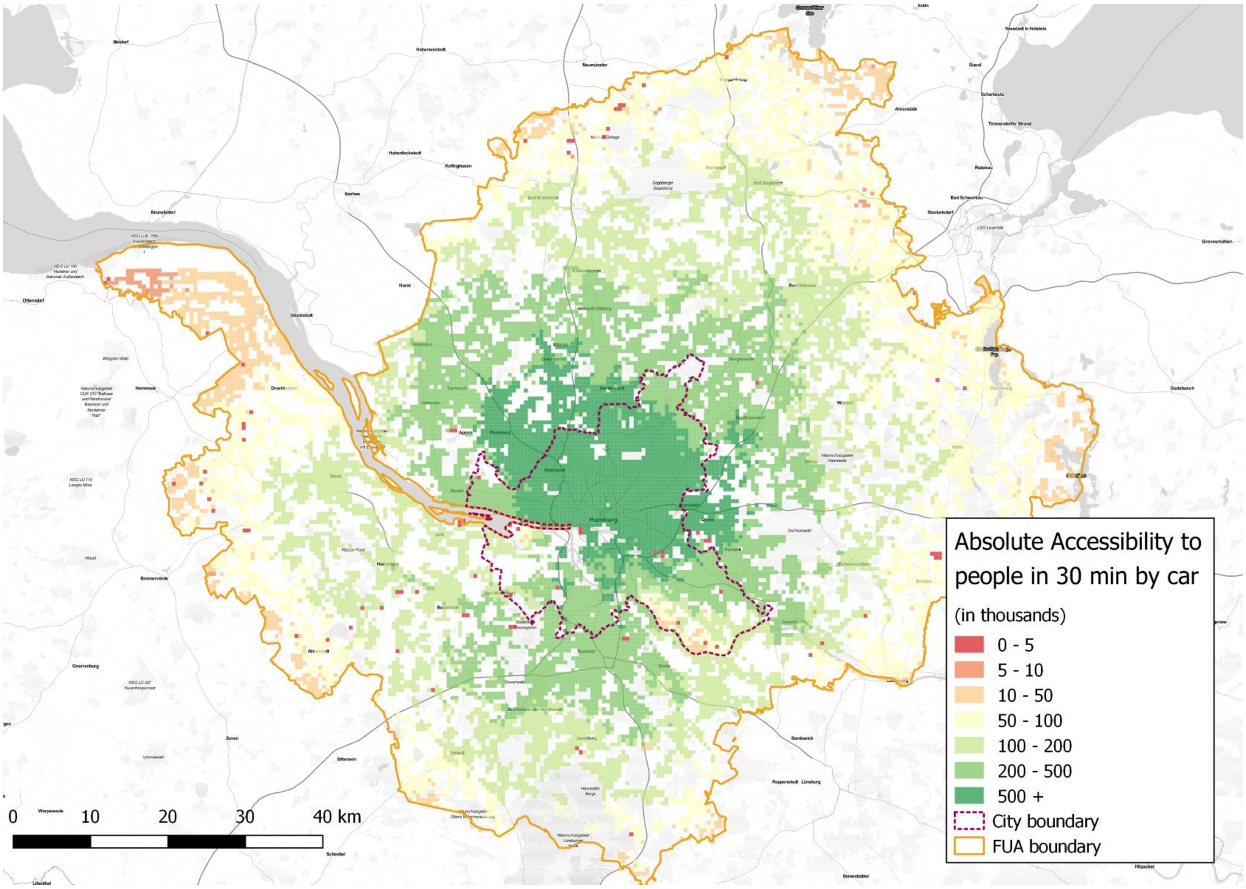
The commuting zone in general has much lower proximity scores, as it is more sparsely populated. Areas near the city boundary, especially in the North have relatively high scores (more than 100 000), but people living in other areas of the commuting zone have much smaller scores going down to as little as 5 000 or 10 000. However, as many inhabitants of the commuting zone live near the city, the population weighted average value is 100 000 people. In short the proximity to population in the city is six times higher than in the commuting zone.

Figure 10. Proximity indicator scores in Hamburg, Germany



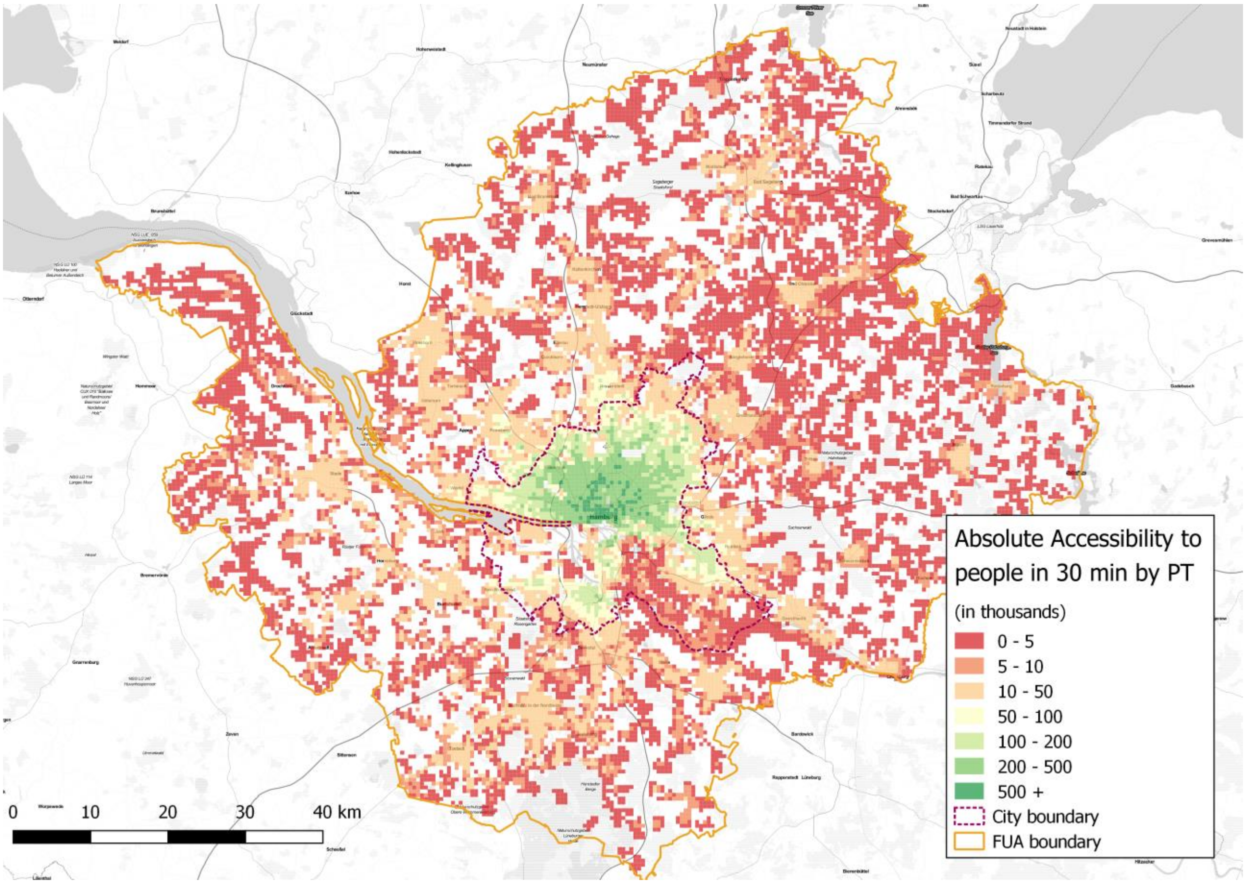
Absolute accessibility describes the number of destinations that can be reached within a certain time threshold by a certain mode. Figure 11 presents the absolute accessibility by car within 30 minutes in Hamburg. There are some similarities with the proximity scores in Figure 10, but overall accessibility scores are higher. That is especially true in the commuting zone, where people who had less than 50 000 inhabitants in an 8 km radius are able to reach more than a 100 000 in 30 min. The major part of the city (geographically) has access to more than 500 000 people, a score that is extended to some parts of the commuting zone. In total, 1.5 million residents of Hamburg are able to reach more than 500 000 people within 30 minutes by car. The highest absolute accessibility score in the city is 1.3 million, whereas it is 1.1 million in the periphery. In terms of average values, the population weighted average for the city is 720 000, while for the periphery it is 270 000. As compared to proximity, car accessibility reduces the difference between the city and the commuting zone from a factor of 6 to a factor of 3.7.

Figure 11. Absolute accessibility scores in 30 min by car in Hamburg, Germany



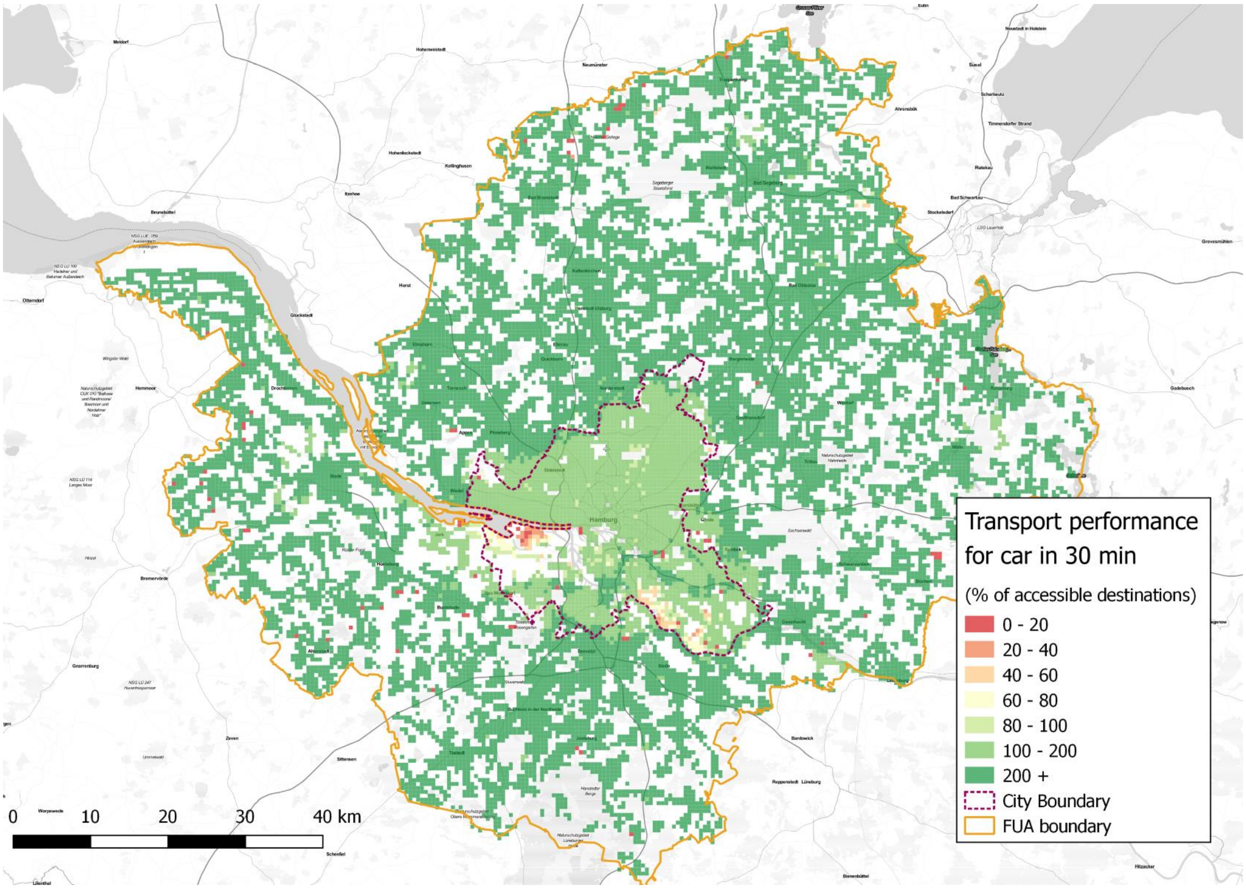
Absolute accessibility is much lower by public transport. Only 150 000 people, all of them living in the city, have access to 500 000 other people within 30 minutes. When taking the use of private car into account, ten times more people can have this level of access. This does not mean that Hamburg is underserved in terms of public transport. In fact, 99.5% of the total FUA population has access to the public transport system. Even in the commuting zone, only 1% is not covered. Still, the public transport network is not as dense and fast as the road network. It is also more concentrated in the city. Thus absolute accessibility by public transport is lower than by car, especially in the commuting zone. Nonetheless, the city of Hamburg has a good level of access to other people when using public transport, with the population weighted average being 245 000 people – one-third of the average value for car. The average value for the commuting zone is only 25 000, 10% of the equivalent car score. While the car reduces the difference in accessibility between the city and the commuting zone as compared to proximity, by public transport the difference actually increases, from a factor of 6 to a factor of 10.

Figure 12. Absolute accessibility scores within 30 minutes by public transport in Hamburg, Germany



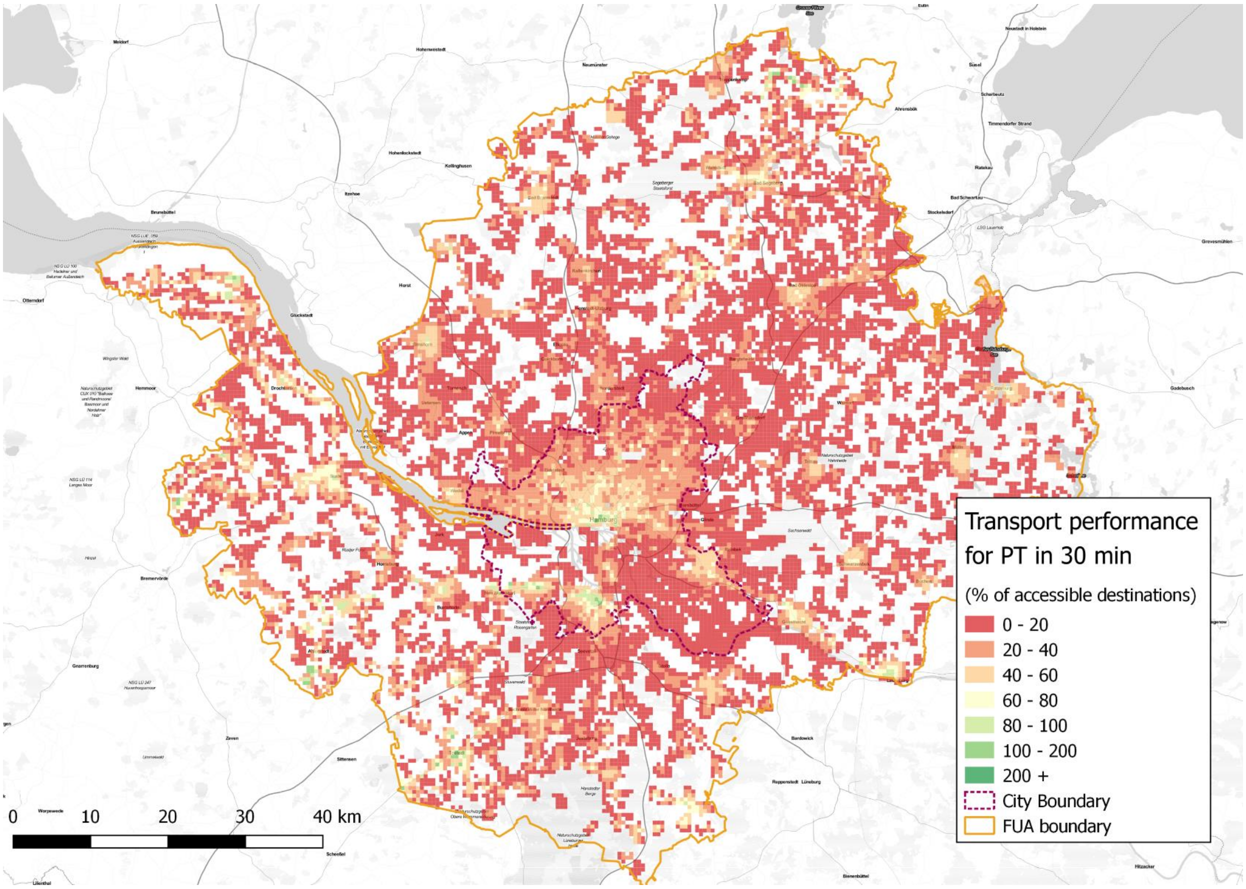
Transport performance generates the difference in absolute accessibility between car and public transport. The proximity indicator is the same for both modes, yet accessibility levels differ. This variation in the levels of access is caused by the relative performance of each mode. Car performs much better in the commuting zone, where congestion and parking are less of an issue. The average transport performance there is 3.6. It is significantly lower in the city (1.27), but it still remains above 1. That means that on average, a person is able to reach more people than those who live around him within an 8 km radius. There are a few locations in the city where transport performance is less than 1, but in each case a big barrier (e.g. the harbour) is the reason for this.

Figure 13. Transport performance for car within 30 minutes from origin in Hamburg, Germany



Transport performance of public transport is much worse to that of car. That is of course due to the nature of the public transport system and network. The concentration of public transport services in the city of Hamburg raises the average transport performance of the city to 0.4. The best served locations of the city, the top quintile, has a transport performance by public transport of more than 0.6. The commuting zone transport performance is not much lower, with an average of 0.31. As seen in Figure 14, there are multiple spots in the commuting zone where the transport performance is comparable with that of the city. These spots highlight the coverage and relatively good service of the public transport system across the FUA of Hamburg.

Figure 14. Transport performance for public transport within 30 minutes from origin in Hamburg, Germany



The results shown in this section for Hamburg were produced for each of the 121 FUAs in Europe. A location specific analysis allows for more relevant policy insights on the local context, as there might be areas with high or low indicator scores that are hidden on the average values. For a benchmarking exercise however, values at the city, commuting zone, or FUA level provide adequate information.

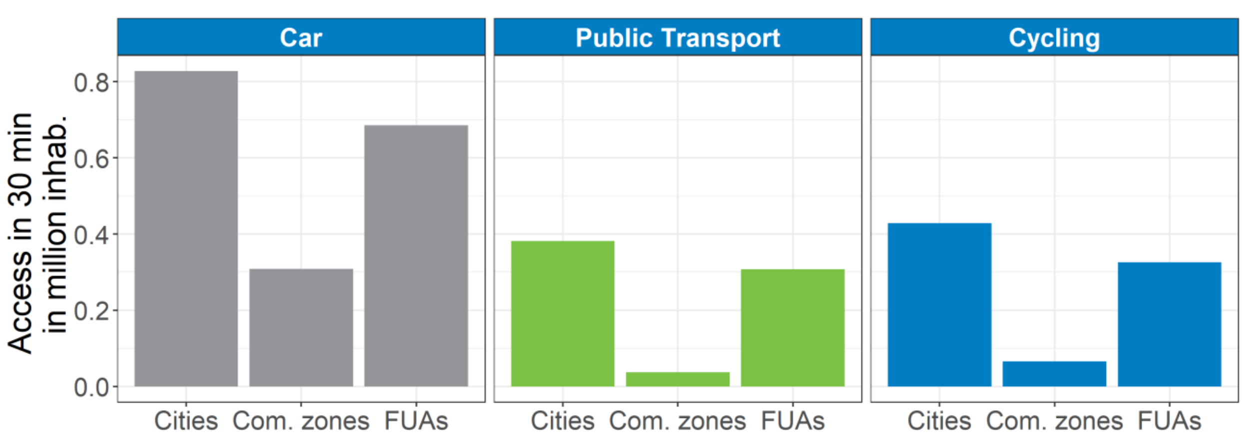
An overview of accessibility in functional urban areas

This section presents an overview of the results of the EC/ITF/OECD Urban Access Framework (UAF) analysis. Each sub-section focuses on a specific issue using a limited number of indicators. Most of the cases examine access to population but the approach can be applied to any category of destination and a service by service analysis is presented in the next section.

Within half an hour, an average inhabitant of a European metropolis can reach 700 000 other people by car, 400 000 by bicycle and 300 000 by public transport. Regardless of the mode, accessibility increases by 10% to 20% within the cities of the FUAs while it is significantly lower in the commuting zones (Figure 15). This mean however, hides high variability in accessibility scores between urban areas, regardless of the mode and the geography considered. For instance, the ratio between the best and lowest performing FUAs is 1 to 12 in accessibility to population by car, 1 to 40 by public transport and 1 to 10 by bicycle.

It is not necessarily in the largest metropolitan areas where the higher accessibility indicators are observed. Although there is a correlation between the size of FUA, in terms of population, and the level of accessibility they offer, there are cases where small urban areas performs better than larger ones. For example, Greater Manchester's FUA has 3 million inhabitants and accessibility to only 290 000 other people by car. This has to do with its polycentric structure, with several secondary urban centres – such as Bolton, Rochdale or Wigan – and sparsely populated areas on the interstitial spaces. On the contrary Thessaloniki's FUA, has 1 million inhabitants and an average accessibility by car of 900 000 people. The geographical structure of the city, with its centre located in a narrow part of land between sea and mountain, concentrates the population there. At the same time a surrounding ring road allows fast connections from one part of the city to the other.

Figure 15. Average accessibility indicators in European FUAs for car, public transport and cycling



Using different distance thresholds may alter the relative performance of modes. Proximity for car, public transport, and bicycle is the same across all time thresholds. Transport performance varies by mode and time threshold. On most occasions, cars have higher performance scores. However when evaluating the 15-minute threshold in cities, bicycles show better performance than cars. That occurs as time spent looking for parking and accessing the vehicle accounts for a substantial part of the 15 minutes. Hence one is not able to travel very far in 15 minutes. The result of this is that bicycles have a higher absolute accessibility score at this time threshold. This is not the case in longer time thresholds nor in the commuting zone, as car performance is much higher than that of bike.

Table 4. Indicator averages for all cities (unweighted)

		Cities			Commuting zone		
		15 minutes	30 minutes	45 minutes	15 minutes	30 minutes	45 minutes
Performance	Car	0.45	1.57	1.87	1.44	2.94	3.51
	Bicycle	0.55	0.63	0.70	0.56	0.49	0.49
Accessibility (population)	Car	50 000	617 000	1 129 000	35 000	267 000	713 000
	Bicycle	107 000	306 000	515 000	17 000	55 000	124 000
	Ratio car to bicycle	0.5	2.0	2.2	2.1	4.9	5.8
Proximity car/bicycle		193 000	488 000	744 000	31 000	111 000	245 000

Data on public transport information is not available in all cities. Nonetheless, the 82 cities where such information is available provide meaningful insight. Public transport performance is below car performance at all time thresholds. However it performs much better in the cities than in the commuting zones. Interestingly, the ratio between car and public transport is not linear. Public transport performance and accessibility are worse at a 30 minute threshold compared both to the 15 minute and the 45 minute thresholds. The first is for the same reason as cycling; car is not very efficient over short distances due to "non-productive" activities (parking and access). Public transport performs better at the 45 minute threshold because at this level, one is able to use trunk public transport services such as subways or trains and reach more destinations. Furthermore, longer time thresholds also reduce the "non-productive" time for public transport, such as access and waiting times.

Understanding the drivers of urban accessibility is challenging at first sight. As illustrated by Figure 16, the distribution of accessibility indicators depicts no clear spatial patterns. At best, one can note that high accessibility is achieved mainly in capital cities with more than 5 million inhabitants. The best performers for access by car are Paris, Madrid and Athens; with an indicator of over 1.5 million inhabitants reachable in less than 30 minutes. For public transport, Paris, London and Vienna have the best scores; with a score of over 600 000 inhabitants reachable in less than 30 minutes.

Figure 16. Accessibility to population in European functional urban areas by car (top) and public transport (bottom)

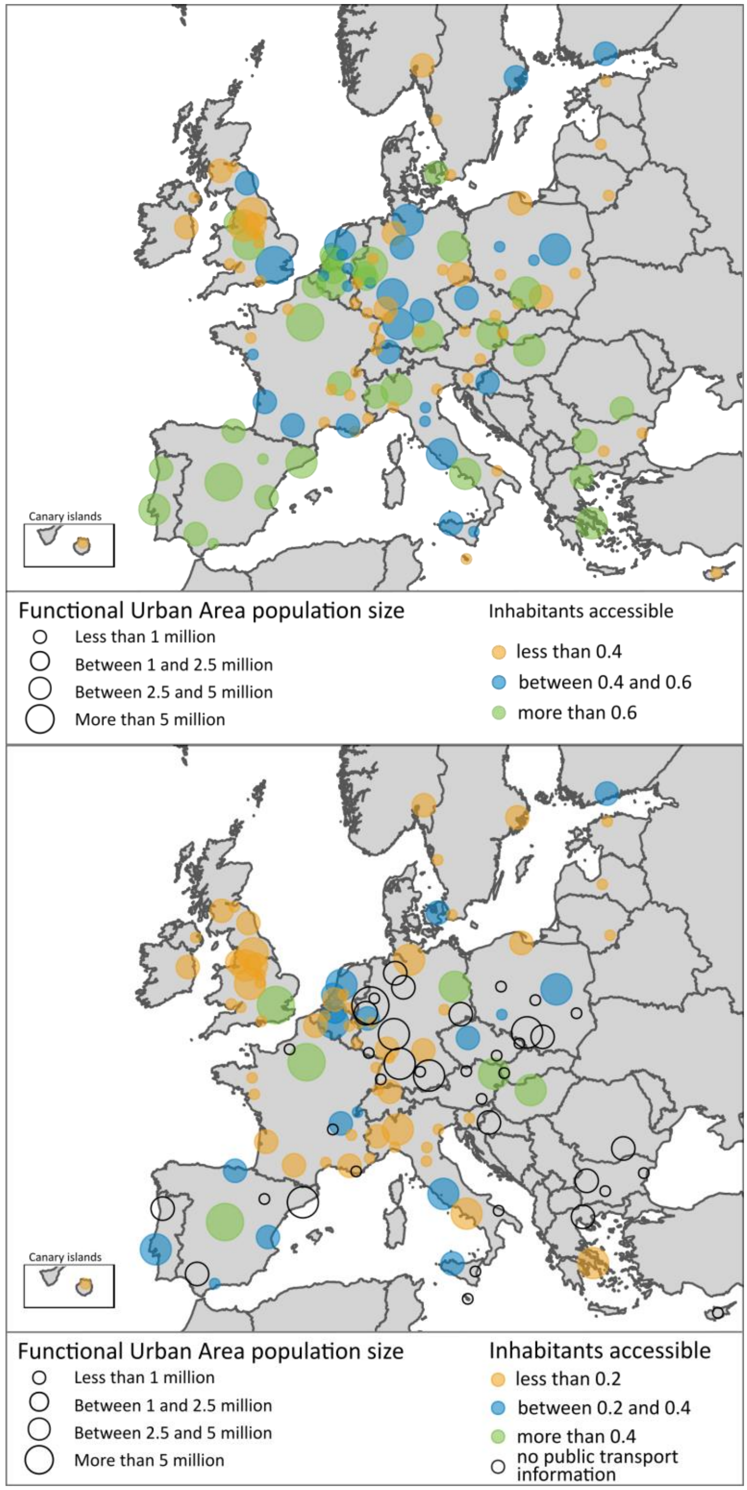


Table 5. Indicator averages for the 82 cities where public transport data is available (unweighted)

		Cities			Commuting zone		
		15 minutes	30 minutes	45 minutes	15 minutes	30 minutes	45 minutes
Performance	Car	0.30	1.30	1.51	1.29	2.62	3.06
	Public Transport	0.16	0.43	0.69	0.19	0.26	0.47
Accessibility (population)	Car	50 000	637 000	1 187 000	36 000	266 000	720 000
	Public Transport	33 000	226 000	568 000	7 000	35 000	133 000
	Ratio car to public transport	1.5	2.8	2.1	5.1	7.6	5.4
Proximity car/public transport		200 000	515 000	791 000	39 000	133 000	285 000

The relative importance of the commuting zone within an FUA, in terms of area and population, is an explanatory factor of accessibility. FUAs with large commuting zones have lower accessibility, because commuting zones are characterised by a low density of services, are remote from the city centres and have low supply of public transport services. There is a significant correlation between accessibility indicators and the share of population living in the commuting zones for all destinations and modes.

Denser cities offer higher accessibility despite being highly congested

The large variability in accessibility is in fact driven by large differences in both transport system performance and proximity of amenities. The complex pattern of accessibility presented in Figure 16 results from the combined effects of those two indicators. This section gives an overview of how transport performance and proximity vary across cities and how this affects accessibility. Transport performance is here defined as the ratio between accessible destinations/amenities and nearby destinations/amenities and captures the efficiency of a mode in getting you to destinations of interest.

Table 6. Indicators used for the analysis in this section

	Categories used
Type	Accessibility, proximity and transport performance
Modes	Car, Public transport
Services	Population
Threshold	30 minutes
Geography	City

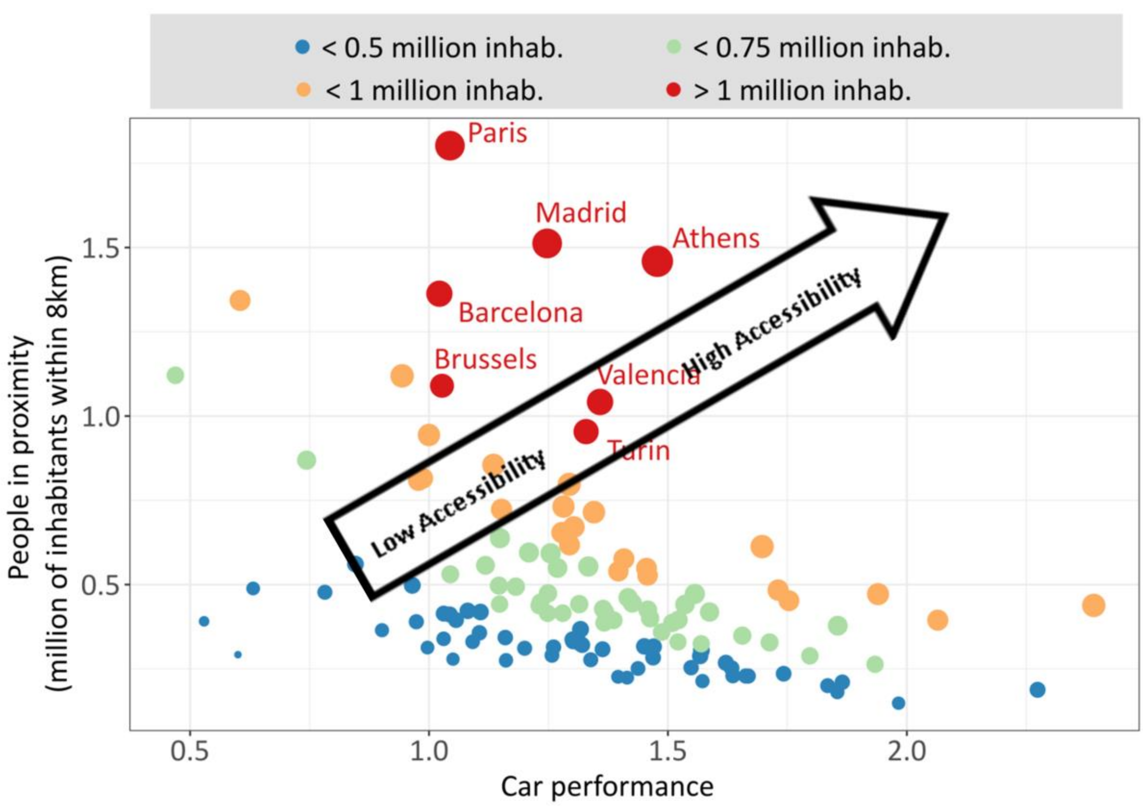
Figure 17 gives an overview of accessibility by cars to population for all cities. It can be read as following: each point represents an FUA; the x-axis indicates the FUA's proximity to population; the y-axis indicates car performance; and finally the circle size is proportional to accessibility. Accessibility is a product of proximity and transport performance and as such transport performance is a synthetic, unit-less measure of the performance of a given transport mode. A FUA will have a high accessibility if it is on the top right corner of the figure and a low one if it is on the bottom left corner.

Proximity and car performance tend to evolve in opposite directions. Dense cities have a higher population density but are usually more congested and the two factors can cancel each other out. Valencia is less congested than Brussels (higher car performance) but has less inhabitants per km^2 (lower proximity) and as such the resulting accessibility is similar (the product of the two is unchanged).

Dense cities offer higher car accessibility despite being congested. This is a result of requiring less distance to travel in order to reach the same number of amenities. At the European level, cities with the highest accessibility by car are also the most congested ones. Although Paris, Madrid, Brussels and Barcelona are among the most congested cities of our sample, these cities also perform best in terms of accessibility by car. This implies that, in terms of accessibility, the benefits of density and a higher proximity to amenities generally outweigh its disadvantages.

Figure 17 also shows the seven cities where an average inhabitant can access more than 1 million inhabitants within 30 minutes by car. It is obvious that all of them have relatively low car performance. Paris has a car performance of 1, while in some other cities it goes up to 2.5. This means that a door-to-door trip in Paris is roughly 40% longer than in the least congested cities. Yet high proximity allows Paris to offer the highest accessibility among all European cities.

Figure 17. Access to people by car in selected European cities



Note: Bubble size is proportional to the population accessible within 30 minutes inside the city. Interpretation of the graph: In Paris, there are approx. 1.75 million people within 8 km in an average neighbourhood. As car performance is 1, the resulting accessibility is 1.75 x 1 = 1.75 million people accessible by car within 30 minutes.

This trend holds true for all big cities. Limiting the results to only cities with populations of more than 1 million inhabitants gives a similar message. In figure 18, cities are ordered by increasing proximity (orange bars). As proximity increases, transport performance decreases (grey points – line). As the cities are denser, they become more congested and have reduced car performance. Absolute accessibility on the other hand increases (blue points – curve).This underlines the importance of proximity in providing accessibility, and is the main reason why denser areas have higher accessibility overall.

Proximity and public transport performance tend to evolve in the same direction (Figure 19). In denser cities, where proximity is higher, mass transit is more feasible. This results in a larger accessibility gap between large and medium sized cities. There is a ratio of 1 to 200 between accessibility in London, Paris and Brussels and the least accessible cities, usually FUAs of around 500 000 inhabitants. London is less dense than Paris but its public transport system is more efficient when considering the functional urban area as a whole. The mass transit network in Paris is well-developed but concentrated inside the Paris municipality while the rest of the city (the "petite couronne") is poorly served by the public transport system. As a result an average door-to-door trip in Paris is 50% longer than in London.

Figure 18. Accessibility (population) by car in 30 minutes, proximity and car performance in cities over 1 million inhabitants

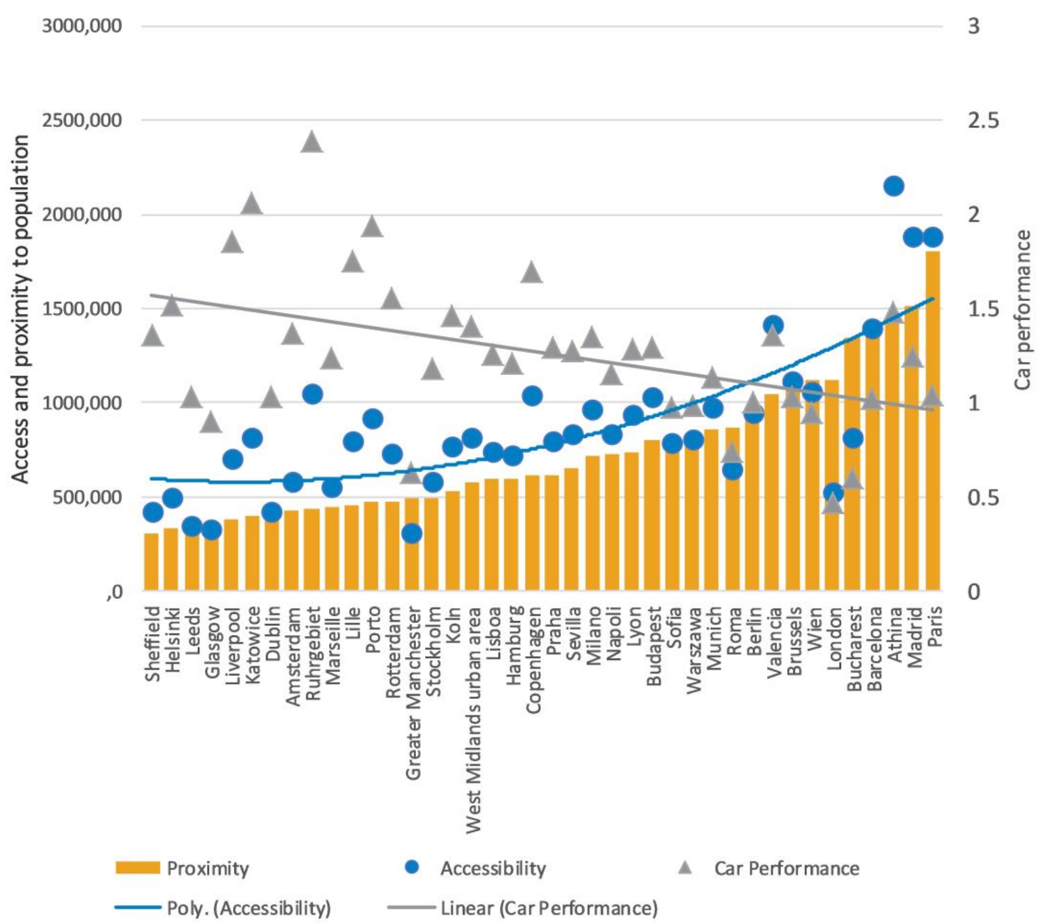
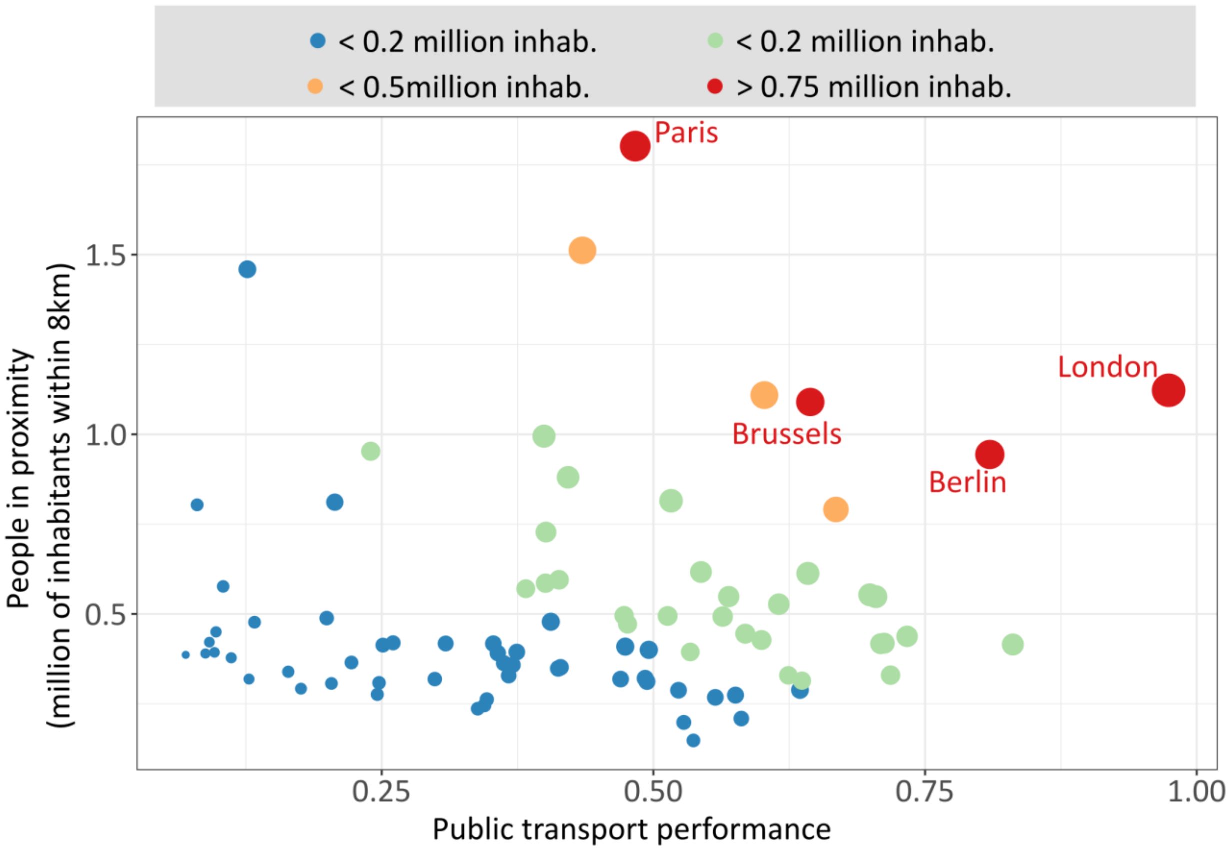


Figure 19. Accessibility to people by public transport in selected European cities



Note: Bubble size is proportional to the population accessible within 30 min in these cities.

Cars provide a greater degree of access than public transport in European cities

In almost all European cities, the car performs better on the accessibility metrics compared to public transport. On average, a door-to-door trip is faster by car even when taking in account peak-hour congestion and parking time (Figure 20). The single city where this is not the case is London where the public transport network is highly efficient (the second best among European cities, just after Oslo) while at the same time the road network performs poorly overall (the worst among European cities).This is a consequence of legacy decisions against building express ways through central London and more recently deliberate policies to reallocate road space to public transport and cycling.

Table 7. Indicators used for the analysis of access by car and public transport in selected European cities

	Categories used
Type	Transport performance
Modes	Car, Public Transport
Services	Population
Threshold	30 minutes
Geography	City

This characterises an average situation and is not the case for *every* trip. There are obviously origin-destination pairs where public transport provides for faster trips in many cities. But even in cities with well-developed public transport networks using a car provides superior service in almost all neighbourhoods for people with access to a car. Outside London, only 1% of the inhabitants of European cities live in neighbourhoods where public transport offers higher accessibility than a car (the figure is 5% including London).

The pattern holds true even in Paris, a city that ranks well in terms of public transport performance. Figure 21 and Figure 22 map private car and public transport performance for Paris respectively. They show that besides a limited number of cells, car use out-performs public transport everywhere. At the same time a large share of passenger traffic is carried by public transport. This is because many people either don't have access to a car, prefer not to drive, have efficient public transport access to their work or no place to park at work. Without that, congestion would severely reduce the performance of the road network and limit the size of the viable commuting zone. In the less densely populated parts of the FUA, where car use greatly out-performs public transport, modal split reflects this: 57% car vs. 38% public transport. In the city centre (marked by the blue line) on the other hand, the performance of public transport is comparable with the car. There public transport accounts for 61% of all trips (25% for car). In the remainder of the city (excluding the Paris municipality) the mode share is balanced, 47% for car vs. 45% for public transport (EGT, 2010). Of course, this should not be attributed only to the performance of each mode. There are many other factors that affect peoples' choices, in particular the relative affordability of public transport and cars.

The two largest European cities, London and Paris, score similarly overall. They both provide a high level of accessibility, but with very different modal splits. The reasons are largely dependent on past policies towards investment in high capacity roads. Nonetheless London demonstrates that it is possible to deliver good levels of accessibility with a smaller role for cars. Regarding the objective of promoting modal shift towards public transport, it can be argued that policies that manage car use are as important as investment in public transport. More generally, the object of urban policy should be improving accessibility rather than improving the performance of individual modes of transport. This implies an integrated approach to transport and land-use planning. In such an approach transport investments are combined with denser urban development especially close to public transport stops. This in turn contributes to increasing proximity with ample space reserved for access by non-motorised modes in the denser areas.

Figure 20. Distribution of public transport (top) and car (bottom) performance across the 121 cities in the study

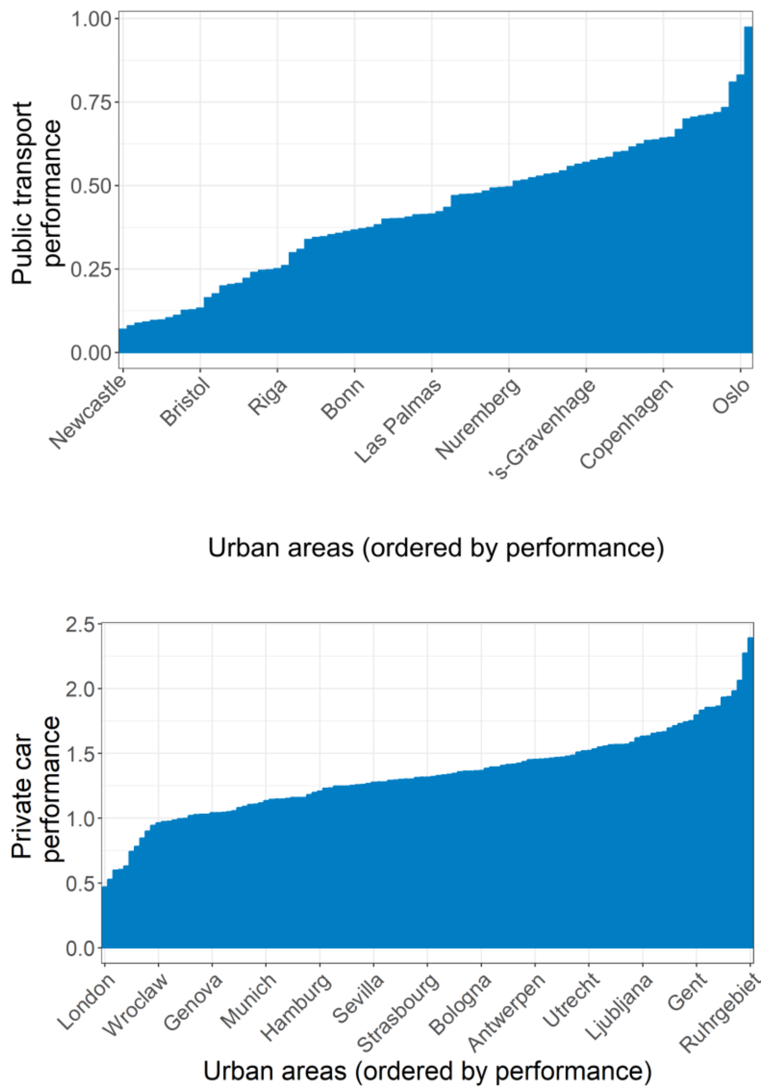


Figure 21. Car performance in Paris

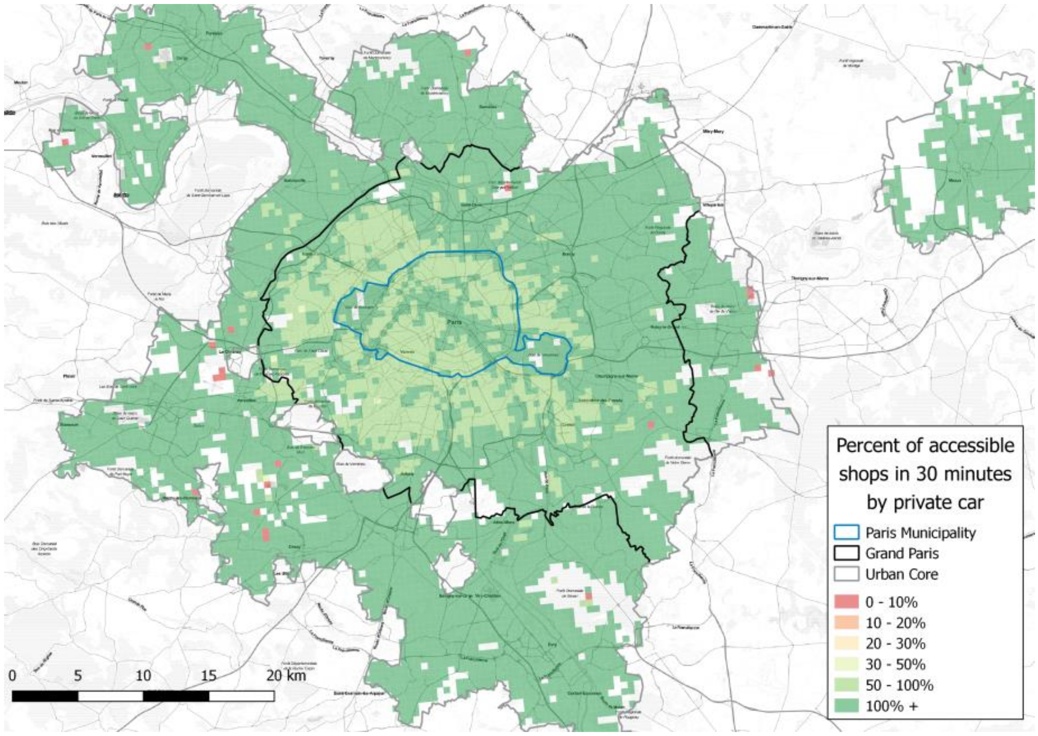
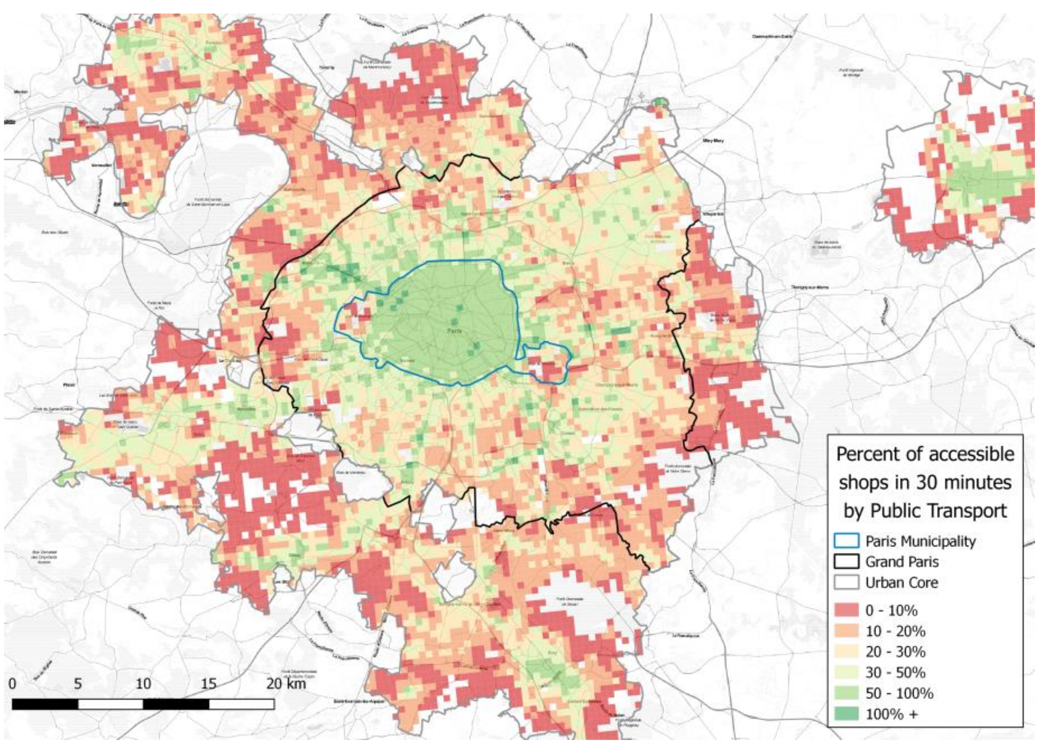


Figure 22. Public transport performance in Paris



Not all European cities are easily walked or cycled

Walkability and cyclability are increasingly important issues for urban planners. Many cities in Europe and elsewhere have been promoting walking and cycling for the last decade (Lavadinho, 2011). In the United States, Redfin, a real estate brokerage, has quantified the concepts with Walk and Bike Scores, two indicators measuring walkability and cyclability on the basis of street topology and proximity of properties to common destinations, such as school, shops and green spaces. The results of their algorithm, available for every address in main Northern American cities have supported numerous studies. For instance Cortright (2009) showed that a higher walkabilty score translates directly into an increase in real estate value. Houses located where walkability is above average are sold at a faster rate, which reflects the value buyers put on accessibility to places and services by walking and suggests that urban development policies should also place a value on walking and cycling too.

Table 8. Indicators used for the analysis of walking and cycling convenience in selected European cities

	Categories used
Type	Transport performance
Modes	Walking, cycling
Services	Population
Threshold	30 minutes
Geography	City

The indicators generated by the urban access framework suggest that not all European cities are walkable. Using a 30 minute walking performance indicator, that divides the number of destinations that can actually be reached within 30 minutes by the number that are located within a 2 km radius (theoretical area that can be reached at a 4 km/hour straight line walking speed), yields average ratios that vary between 0.6 (Belfast, Greater Manchester, or Liverpool) and 0.8 (Varna, Thessaloniki, Bari). The difference corresponds to 15% additional time taken to make trips on foot and a 33% reduction in the mass of activities that can be reached by walking on average. This is explained by urban forms that either favour or neglect street connectivity, with large block size and a low density of street intersections reducing walkability. The average figures hide significant variability within cities. In Leeds, Dublin and Greater Manchester more than 10% of the population lives in neighbourhoods with walking performance under 0.45. This implies that these neighbourhoods were not planned for walking, with a lack of dedicated walking paths between large blocks (e.g. industrial sites) and a prevalence of high traffic roads. In an increasing number of cities, analysis of neighbourhood walkability is conducted to identify where targeted investments are needed. Our results suggest that this practice should be generalised.

Out of 121 cities analysed, Belfast is the worst performer in terms of walking. Figure 23 reflects three main contributory factors. First, the residential areas at the fringe of the city have low walkability because they are organised around long parallel streets that were clearly designed with the aim of easing car movement but not facilitating walking. Second, an insufficient number of pedestrian bridges cross the main river, impeding people crossing the city on foot. Pedestrian bridges have been central in policies promoting walking in other cities. For example in London, the plan to increase walkability and make London the most walkable city by 2015 (launched in the early 2000s by Mayor Ken Livingstone) included the construction of several pedestrian bridges across the river Thames. In Belfast, several major industrial sites, including some around the harbour, create physical barriers and force pedestrians to make significant detours in order to reach their final destination. In some places, high capacity roads, especially three urban motorways (the M1, M2 and M3) crossing the city, generate a similar effect. This community severance effect is a well-documented drawback of high capacity transport infrastructures (Ancies et al., 2016) that should be better accounted for in transport planning guidelines (Héran, 2011).

The ability to cycle is similarly affected and dependent on a number of additional factors: the availability of protected cycling lanes, the quality and safety of intersections, the speed of motor vehicles, the slope of roads, etc. More generally cycling must be safe and importantly perceived as safe (ITF, 2017b). The urban access framework currently only takes road slope into account in computing accessibility, since no reliable data can be found for the other factors at a pan-European level. Nevertheless, our results show that bike performance can vary from 0.25 (Lisbon, Genoa) to 0.8 (Bari, Malmo).

Figure 23. Neighbourhoods with low walking performance in Belfast

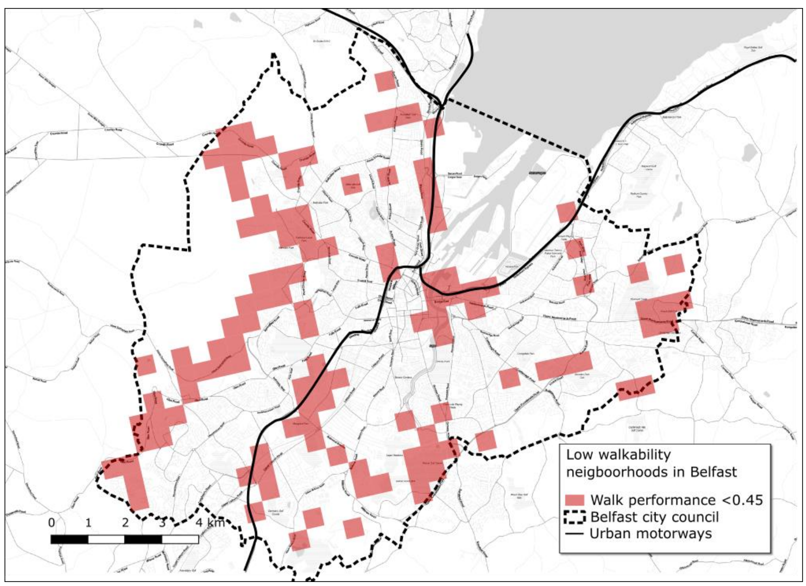
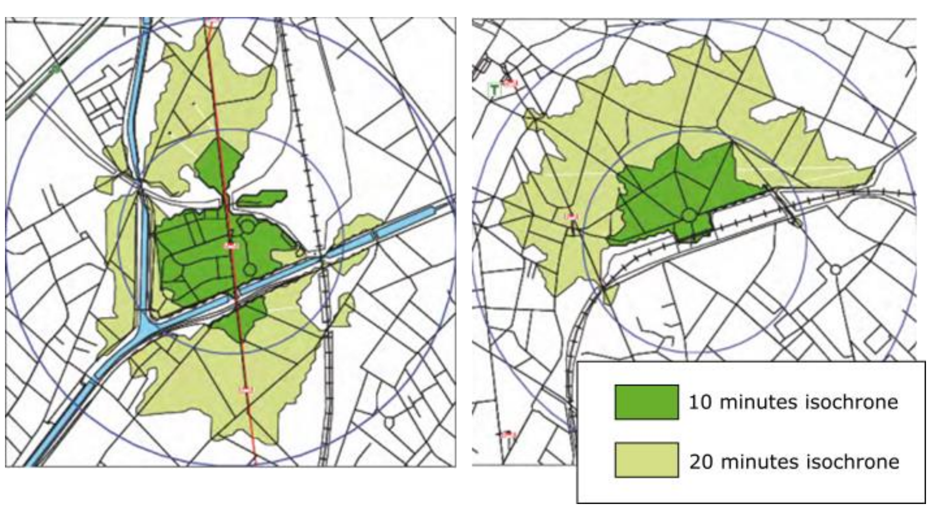


Figure 24. Walkability analysis in Lille



Source: Adapted from Héran (2015).

Accessibility in the commuting zone is always lower than in the city, but some commuting zones still perform well

Cities record the highest absolute accessibility levels. For every FUA, the city area always scores higher on the accessibility indicators than the commuting zone. This is easily explained. The city is by definition denser and concentrates more people and more destinations. The exception to this rule is green spaces, since many commuting zones have more and larger green areas, including forests. But FUAs vary greatly (Figure 25). As shown in the figure, commuting zones with the highest level of access by car can provide better access than most cities. Turin and Naples (Italy), Ruhrgebiet (Germany) and Porto (Portugal) all can provide their commuting zone inhabitants with access to more than 500 000 people. This level of accessibility is better than, for instance, the city dwellers of Bratislava (Slovakia), Bremen (Germany) and Bristol and Sheffield (United Kingdom). However, it cannot compare to the level of access to people that citizens of Athens (Greece), Madrid (Spain) or Paris (France) have – over 1.5 million.

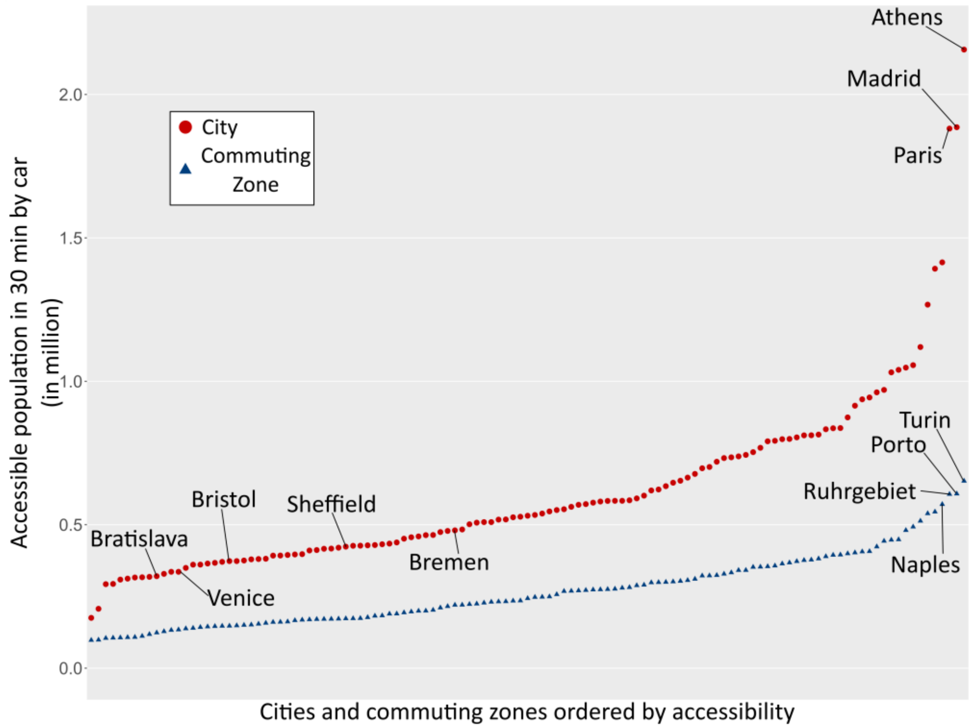
Table 9. Indicators used for the analysis of accessibility in inner cities versus commuting zones

	Categories used
Type	Absolute accessibility, Transport performance
Modes	Car, Public transport
Services	Population
Threshold	30 minutes
Geography	City and commuting zones

There are different reasons that make commuting zones perform well. For instance, Naples and Porto have very small commuting zones in terms of total area. The city of Naples covers 78% of the total FUA area, the city of Porto 67%. This allows people living in the commuting zone to reach the city, and therefore high numbers of people, relatively fast. The situation in Turin is quite different; about 50% of the total population lives in the commuting zone. The large number of people, combined with the better transport performance of peripheries allows inhabitants of the commuting zone of Turin to have high absolute accessibility to people within 30 minutes by car. Ruhrgebiet is a different case altogether. Ruhrgebiet is a conglomeration of cities, making it a polycentric FUA. Therefore many people living in the commuting zone (1.5 million) have access to multiple cities within a 30 minute drive.

Public transport also performs worse in the commuting zone. As one would expect, public transport coverage is spatially focused in cities, where 95% of all inhabitants can access the network. Among the 82 cities for which accessibility with public transport was computed, 73 provide access to at least 90% of their population. In the commuting zones of these cities, three out of ten people do not have access to the public transport network. The share of uncovered people in the commuting zones can vary greatly however. In 55% of all commuting zones (45 out of 82), public transport is provided to 90% or more of the population. The share of inhabitants covered decreases drastically in the remaining 37, with the bottom 12 covering less than 20% of their total population. In these urban areas, the public transport networks are likely planned to cover the cities and only reach the beginning of the commuting zone.

Figure 25. Absolute accessibility to people by car within 30 minutes in cities and commuting zones



The public transport performance for the covered population in the commuting zones is lower than in cities. The median value of public transport performance in the commuting zones is 0.25, 70% of the median value in cities (0.36). In the 90th percentile however, the difference between commuting zones and cities is smaller, only 15%. The top 10% performing areas in commuting zones have a public transport performance of at least 0.70, compared with 0.82 in cities. This points out how high speed and high capacity services, such as suburban rail, can provide commuting zone populations with quick access to the city.

Transport performance for car is much higher in the commuting zones. In European cities, due to lower speed limits and traffic, the average transport performance is 1. Even in the best performing cities, transport performance is 1.7. On the commuting zones on the other hand, lack of traffic allows cars to travel faster. The average transport performance is 2.43; more than double that of cities. The distribution of population in commuting zones also helps. As the nearby population is small, reaching additional people increases the transport performance quicker.

Even large European capitals can have low accessibility scores

Although accessibility to population is a useful proxy to start with, it imperfectly describes the spatial distribution of opportunities within a city. As argued previously, accessibility has several dimensions and, in this work, they are measured by a large number of indicators. A concise overview of urban access is a complex exercise. It is difficult to state that a given city has good accessibility *overall.* For example it might offer excellent access to schools on foot to its inhabitants while access to shops by public transport is low. Depending on the viewpoint, this city might be regarded as offering overall good accessibility if education is regarded as an absolute priority.

Table 10. Indicators used for the analysis of accessibility for large European cities

	Categories used
Type	Absolute Accessibility
Modes	Car, public transport and bicycle
Services	Schools, shops, hospitals
Threshold	30 min
Geography	FUA

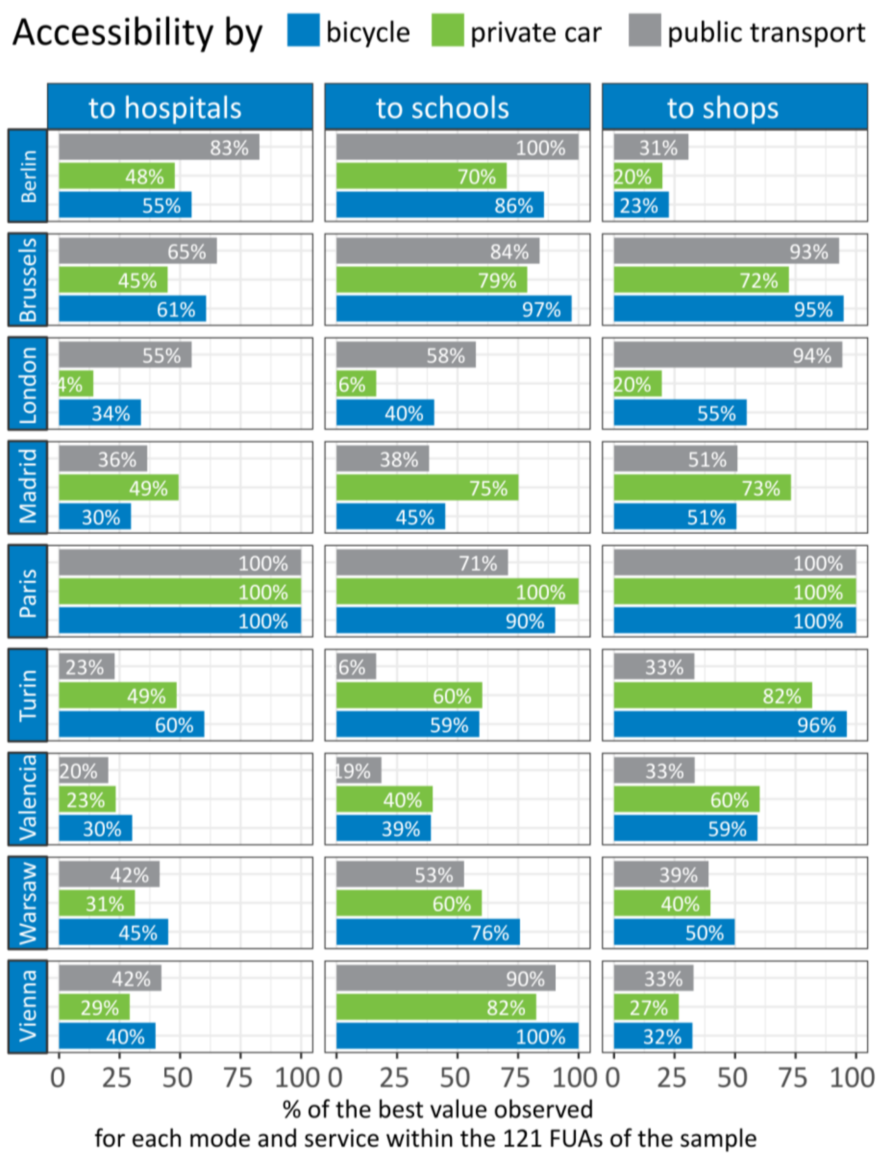
Some FUAs, mainly capitals, perform well for most services and most modes. Generally, if a FUA performs well in terms of access to shops by public transport it will also perform well in terms of accessibility to school by walking. In other words, accessibility indicators are strongly correlated. However, this is a tendency rather than a rule: even metropolitan areas that rank extremely well for most indicators might score low for some of them.

In particular, Paris, Madrid, Berlin, Vienna, Brussels, London, Turin, Valencia and Warsaw rank well in many dimensions. The analysis is limited to nine indicators: access to three destination types (schools, shops and hospitals) by three different modes (bicycle, private car and public transport) for a time threshold of 30 minutes. For more than half of the indicators considered, these FUAs are among the top 10%. Most are large capital cities. Large cities have a higher provision of services and are generally denser, yielding to higher accessibility values. While this reflects the effect of size on overall accessibility, the different indicators can lead to more meaningful insights.

Figure 26 depicts the nine indicators for these nine FUAs. It shows that, although having overall good accessibility levels, these metropolises still lag behind on certain dimensions of accessibility. In particular it shows that:

- Access to shops is low in Berlin, regardless of the mode. This is explained by a very low density of population that lives outside the city centre: there are only 280 inhabitants per km2 in Berlin's FUA compared to around 1 000 in London or Paris. Yet access to schools and hospitals is excellent, which reflects a high provision of public services.
- High accessibility is not reserved for capitals. Valencia and Turin offer good levels of accessibility to their inhabitants. In particular they score well in accessibility by bike: for instance population accessibility by bike in Valencia is 80% that of Paris. This is because Valencia's FUA is compact with only 20% of its inhabitants living in the commuting zone. On the contrary both Valencia and Turin tend to have low accessibility by public transport.
- London has low accessibility by private car while having excellent accessibility by public transport, regardless of destination. This is a consequence of a high level of congestion, reflecting legacy decisions not to build expressways in central London, and more recently the result of deliberate policies to reducing the share of road space dedicated to cars.
- Paris has a high score on nearly every indicator. This is the result of a combination of factors: a high population density, a well-developed network of urban motorways, a dense network of underground lines in its centre, a high provision of public services across the territory, etc. Yet as it will be shown later there is room for improvement in other aspects. For instance access to green spaces is low in the French capital.

Figure 26. Accessibility indicators for nine functional urban areas expressed as % of the best observation in the total sample



Access to services in European urban areas

In this section, the EU-ITF-OECD Urban Access Framework (UAF) was used to measure accessibility to destinations of a specific category such as services and amenities. Results for each service category are associated with a specific policy question. For each question, specific indicators are used to support the analysis, with assumptions and methodology summarised in a box.

Can you reach the hospital in time?

Having access to a hospital can be critical, particularly in the event of an emergency, when even a few extra minutes can be crucial. There have been studies (Pell et al. 2001), statistics and multiple news stories (The Guardian, 2017) that show the consequences of a delayed response on survival rates. To avoid these consequences, the NHS in the UK sets their response time target for all high emergency calls to 15 minutes. Similar targets are common across OECD countries. Although there are many factors that can determine whether a patient will get the appropriate treatment in time, transport barriers are often cited as major factors contributing to the unmet health-related urgent needs.

The importance of universal access to emergency care is evident in the good coverage that is provided in Europe's metropolitan areas. About 97% of the population living in FUAs can reach a hospital within 30 minutes. In the densely populated central cities of the metropolitan areas, the coverage is universal (99.5%). Even in the city with the lowest score, the share of population that can reach a hospital within 30 minutes is 95%. The situation is also very good in commuting zones, where 92% of all inhabitants can get to a hospital within 30 minutes. Average numbers, however, can hide disconnected neighbourhoods within cities or in the commuting zones.

For example, the per cent of commuting zone inhabitants with access to a hospital in Sofia is the lowest in all of Europe (40%). Lisbon has similar performance, with one out of two persons unable to reach a hospital within 30 minutes. The situation is slightly more favourable in Tallinn and Bucharest, where 72% and 78% of the population can reach a hospital by car within 30 minutes. In contrast, all residents of Ghent and Glasgow can reach a hospital within 30 minutes.

The shares of people with or without access can be translated into the average number of hospitals that residents can reach, which facilitates deconstructing accessibility into its components, by using the framework. The average inhabitant of Lisbon's commuting zone can reach only one hospital, while someone in Sofia can reach two. These values are much lower than in Tallinn where the absolute accessibility is 5.5 hospitals or in Bucharest where it is 7.7 (Figure 27). At the upper end, a person living in the commuting zone in Glasgow or Ghent can reach 10 and 13 hospitals respectively within 30 minutes. The European-wide commuting zone average is 8.7 hospitals. It is worth pointing out that the four commuting zones that perform below average are all national capitals. Capitals tend to have larger capture areas and commuting zones that include other smaller towns. These towns, being in close proximity to the capital city, are highly depended on services of the city, especially for big regional amenities like hospitals. If they were located in a different setting, their size would likely warrant a hospital of their own.

High proximity to hospitals is more important than good transport performance

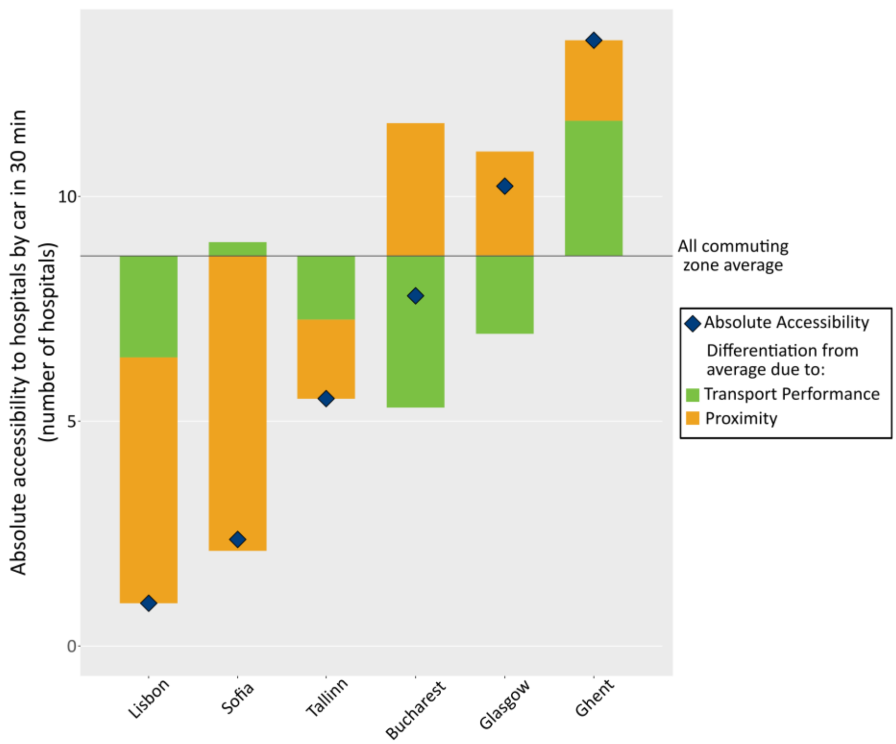
What supports access to health care services in the commuting zones? The study reviewed this for six European FUAs; Bucharest in Romania, Ghent in Belgium, Glasgow in the United Kingdom, Lisbon in Portugal, Sofia in Bulgaria and Tallinn in Estonia. In two, out of the six metropolitan areas, commuting zones provide sufficient access levels to hospitals for everyone in the commuting zone, whereas the other four have large gaps. To understand what drives the differences in access to hospitals, the gap is broken down into the proximity and transport performance using the framework.

In three of the four FUAs with below-average access, it is the distribution of the population and the lack of proximity that accounts for the largest part of the gap (Figure 27). In Lisbon and Sofia, the performance of the transport network compounds the challenge that the spatial structure of the FUA poses. The underperformance of the road transport network in Lisbon reduces the number of hospitals that can be reached by about two compared to the EU average, while the lack of proximity of residents accounts for the remaining six. The gap for Sofia is due equally to transport performance and the low proximity.

Bucharest stands out among those with low levels of access to health services in the commuting zone as the underperformance of the transport system negates the benefit that the spatial structure of the FUA provides. With a transport system that would perform at EU-average levels, residents in the commuting zone of Bucharest would actually have more access than the average resident in an EU commuting zone. Glasgow faces a similar situation. It is only because of the relatively high proximity between the place of residence of people in the commuting zone and the hospitals in the FUA that the accessibility is above average; transport performance contributes negatively.

In Tallinn and Ghent the above EU-average efficiency of the transport systems provide a positive contribution to access to health services. Gent’s transport system provides access to 3.9 additional hospitals compared to the EU average, which ranks among the top 15% of transport performance in the commuting zone of European FUAs. This amplifies the positive impact that is produced by the high proximity to hospitals in Ghent.

Figure 27. Absolute accessibility to hospitals by car and the effects of transport performance and proximity



Absolute access to hospitals in Europe

This section does not evaluate response times of emergency services; but rather examines differences between the average time it takes to reach a hospital in Europe by car and the share of people that do not live within a reasonable travel time from at least one. It can help identify issues with emergency response, but is more directly relevant to hospital visits for the friends or family of patients and access to non-emergency services in hospitals.

The average travel time to a hospital by car in Europe is less than 14 minutes. This value reflects the door-to-door travel time an average inhabitant of European FUAs needs to reach the nearest hospital. Across Europe, this value ranges from just less than ten minutes in Athens, Greece to twenty-two minutes in Linz, Austria. Figure 28 shows the average travel times in all FUAs. The FUAs with higher than average travel time are mostly located in the Eastern and Northern Europe, but some cases can be found in the United Kingdom and on the Iberian Peninsula. In cities, the average travel time drops to less than 12 minutes, with a minimum of seven and a half minutes in Brussels, Belgium and a maximum of close to 19 minutes in Stockholm, Sweden. In the commuting zone, there are multiple cases with an average travel time of 25 minutes or more, with Sofia, Bulgaria having the maximum (30 minutes). Nevertheless, the average travel time for all commuting zones is not high in comparison to average times in the central city (16.5 minutes).

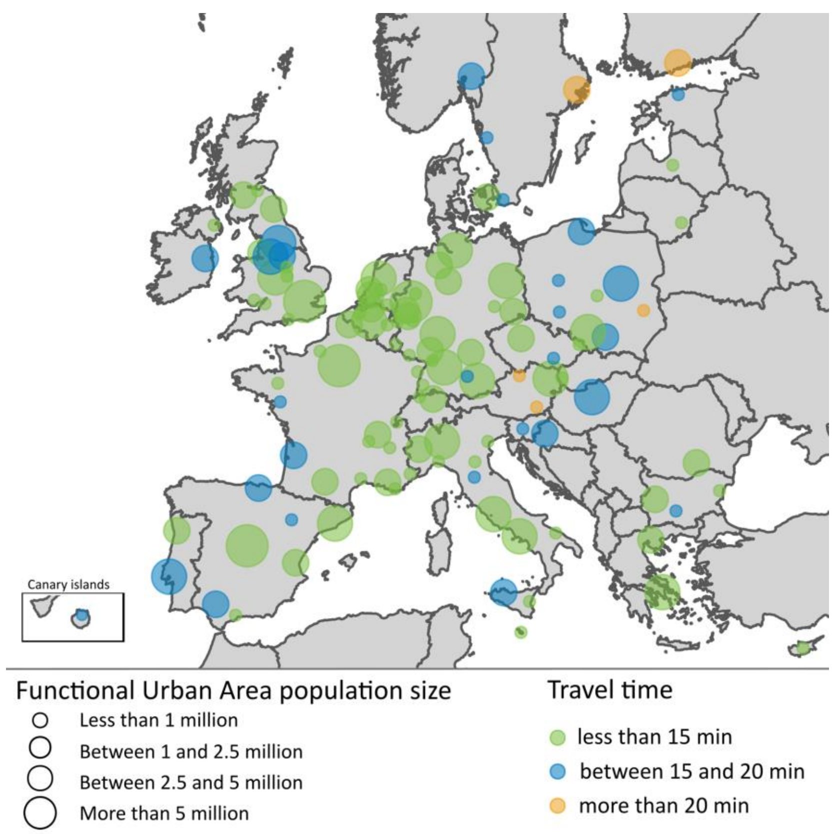
Box 3. Methodology and assumptions

Hospitals include all public or private facilities that are characterised as hospitals in European FUAs. The source of the location data of hospitals come from open/crowd sourced data. To avoid counting the same hospital multiple times due to naming mismatches or other issues, an upper limit of four hospitals per 500 m x 500 m grid in the commuting zone. Access to the nearest hospital by car in 30 minutes is computed door-to-door and includes access and parking time (up to 15 minutes total).

Average travel time to a hospital by car is estimated as follows:

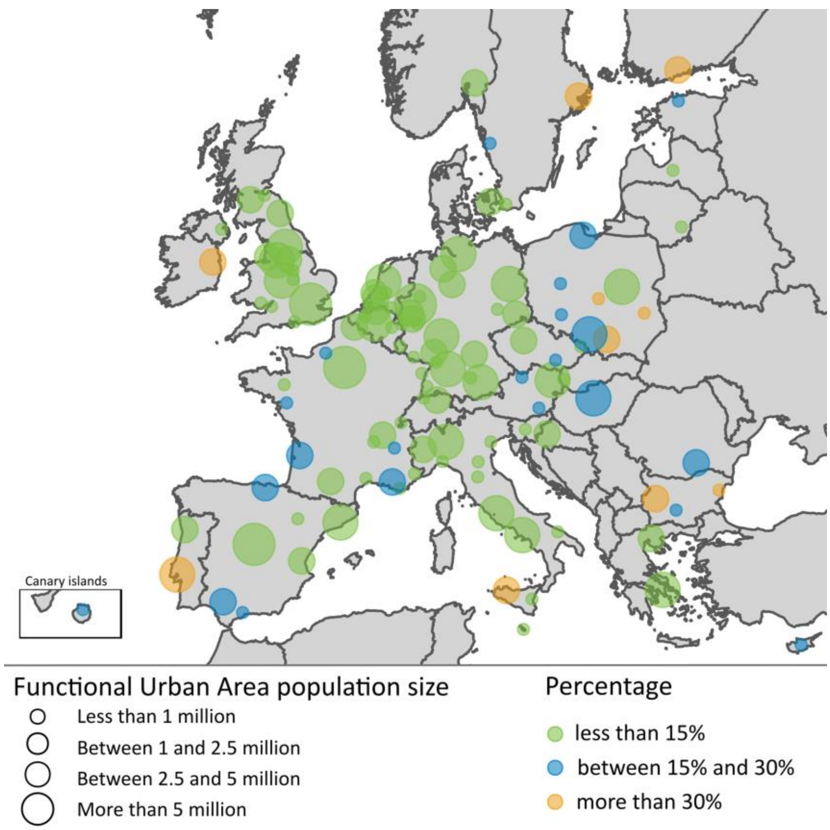
- First the share of total population that can reach a hospital in 5 minutes is computed.
- The share of additional population that can reach a hospital in 10 minutes is computed.
- This process is repeated for every 5 minute interval until 60 minutes. Any remaining population is considered to have access within 60 minutes.
- The share of population for each time segment is multiplied by the time.

Figure 28. Average travel time to the nearest hospital in European Functional Urban Areas by car



The urban access framework is flexible enough to model access within different parts of the city and allows for different degrees of congestion to dive deeper into accessibility within cities. But since the Framework focuses on benchmarking across a large number of urban areas the results should of course not replace detailed local analysis. Nonetheless, there seem to be some gaps in access to health care services in the commuting zones of some European metro areas. In total, 5 million Europeans who live in commuting zones cannot reach a hospital within 30 minutes (Figure 29). Particularly in commuting zones in Eastern and Southern European metropolitan areas, a significant share of the population (30% or more) cannot reach a hospital within 30 minutes by car.

Figure 29. Inhabitants of commuting zones without access to at least one hospital in 30 minutes by car



Can European students go to school alone?

Appropriate access to education via schools is essential. Every day, millions of students need to go to school and when it cannot be reached timely by other modes they depend on their parents. Numerous studies have examined the consequences of car-dependent access to schools:

- Active modes of travel to school can help reduce obesity rates (Janssen et al. 2005, Lubans et al. 2011)
- Parents may be forced to choose between professional and family priorities (Audrey, 2016)
- Mothers often take a disproportional weight of unpaid child-related burdens and that includes taking them to school (OECD/ELS 2016).

Non-car access to schools is less of an issue in metropolitan areas yet there is room for improvement. Overall, eight out of ten primary school and six out of ten high-school students can walk to school within

15 minutes. Cities, being denser and more concentrated have better coverage of schools in walking distance. In total, 3 out of 4 students can walk, and 19 out of 20 can bike to a high school in less than 15 minutes. In the commuting zones, walking to school is not an option for almost 40% of primary schools students and 65% of high-school students. This is where the role of public transport in serving students becomes essential. In FUAs where public transport data information is available, the share of students that can go to school alone increases on average by 25%. Nonetheless, even with public transport services, more than three out of ten high-school students in the commuting zones are dependent on car travel.

In a similar manner with the previous section, these shares can be translated into average number of schools that residents can reach, which allows breaking down accessibility into its components, transport performance and proximity. For example in the commuting zone of Helsinki, the average inhabitant is able to reach 74 schools in 30 minutes by public transport, a value that is among the top ten in Europe. In Belfast or Toulouse on the other hand, a person can reach only five and ten schools respectively. The European wide commuting zone average is 28 schools.

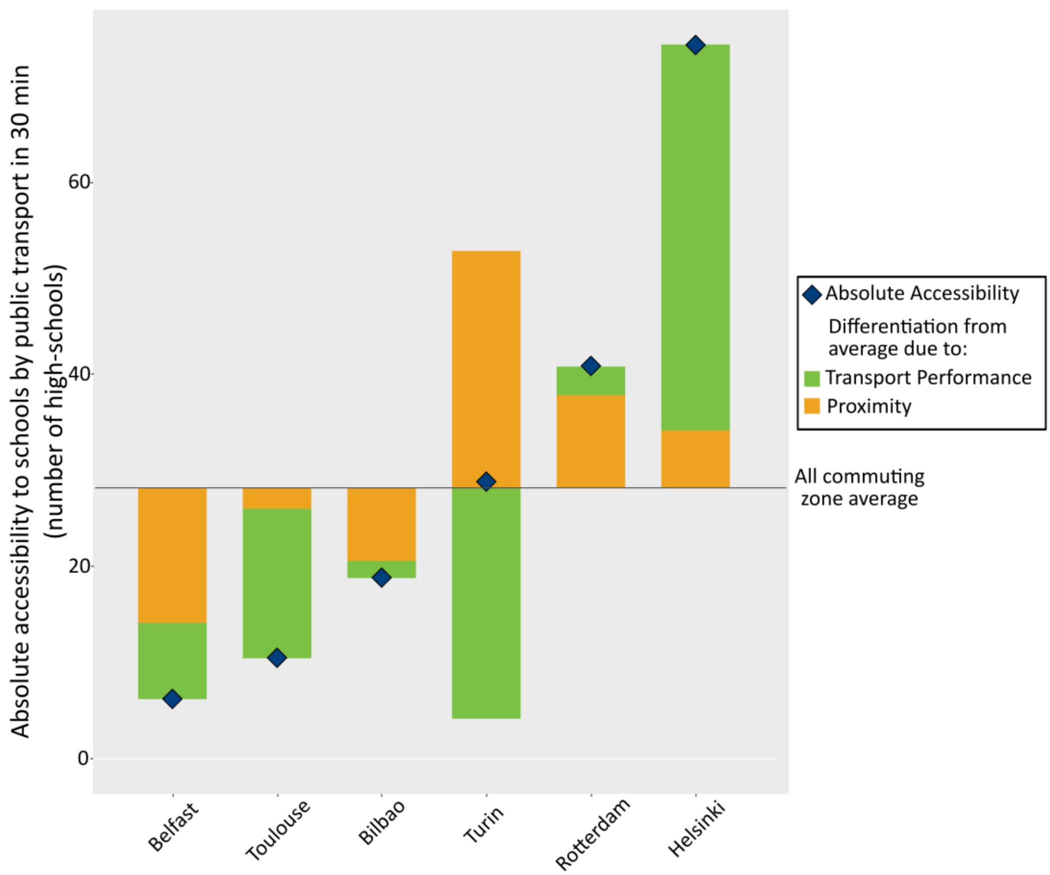
The public transport performance is the driver of accessibility to schools

Comparing FUAs where accessibility to schools has been computed for public transport with FUAs where public transport information was not available would lead to skewed results. Therefore, for the remainder of this section, the analysis will focus on cities where public transport accessibility was computed. Six European commuting zones are selected to demonstrate the effects of proximity and transport performance in absolute accessibility to schools: Toulouse (France), Belfast (UK), Bilbao (Spain), Helsinki (Finland), Rotterdam (The Netherlands) and Turin (Italy).

In each of the six commuting zones there is a share of high-school students whom cannot reach their school by public transport within 30 minutes. In the cases of Rotterdam and Turin this share is very small, only 5% and 12% respectively, whereas in Bilbao (34%) and Helsinki (45%) this per cent is higher. In the two under-performing cities, the majority of students cannot rely on public transport. Only 28% of high-school students are able to reach their school within 30 minutes by public transport in Toulouse and only 13% in Belfast.

The absolute accessibility indicator for a 30 minute public transport ride is used to evaluate these commuting zones. The values of the indicator are compared with the European average and the difference is decomposed into the two other indicators, proximity and transport performance. This process identifies the relative effect of the two indicators in driving absolute accessibility above or below the average. Figure 30 demonstrates these effects.

Figure 30. Absolute accessibility to schools by public transport and the effects of transport performance and proximity



The ranking of the cities in terms of absolute accessibility is similar with the one for the share of students with access a school by public transport. The only notable difference is Helsinki, which has by far the highest absolute accessibility; and yet provides access to high-schools by public transport to only 55% of its students. This is explained by the fact that Helsinki is a capital city. Capitals generate higher economic activity and as such have people commuting from larger distances, creating a larger commuting zone. Larger commuting zones are more likely to have gaps in public transport coverage.

High accessibility can be the result of a good transport system, high availability of nearby destinations, or a product of both. The commuting zone with the highest absolute accessibility score amongst the selected six is Helsinki. The average inhabitant there can reach 70 schools, compared with the 28 for the average European. This very good performance is a result of Helsinki's transport system. The commuting zone of Helsinki has a transport performance of 0.68 which is the best of all European commuting zones. The European average is 0.29. The proximity indicator is also above average, in the 60th percentile – 109 to 97. An interesting contrast with Helsinki is Turin. The proximity indicator in the commuting zone of Turin is in the 95th percentile, with 211 schools in an 8 km radius. In most cases, this would push the absolute accessibility very high, but the transport performance of the commuting zone of Turin is extremely low. With a transport performance score of 0.13, the absolute accessibility score is 29, barely above average. Rotterdam finally has a commuting zone with a high accessibility to schools, powered by both transport and land use. The transport performance of public transport in Rotterdam is 0.31 and the proximity indicator is 128, both above average.

On the other end, low accessibility can be also attributed to either dimension. Toulouse has a slightly below average proximity score of 86, but with a very low transport ratio of 0.13. As a result, the average inhabitant in the commuting zone of Toulouse can only reach ten schools in 30 minutes by public transport. The opposite is true for Bilbao. The transport performance is just below average, but the lower proximity leads to an accessibility score of 18. Lastly in Belfast, a person living in the commuting zone can reach on average only six schools. This score ranks on the bottom 10% amongst all European cities with public transport. This low accessibility is caused by poor performances in both transport and land use dimensions.

Box 4. Methodology and assumptions

In the amenity category, schools include all educational facilities from pre-school to post-secondary, excluding universities and other tertiary facilities. A probabilistic approach is used to separate primary, secondary, and other levels of education. The total school numbers of several European countries were sampled. On average, 50% of the total number of schools is primary schools and 25% is secondary schools. Therefore, to have access to a primary school, access to at least two schools is required; for high schools, access to at least four schools is necessary.

This approach does not guarantee that one of the four nearest schools will be a secondary-level school, or that it is the facility where a student is enrolled. All estimations in this work reflect the access levels of the average person.

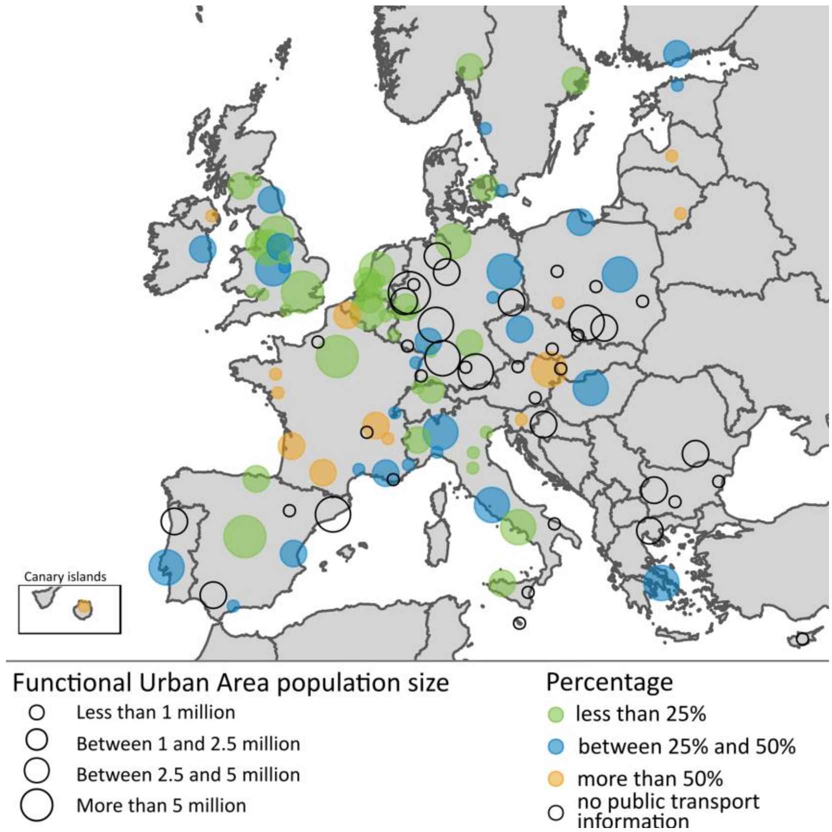
All travel times in this analysis are computed door to door and as such certain assumptions are made (see Methodological Annex for more information).

A school is considered accessible by a given mode when travel time is less than:

- 15 minutes on foot
- 15 minutes by bike
- 30 minutes by public transport

The average household size in Europe has 2.3 members, (Eurostat): https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Household_composition_statistics#Household_size

Figure 31. Inhabitants of commuting zones without access to a high-school by public transport in 30 minutes or walking in 15 minutes



Can non-commuting trips be done on foot?

In Europe two out of three trips are non-commuting trips with varying purposes and destinations (shops, restaurants, recreational activities or other). These destinations are spread throughout the urban areas, but they are more concentrated in cities. For any trip, regardless of destination, a shorter travel time is preferred to a longer one. It can be argued that one of the driving forces behind the formation of cities was the cost of travel. Cities are formed in order to bring people and activities closer and reduce transport related costs. Throughout history, people in cities were able to reach desired destinations faster and easier than people living on the periphery of metropolitan areas. The development of faster transport modes (among other things) facilitated the growth of cities by further reducing travel costs. Even today, in the era of the automobile, having destinations in close proximity and walking distance is considered a desirable characteristic. Being able to walk to your destination is associated with many benefits:

- It increases the levels of physical activity. Walking is associated with multiple health benefits.
- It reduces the carbon footprint of an individual and a city. Walkable cities have reduced CO^2 emissions from transport (Frank et al. 2006).
- Studies have associated the ability to walk to your destinations (walkability) with higher quality of life (Jaśkiewicz and Besta, 2014.

- Increases the attractiveness of the city for residents and tourists

The ability to make non-commuting trips on foot can improve quality of life and reduce transport emissions significantly. To address this issue, walking accessibility for non-commuting trips in Europe was evaluated using the Framework. What level of access is considered good enough? Is reaching a minimum number of destinations enough for these categories? Is there an added benefit from having a high variety of choice? To examine both angles, two levels of accessibility were proposed:

- A minimum basket of services
- A high variety of options

Box 5. Methodology and assumptions

Non-commuting trips include trips to restaurants, food shops, and recreational activities. The last category includes theatres, museums, cinemas, stadiums and tourist and cultural attractions.

To be able to reach a minimum basket of services on foot a person must be able to reach:

- three restaurants within 30 minutes
- five food shops within 30 minutes
- two recreational activities within 30 minutes

To have a high variety of options on foot a person must be able to reach:

- ten restaurants within 30 minutes
- twenty food shops within 30 minutes
- five recreational activities within 30 minutes

In principle, non-commuting trips include trips to other destinations such as family or other services that are not captured in this group. Still if a person is able to reach this selection of destinations within 30 minutes it is very likely that they will be able to reach most of the other destinations.

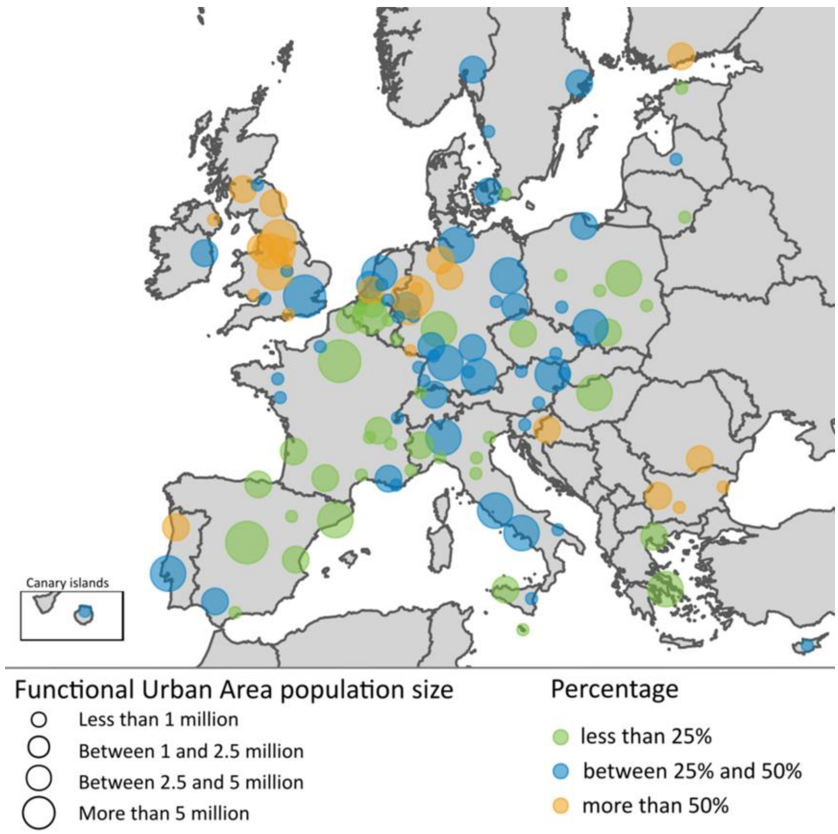
For a walking trip of 30 minutes, the equivalent proximity indicator is of a 2 km radius.

The two categories address different dimensions of whether Europeans can do their non-commute trips on foot. The first group, *a minimum basket of services*, is a compilation of a minimum number of amenities that are necessary for everyday life. Someone with this level of access is able to cover some of their basic needs with a short walking journey. The second group, *a high variety of options*, requires a higher number of locations in each category. With this level of access, a person is not limited to the minimum of options nearby. They have instead a wider range of choices for each amenity category located a short walk away. This section will examine the share of population that has each level of access in Europe. The analysis will focus only on selected cities, since walking accessibility and the concentration of amenities in the commuting zones is generally much lower.

Only 66% of Europeans who live in cities can reach a minimum basket of services on foot. In some cities, everyone has this level of access, but in the worst performing European cities only one in four inhabitants can reach this minimum basket of services on foot. Figure 32 shows the per cent of people in

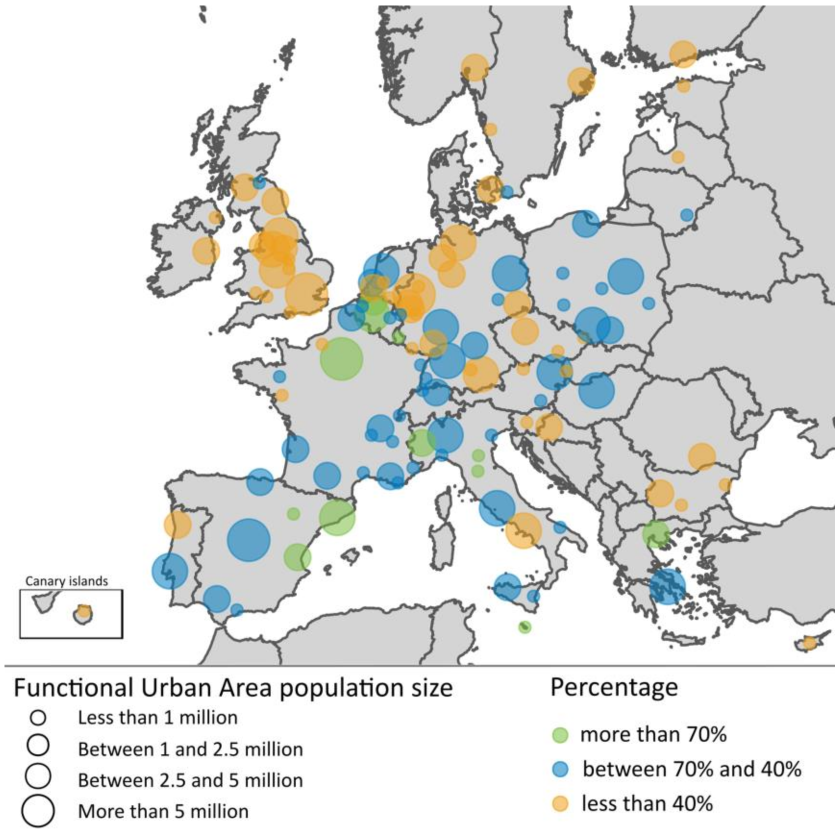
European cities that cannot walk to this basket of destinations. The low performance of the United Kingdom really stands out, along with the medium/low performance in most German cities. Overall, cities in Mediterranean countries, Poland and Belgium give a basic level of access for non-commuting trips to most of their inhabitants.

Figure 32. City inhabitants without a minimum basket of services on foot in 30 minutes



Four out of ten Europeans who live in cities have a high variety of options. Access to a minimum basket of services ensures that a person can do non-commuting trips on foot. Having walking access to more destinations gives Europeans a higher variety of choice. The per cent of inhabitants that have access to a high variety of options on foot ranges from 90% in Barcelona and Antwerp to 10% in Brno and Liverpool. Figure 33 shows the per cent of people in European cities that have a high variety of options for non-commuting trips by walking. A big share of the population with this level of access is mostly encountered in cities in Southern Europe and some big cities in Western Europe. In contrast, cities in Northern and Central Europe, the United Kingdom and Germany do not provide a high variety of options to their inhabitants.

Figure 33. City inhabitants with a high variety of options for non-commuting trips by walking in 30 minutes

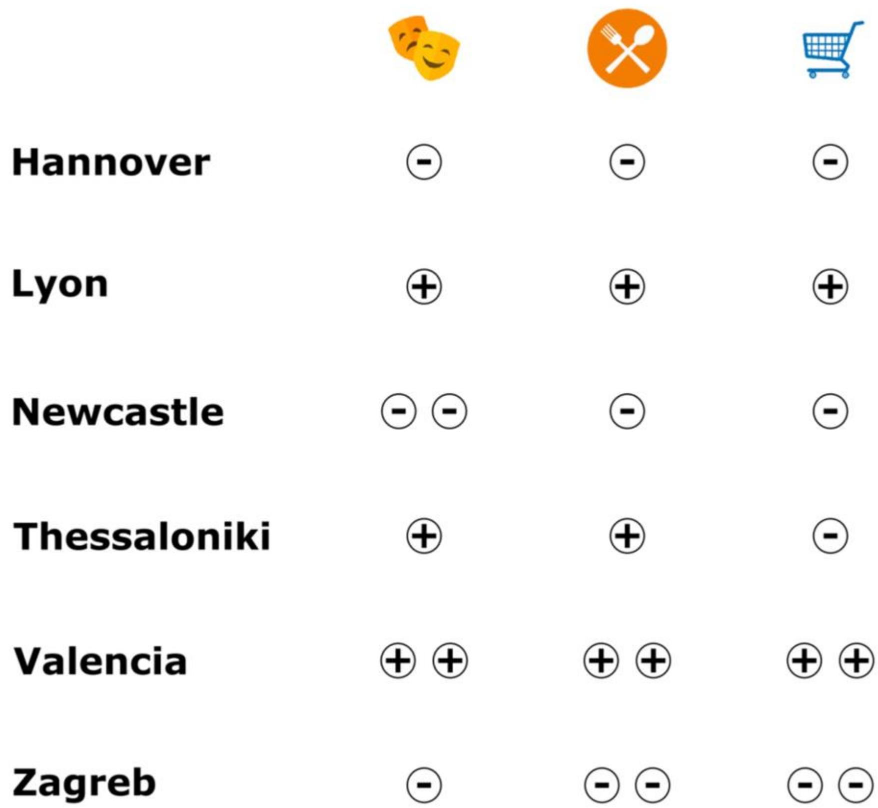


High proximity to multiple destinations is key

Walking accessibility depends mostly on factors associated with land use and density of destinations. Access by walking is computed using a fixed speed; therefore transport performance has very low variability between cities. This leaves proximity as the main indicator that drives accessibility. Amongst European cities, the average number of accessible destinations in each category varies greatly. The best performing cities in each category offer a lot more options to their inhabitants. The ratio between the lowest and the highest performance for restaurants is 55, for recreational activities 34, and for food shops 80. Some cities perform well in one category and poorly in another, and as such score badly in providing access to a basket of services. Figure 34 summarises scores on the proximity indicator for a range of services in some under- and over-performing cities. These are: Zagreb (Croatia), Newcastle (the United Kingdom), Hannover (Germany), Thessaloniki (Greece), Lyon (France) and Valencia (Spain). The signs of the infographic are as follows:

- “- -“ for a performance between 0 and the 25th percentile
- “-“ for a performance between the 25th and the 50th percentile
- “+“ for a performance between the 50th and the 75th percentile
- “+ +“ for a performance between the 75th and the 100th percentile

Figure 34. Relative performance of the proximity indicator in each category



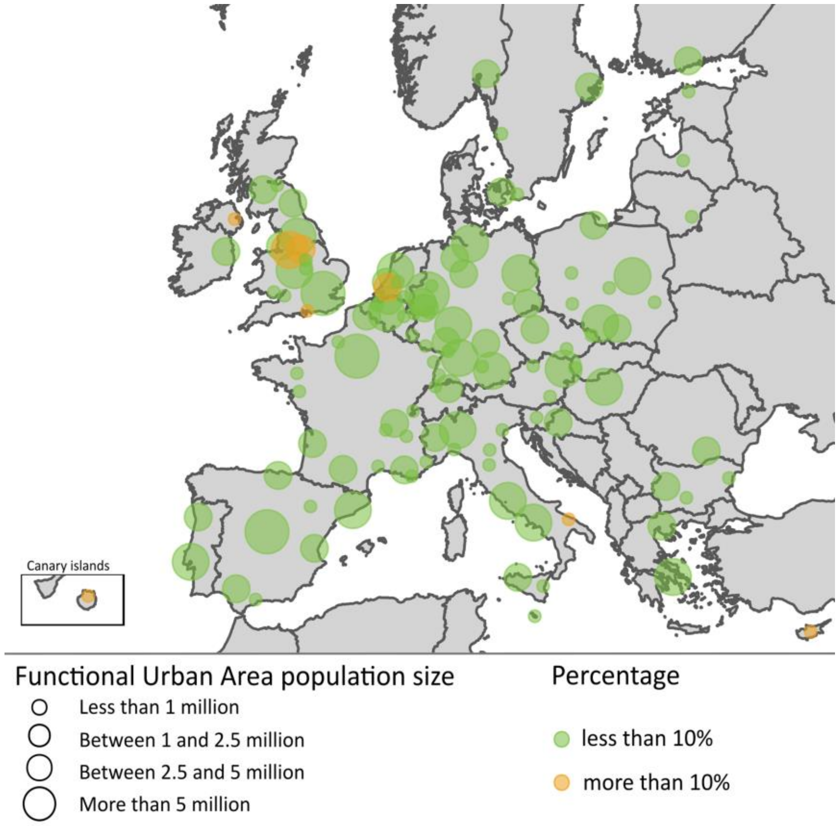
Note: First category is recreation, second restaurants and third food shops.

Can you ride to a park?

In the European cities examined, 97 out of 100 people can ride a bicycle to a park within 15 minutes. Access to green spaces is often considered one of the important factors of city liveability and quality of life. Large green urban areas break the urban continuum and provide an area where people can relax or do sport. Figure 35 shows the proportion of inhabitants that are not able to reach 1 hectare (10 000 m^2) of green space within a 15-minute ride by bicycle. In the majority of the European cities selected for this study that percentage is below 10%, with some underperforming FUAs located in Southern Europe, the Netherlands and the United Kingdom.

The European Commission Directorate for Regional and Urban Policy published a work on this subject a few years ago, measuring access to green spaces in European urban areas (Poelman, 2016). They measured the population-weighted median surface area of green spaces that Europeans can reach within 10 minutes on foot. The results found that the majority of European cities are able to provide most of their inhabitants with a basic access to green space; and that in many cities people are able to reach large green spaces within a short walking distance. No statistical correlation was found however between the total amount of green space in an FUA with the level of accessibility to green spaces. This indicates the variable nature of this amenity category, which does not follow a distribution pattern similar to the other amenities examined. To further advance research on the subject of accessibility to green spaces, this section will focus on a different mode – cycling.

Figure 35. Inhabitants of the functional urban area without access to one hectare of green space within 15 minutes by bike



Only 2.5% of all Europeans that live in urban areas cannot ride a bicycle to a hectare of green space within 15 minutes. This figure is lower than the same one for walking, and is replicated for each urban area individually. This is an expected result as one can travel much faster by bicycle, despite difficulties that can arise from road slope and travelling on roads with heavy traffic. Surprisingly, the share of people living in cities that can access a hectare of green space (99%) is higher than the commuting zone (94.5%). One would expect commuting zones, being much less dense and spread apart to have more access to dedicated green space. This can be attributed to two factors. The first is that green spaces are less of a policy priority outside the cities. Most people in the commuting zones live in houses with gardens with natural green spaces and forests nearby, albeit not in the direct vicinity. The second factor comes from the definition of green space assumed in the analysis. Only green urban spaces and forests were considered, excluding pastures, farmland, and other types of land use which are common in commuting zones. These areas definitely make commuting zones greener, but are privately owned. In any case, the lowest share of access to green spaces in any urban area by bike from within the selected cities for the study is around 80%, and that is found on a volcanic island with steep slopes, Las Palmas, Spain.

In terms of absolute accessibility, the average cyclist in Europe can cover 2.5 km^2 within 15 minutes and over 11 km^2 within 30 minutes. The same coverage for 15 minutes, however, ranges from 0.2 km^2 to over 5 km^2 and between 0.4 km^2 and almost 30 km^2 for 30 minutes. The lower-end values are in Valletta, Malta and Las Palmas, Spain which are both islands with dense cities. Excluding these two, most low-performers are found in Southern Europe and the United Kingdom, with absolute accessibility to green spaces within 15 minutes above 0.5 km^2. Urban areas with high accessibility scores on the other hand are found in Germany, Poland, and Northern Europe. These results are very much in line with the green share of the urban area, as demonstrated by the European Commission (Poelman, 2016).

Is public transport inclusive?

Since the 1970s, policies have aimed at making public transport affordable to poor households in most European cities (Faivre d'Arcier, 2012). Better accessibility by public transport is recognised as a lever to improve access to opportunities for deprived neighbourhoods and has been shown to be crucial for upward economic mobility. For instance, Chetty, Hendren and Katz (2016) have shown that shorter commuting time is the strongest factor in the odds of against escaping poverty. Public transport brings wider social benefits through providing better access to services and opportunities to disadvantaged groups and thereby promoting social equity.

How well do transport systems contribute to social objectives? How does accessibility by public transport vary with income levels? To explore this, a case study on selected French cities was conducted. The relationship between accessibility to shops within 30 minutes, here chosen as proxy to the overall access to amenities, and average income is examined (Box 6).

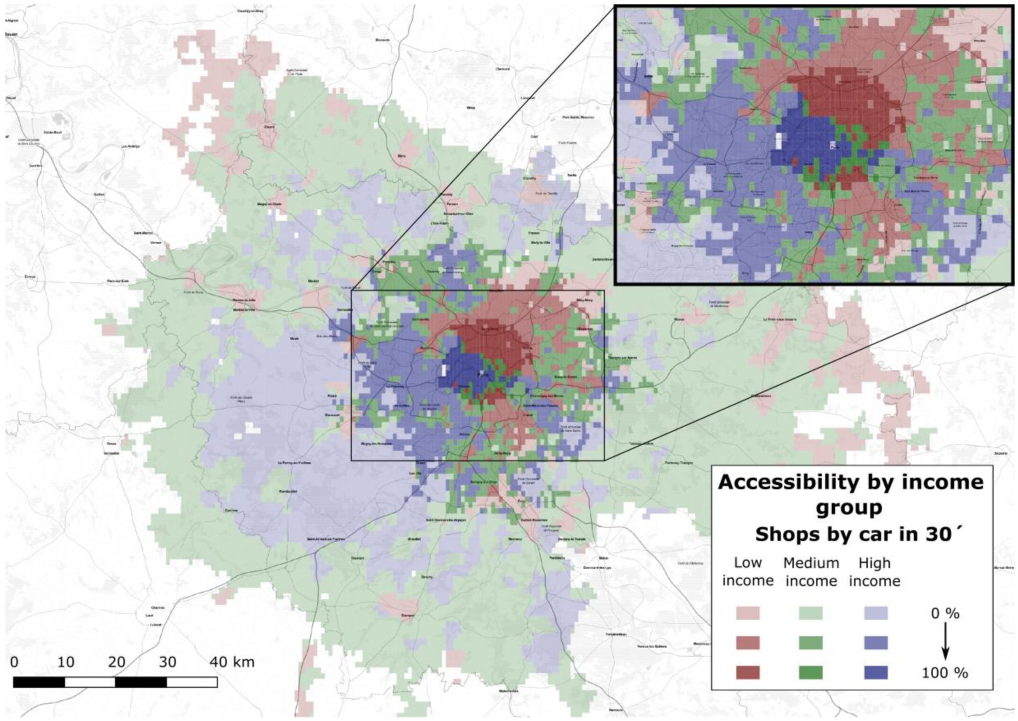
Public transport in Paris provides higher levels of accessibility to high-income areas

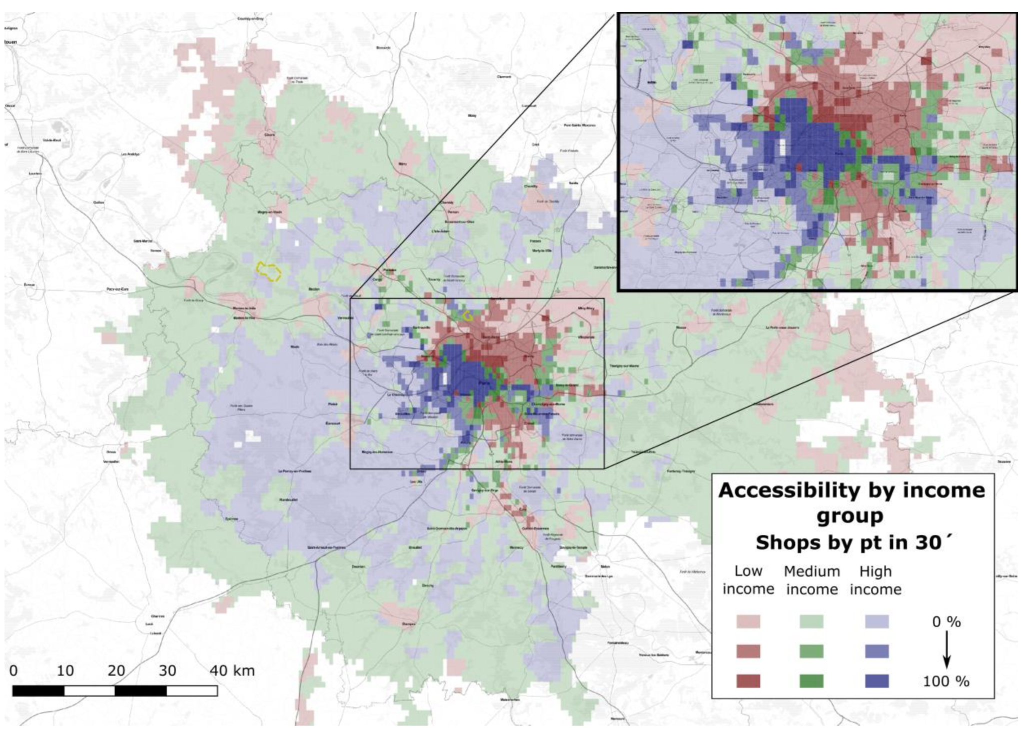
In Paris' FUA, there is a correlation between income and accessibility by public transport: the higher the average income of a neighbourhood, the higher its accessibility. Wealthier income groups enjoy accessibility levels that are three times higher than medium and low income ones. In particular the northeast suburbs, where the great majority of the population with lower income live are badly served by public transport (Figure 36). On the contrary, the city centre (municipality of Paris) and the south and southwest suburbs are mostly inhabited by people with higher income well-served by public transport.

This is a result of the urban evolution of the city during the 20th and 21st centuries, with land values rising, especially in areas with good transport connections, effectively pushing low income residents further out. At the same time, people with a medium income that couldn't afford to live in the city centre, moved even further out, where they could take advantage of lower land values. This evolution over decades highlights the importance of continuity in policy making and the multidimensionality of such issues.

Surprisingly, accessibility by car is not correlated to income. Lower income neighbourhoods are well served by urban motorways. This has to do with the fact that high income suburbs are usually less dense.

Figure 36. Accessibility to shops in Paris by income group by car (top) and public transport (bottom)





Box 6. Evaluation of average income at the neighbourhood level

The smallest geographical level that the French National Statistics Institute publishes data on is called "Ilots Regroupés pour l'Information Statistique (IRIS)" –"aggregated units for statistical information", and the target-size per basic unit is 2 000 inhabitants. At a maximum this can be the size of a municipality, but that is mostly observed in rural areas and not in the case of FUAs. To create an income vs. accessibility analysis IRIS data was aggregated and joined with the spatial grid that is the basis of the accessibility analysis. The income levels in each city are split into three groups with an equal count of observation in each: low, medium, and high. Accessibility indicators for each group are then compared with the absolute accessibility scores in each grid.

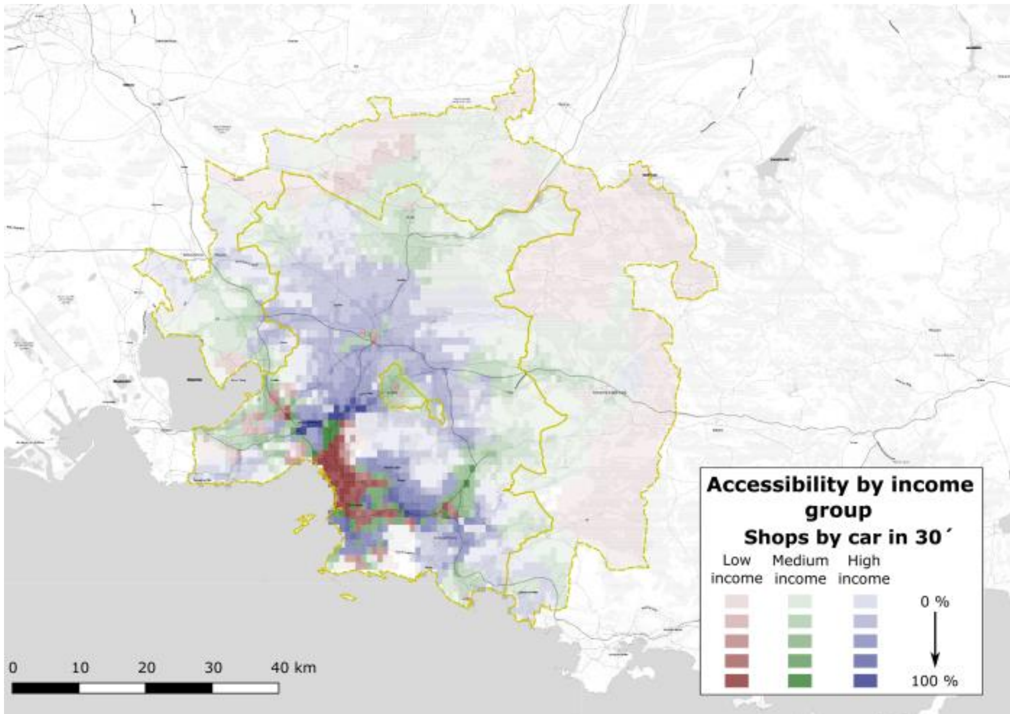
French cities have different accessibility patterns

The city of Paris does not always reflect how other French urban areas perform in terms of accessibility and income. Some large cities have more inclusive transport systems in the sense that the correlation between accessibility and income is weaker or can even work in the opposite direction.

Marseille, the third biggest FUA of France has a very different structure. The city centre is a location where mainly people with low income reside. Middle and high income inhabitants live in the surrounding areas north and east of the city centre. However, in the FUA definition, all of these areas are included in the city. When examining accessibility to shops in Marseille (Figure 37), this structure leads to higher access levels for people with low income living in the city centre. This is even more noticeable in accessibility by public transport.

Another example of how population is spread across a FUA is Rennes. Rennes, a medium-sized French FUA, has a much more circular structure in terms of the income levels of the inhabitants. Beyond the city centre, where a mix of people with all levels of income reside, a ring of high income population can be found; followed by a ring of medium income, before finally reaching an outer ring of low income. In terms of absolute accessibility to shops by car, this translates to the city centre having the highest levels, and then the ring of high income inhabitants. As can be expected, the further from the city centre the lower the accessibility. Absolute accessibility by public transport on the other hand is only relatively high in the city centre and in corridors along the first ring, reaching only high-level income neighbourhoods.

Figure 37. Accessibility to shops in Marseille by income group by car (top) and public transport (bottom)



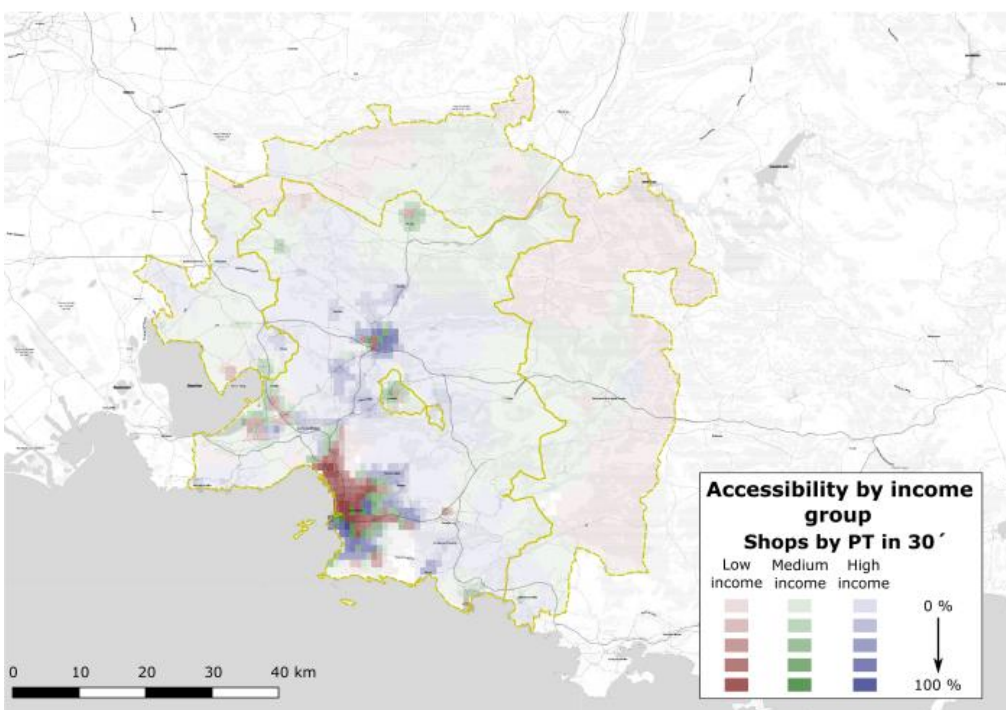
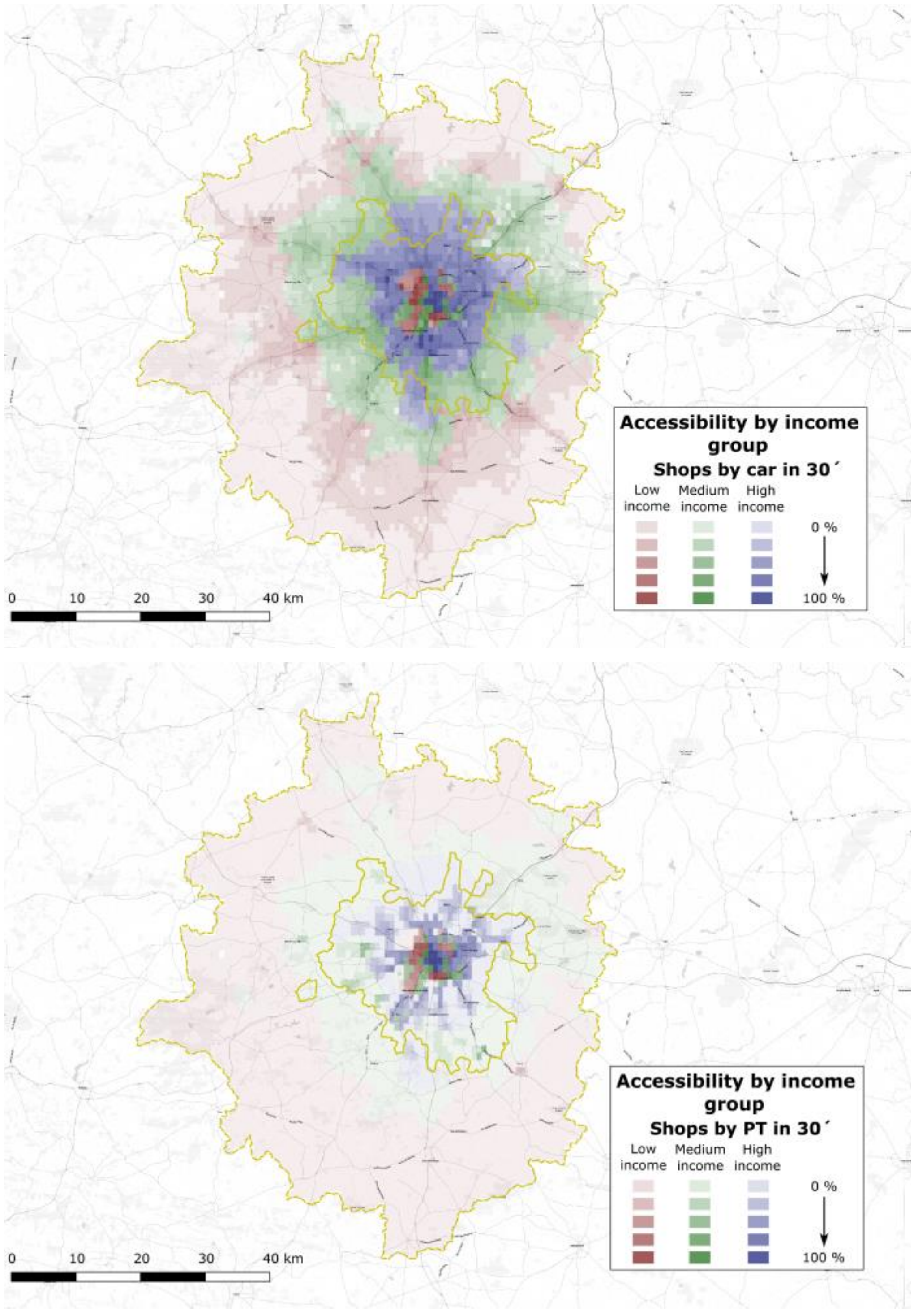


Figure 38. Accessibility to shops in Rennes by income group car (top) and public transport (bottom)



Figures 39 and 40 show the average absolute accessibility to shops for nine French cities split by income class by car and public transport respectively. An interesting pattern regarding accessibility by car is the "U-Shape" that is observed in many French cities. In those, medium-income residents have lower accessibility compared with low and high income groups. This is typically a result of the evolution of cities similar to Paris and its suburbs, and the concentration of amenities in the city centres.

When accessibility by public transport is examined, the U shape is much less evident. Public transport services are often spatially concentrated in city centres and suburbs have less frequent and low capacity services. This leads to the much higher access levels of high income people in Paris compared to the low and medium income groups. It also leads to the higher levels of access for low income inhabitants in Marseille and for medium-income residents in Lyon.

At a FUA-wide scale, cross-examining accessibility and income can provide some useful insights; particularly some that are unexpected for someone unfamiliar with the evolution of a specific city. Spatial and social equity are two elements that can be addressed by this exercise, identifying locations or specific groups that are underserved. Such analyses can inform and guide policy making into making urban areas more inclusive and sustainable.

Figure 39. Average absolute accessibility to shops in French metro areas by car split by income group

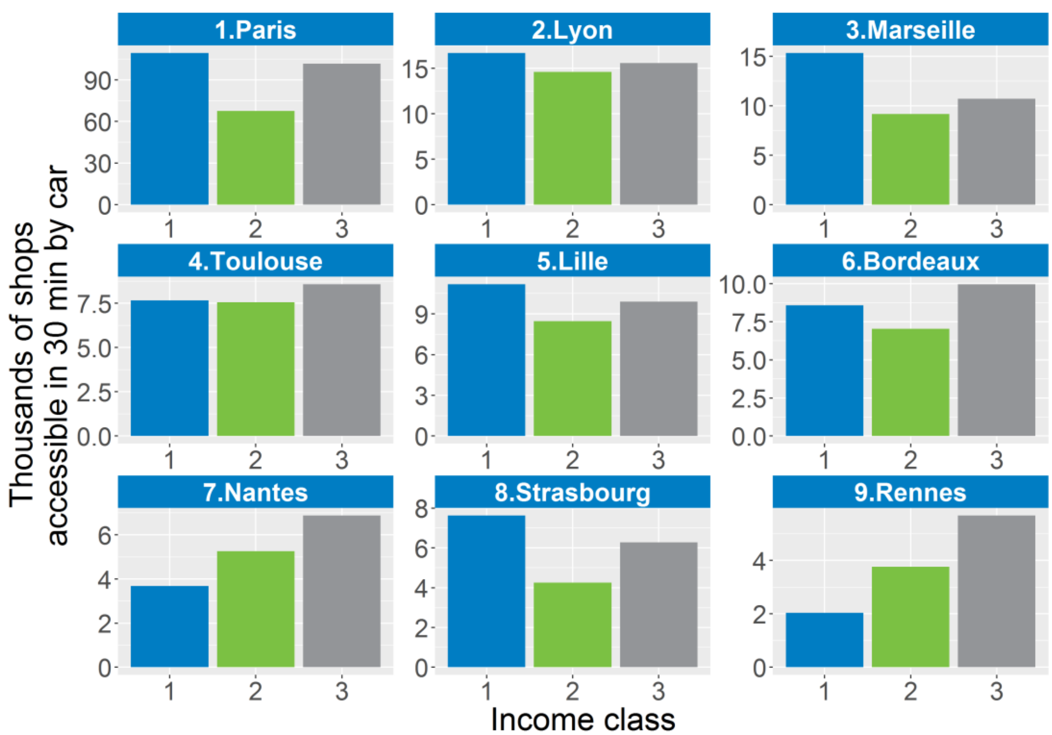
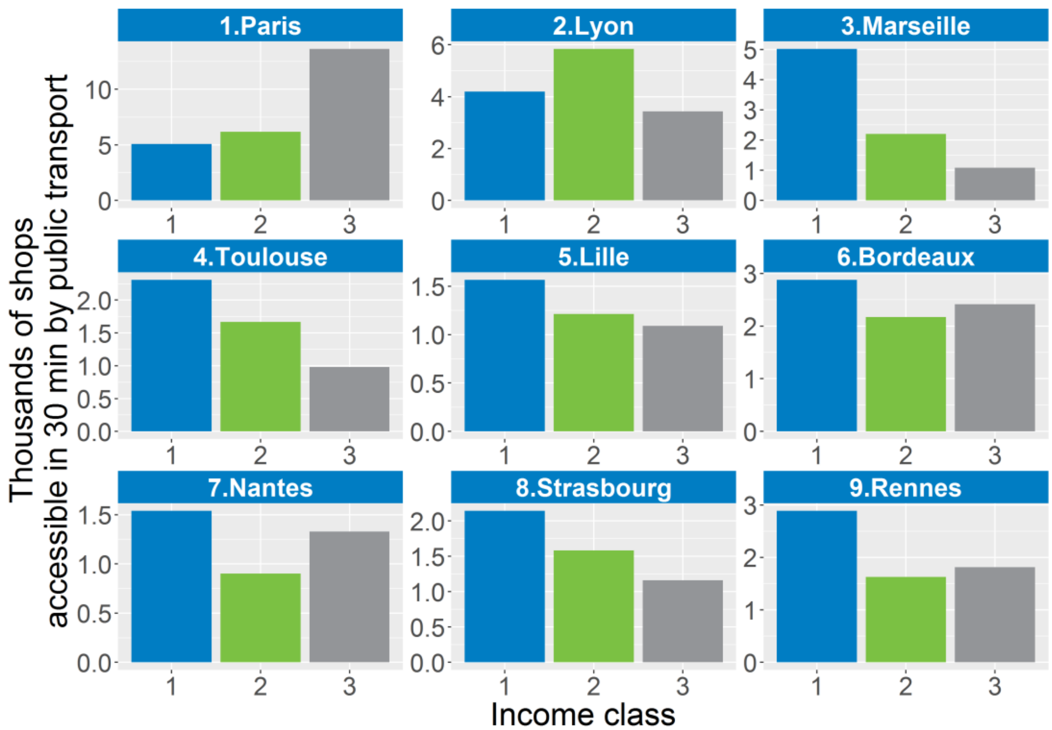


Figure 40. Average absolute accessibility to shops in French metro areas by public transport split by income group



Income groups: 1=low; 2=medium; 3=high

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Annex

A method to create a standardised global amenity dataset

Most countries maintain a registry of businesses and services in general, but this information is rarely publicly available. Even if available, countries use different classification methods. To ensure compatibility of the data, and guarantee comparable results, data used for different service categories needs to come from the same sources and be treated with the same methodology. Websites that provide mapping services, such as Google Maps, OpenStreetMaps (OSM), and TomTom are reliable potential sources, as they have data for a range of different services globally.

These sources combine freely available official information differently, purchased public or private datasets, and volunteered geographical information. It is important to understand that none of this data is exhaustive everywhere and errors will always occur, so data verification, where possible, is crucial, and ultimately some compromises must be made.

Despite the potential of Google data, legal constraints prohibited us from using it. Therefore to identify the most suitable dataset, the OSM and TomTom data were compared to data from official sources. The selected object for comparison was education facilities in the United Kingdom from preschool until university. The level of spatial analysis was a 1 km^2 square grid, and a simple linear regression was used to estimate the similarity of the different datasets. The regression with OSM had an R2 of 0.61, while the regression with TomTom a R2 of 0.91. It is obvious that at this level of spatial analysis, TomTom is a significantly better source. For this reason, TomTom data was chosen from these two as the main data source for the location of services and aggregated into the amenity categories shown. TomTom data was provided and aggregated to the grid level by category by the Joint Research Centre of the European Commission.

However, it was obvious that some gaps in the data still existed. Even without being able to compare with official data sources, some cities had relatively low numbers of certain amenities. In order to avoid discarding those cities or having misinforming indicators, it was decided to supplement these cities with OSM data. As a result, TomTom and OSM data were merged. To avoid double counting during the merging process, only in grid cells where the TomTom amenity value was zero were considered and merged.

This method facilitates the creation of a standardised dataset of amenities, which can be used to measure accessibility in a comparable manner across cities and countries, fulfilling both goals that are set for these indicators.

Computation assumptions

All origin and destination grids are connected to the road network only when a road exists within a maximum distance of 1 km. They are connected to the nearest ten roads using a straight line. Travel speed on these straight lines is 16 km/h for car and bicycle and 4 km/h for walking.

To ensure that the travel time computation is realistic, different assumptions are made for each mode.

Travel time by car:

- Cars can travel in all road categories except in roads designated exclusively for pedestrians or cyclists.
- Travel time is computed using free-flow speeds reduced by peak time delay (based on congestion data). Two delay coefficients are used. A higher one for roads in the city and high capacity roads (highways and trunk roads) in the commuting zone; a lower one for other type roads in the periphery.
- Certain delays are added at trip origin and destination based on the population density of the grid compared to all the grids in Europe.

  Up to five minutes are added for car trips in order to compensate for the time spent accessing the vehicle in at the trip's origin. One minute is added if the population density is at the bottom 20%, five minutes if the population density is at the top 20%.

  Up to ten minutes are added for time spent looking for parking and the time required to reach the final destination. One minute is added if the population density is at the bottom 10%, ten minutes if the population density is at the top 10%.

Travel time by public transport:

Public transport is only considered as an option if the nearest public transport stop is located within 1 km from the trip origin.

The road network is used to reach the public transport stop at trip origin and the final destination with a fixed walking speed of 4 km/h.

Peak hour service travel times and frequencies are used.

Travel time includes:

- Access time to the public transport stop
- Waiting time (equal to half of the headway)
- On-board time
- Transfer time (if necessary)
- Walking time to the final destination.

Travel time by walking:

A fixed walking speed of 4 km/hour was used. High capacity roads (highways and trunk roads) are excluded.

Travel time by bicycle:

- A fixed riding speed of 16 km/hour is used
- High capacity roads (highways and trunk roads) are excluded
- A positive road gradient has a stepwise increase in perceived length, using a formula to estimate the effect of road gradient.

*Formula for road gradient effect: mg=1+a*s*100*

Where: mg= effect of road gradient, s= road gradient,

$$a = \begin{cases} 0 \text{ for } s \leq 1\%, \\ 0.1 \text{ for } 1\% < s \leq 2\%, \\ 0.2 \text{ for } 2\% < s \leq 3\%, \\ 0.4 \text{ for } 3\% < s \leq 4\%, \\ 0.5 \text{ for } 4\% < s \leq 5\%, \\ 0.6 \text{ for } 5\% < s \leq 6\%, \\ 0.7 \text{ for } s > 6\% \end{cases}$$

Destinations:

Indicators are computed for all capitals and FUAs with more than 500 000 inhabitants in Europe, a total of 121 urban areas. Seven specific types of destination were selected for analysis, each of them associated with a specific policy issue.

All activities are generated by the presence of *people*. People can additionally be considered as a proxy for opportunities. Areas that have access to more people are assumed to have access to a larger number of desirable destinations of all kinds. Access to people is measured as a baseline and as a control for the other destination types.

Schools and hospitals are two categories of service whose location is often regulated by the government. Ensuring easy and fast access to these destinations for everyone is a common goal for administrations. Timely access to hospitals can literally be a matter of life and death. Schools are a destination that is visited daily by a large segment of the population that cannot drive a car. There are many benefits associated with the ability of students to go to school on their own, both for them and for their parents.

Food shops and restaurants are destinations that are largely driven by the free market and demand. Their existence depends on people being able to reach them. They are therefore often located in areas with increased activity or high connectivity to the rest of the city. Nevertheless, they are an essential part of everyday life, and as such they can be found in any part of the urban area. The variable nature of what is offered by restaurants means that the quantity of restaurants that can be reached is also relevant to the nature of accessibility. Having access to multiple shops and restaurants is often associated with a high quality of life.

The location of *recreation* destinations is mostly related to centrality. They are destinations that have certain gravity, even if they are not visited daily. Because of this gravity effect they often attract other destinations nearby, especially market-driven services such as shops and restaurants.

Access to *green spaces* is often considered as one of the most important factors of liveability and quality of life in cities. Beyond a minimum level of access to a park, large green areas break the urban continuum and provide an area where people can take a break from everyday life, relax, or do sports.

Table 11. European cities in the study

FUA code	European city	Public transport (existence of GTFS data)	Total Area (km2)	Total population
AT001	Vienna	Yes	8 817	2 811 186
AT002	Graz	No	3 479	629 161
AT003	Linz	No	4 404	789 811
BE001	Brussels	Yes	2 681	2 513 849
BE002	Antwerp	Yes	1 004	1 041 811
BE003	Ghent	Yes	1 286	638 941
BE005	Liege	Yes	1 186	705 461
BG001	Sofia	No	10 797	1 681 592
BG002	Plovdiv	No	5 961	671 573
BG003	Varna	No	3 822	472 654
CH001	Zurich	Yes	1 728	1 487 969
CH002	Geneva	Yes	282	489 524
CH003	Basel	Yes	1 361	706 239
CY001	Nicosia	No	9 253	854 802
CZ001	Prague	Yes	11 425	2 619 490
CZ002	Brno	No	7 188	1 178 812
CZ003	Ostrava	No	5 430	1 209 879
DE001	Berlin	Yes	17 480	5 207 915
DE002	Hamburg	Yes	7 308	3 282 164
DE003	Munich	No	5 501	2 879 107
DE004	Cologne	Yes	1 626	1 987 901
DE005	Frankfurt	No	4 305	2 671 358
DE007	Stuttgart	No	3 653	2 757 930
DE008	Leipzig	Yes	3 978	1 027 484
DE009	Dresden	No	5 833	1 341 818
DE011	Dusseldorf	No	1 200	1 545 431
DE012	Bremen	No	5 896	1 269 755
DE013	Hannover	No	2 973	1 306 316
DE014	Nuremberg	Yes	2 934	1 333 043
DE027	Freiburg im Breisgau	No	2 211	651 257
DE033	Augsburg	No	1 998	668 522
DE034	Bonn	Yes	1 294	919 979
DE035	Karlsruhe	Yes	1 258	750 336
DE038	Ruhrgebiet	No	4 438	5 118 681
DE040	Saarbrucken	No	1 538	804 286
DE084	Mannheim-Ludwigshafen	Yes	2 046	1 177 545
DE504	Muenster	No	1 415	530 865
DE507	Aachen	Yes	707	552 472
DK001	Copenhagen	Yes	2 779	2 014 225
EE001	Tallinn	Yes	4 338	583 728
EL001	Athens	Yes	3 817	3 773 559
EL002	Thessaloniki	No	3 683	1 108 085
ES001	Madrid	Yes	8 031	6 476 838
ES002	Barcelona	No	7 729	5 474 482

FUA code	European city	Public transport (existence of GTFS data)	Total Area (km2)	Total population
ES003	Valencia	Yes	10 806	2 522 383
ES004	Seville	No	14 036	1 943 191
ES005	Zaragoza	No	17 275	961 518
ES006	Malaga	Yes	7 309	1 646 777
ES008	Las Palmas	Yes	1 560	857 702
ES019	Bilbao	Yes	2 212	1 134 514
FI001	Helsinki	Yes	9 568	1 638 293
FR001	Paris	Yes	12 070	12 193 865
FR003	Lyon	Yes	3 259	1 860 112
FR004	Toulouse	Yes	6 358	1 371 044
FR006	Strasbourg	Yes	4 797	1 122 696
FR007	Bordeaux	Yes	10 160	1 590 570
FR008	Nantes	Yes	6 912	1 397 437
FR009	Lille	Yes	5 750	2 612 189
FR010	Montpellier	Yes	6 162	1 147 246
FR011	Saint-Etienne	No	4 804	761 765
FR013	Rennes	Yes	6 839	1 063 811
FR026	Grenoble	Yes	7 879	1 265 869
FR032	Toulon	No	1 048	561 322
FR203	Marseille	Yes	11 279	3 099 950
FR205	Nice	Yes	4 296	1 081 455
FR215	Rouen	No	6 321	1 257 594
HR001	Zagreb	No	4 930	1 243 779
HU001	Budapest	Yes	6 916	3 000 076
IE001	Dublin	Yes	6 988	1 917 677
IT001	Rome	Yes	5 363	4 353 738
IT002	Milan	Yes	2 764	4 316 398
IT003	Naples	Yes	1 179	3 107 006
IT004	Turin	Yes	6 827	2 277 857
IT005	Palermo	Yes	5 009	1 268 217
IT006	Genoa	Yes	1 834	850 071
IT007	Florence	Yes	3 514	1 014 423
IT008	Bari	No	3 863	1 260 142
IT009	Bologna	Yes	3 703	1 009 210
IT010	Catania	No	3 574	1 113 303
IT011	Venice	Yes	2 473	854 275
LT001	Vilnius	Yes	9 730	805 173
LU001	Luxembourg	Yes	2 595	590 667
LV001	Riga	Yes	304	641 423
MT001	Valletta	No	247	428 091
NL001	's-Gravenhage	Yes	263	853 987
NL002	Amsterdam	Yes	5 263	2 729 421
NL003	Rotterdam	Yes	1 547	1 445 056
NL004	Utrecht	Yes	1 449	1 284 504
NL005	Eindhoven	Yes	1 458	761 763

FUA code	European city	Public transport (existence of GTFS data)	Total Area (km2)	Total population
NO001	Oslo	Yes	5 371	1 271 127
PL001	Warsaw	Yes	9 925	3 369 567
PL002	Lodz	No	2 499	1 079 031
PL003	Krakow	No	4 381	1 472 784
PL004	Wroclaw	Yes	293	634 192
PL005	Poznan	No	5 189	1 178 442
PL006	Gdansk	Yes	4 717	1 309 027
PL009	Lublin	No	4 221	709 266
PL010	Katowice	No	5 579	2 713 464
PT001	Lisbon	Yes	3 015	2 821 349
PT002	Porto	No	2 041	1 719 021
RO001	Bucharest	No	1 804	2 287 347
SE001	Stockholm	Yes	7 153	2 269 060
SE002	Goteborg	Yes	28 778	1 671 783
SE003	Malmo	Yes	11 302	1 324 565
SI001	Ljubljana	Yes	2 334	539 672
SK001	Bratislava	No	2 053	641 892
UK001	London	Yes	10 341	14 187 146
UK002	West Midlands urban area	Yes	803	2 516 264
UK003	Leeds	Yes	891	1 118 711
UK004	Glasgow	Yes	3 790	1 836 014
UK006	Liverpool	Yes	908	1 530 512
UK007	Edinburgh	Yes	1 761	880 400
UK008	Greater Manchester	Yes	3 325	3 287 460
UK009	Cardiff	Yes	1 537	1 129 971
UK010	Sheffield	Yes	368	576 167
UK011	Bristol	Yes	1 514	1 133 729
UK012	Belfast	Yes	956	690 791
UK013	Newcastle upon Tyne	Yes	5 490	1 167 815
UK014	Leicester	Yes	3 160	1 415 597
UK023	Portsmouth	Yes	330	670 017
UK029	Nottingham	Yes	75	323 475

Table 12 Public transport coverage of functional urban areas in the study

FUA code	European city	FUA	City	Commuting Zone
AT001	Vienna	67.1%	99.9%	10.0%
BE001	Brussels	99.2%	100.0%	98.5%
BE002	Antwerp	98.2%	100.0%	96.6%
BE003	Ghent	99.0%	100.0%	98.3%
BE005	Liege	99.1%	100.0%	98.2%
CH001	Zurich	99.4%	99.9%	99.0%
CH002	Geneva	99.5%	99.9%	98.9%
CH003	Basel	99.5%	100.0%	98.8%
CZ001	Prague	91.2%	100.0%	76.3%
DE001	Berlin	99.5%	100.0%	98.5%
DE002	Hamburg	99.5%	99.9%	98.9%
DE004	Cologne	99.9%	100.0%	99.6%
DE008	Leipzig	70.7%	99.9%	39.2%
DE014	Nuremberg	99.6%	100.0%	99.1%
DE034	Bonn	98.5%	100.0%	97.4%
DE035	Karlsruhe	99.5%	99.9%	99.2%
DE084	Mannheim-Ludwigshafen	69.7%	93.5%	48.2%
DE507	Aachen	99.6%	99.8%	99.5%
DK001	Copenhagen	99.0%	100.0%	97.6%
EE001	Tallinn	98.6%	100.0%	95.3%
EL001	Athens	96.1%	100.0%	54.0%
ES001	Madrid	96.7%	99.9%	83.0%
ES003	Valencia	79.2%	88.3%	41.3%
ES006	Malaga	66.7%	80.9%	3.9%
ES008	Las Palmas	56.3%	73.7%	4.1%
ES019	Bilbao	95.9%	99.9%	82.8%
FI001	Helsinki	90.0%	99.9%	61.4%
FR001	Paris	98.2%	100.0%	91.1%
FR003	Lyon	77.4%	99.9%	30.3%
FR004	Toulouse	74.6%	99.5%	40.7%
FR006	Strasbourg	74.9%	99.9%	35.0%
FR007	Bordeaux	69.7%	99.8%	17.9%
FR008	Nantes	67.9%	97.6%	6.6%
FR009	Lille	85.1%	99.2%	26.6%
FR010	Montpellier	70.9%	99.4%	17.0%
FR013	Rennes	63.4%	97.8%	14.1%
FR026	Grenoble	73.4%	99.8%	31.8%
FR203	Marseille	83.9%	91.2%	35.5%
FR205	Nice	75.5%	82.1%	44.3%
HU001	Budapest	68.9%	100.0%	23.5%
IE001	Dublin	75.0%	98.0%	23.1%

FUA code	European city	FUA	City	Commuting Zone
IT001	Rome	67.1%	97.7%	8.9%
IT002	Milan	63.2%	71.0%	28.7%
IT003	Naples	48.5%	53.5%	3.0%
IT004	Turin	97.3%	100.0%	94.6%
IT005	Palermo	69.6%	92.2%	14.6%
IT006	Genoa	88.9%	99.9%	42.7%
IT007	Florence	98.0%	100.0%	96.3%
IT009	Bologna	97.6%	100.0%	95.2%
IT011	Venice	96.8%	99.1%	95.0%
LT001	Vilnius	83.7%	99.3%	30.0%
LU001	Luxembourg	99.1%	100.0%	98.9%
LV001	Riga	74.2%	99.9%	18.6%
NL001	's-Gravenhage	99.6%	99.9%	98.2%
NL002	Amsterdam	98.6%	99.5%	96.3%
NL003	Rotterdam	99.1%	99.9%	96.9%
NL004	Utrecht	98.6%	99.9%	97.4%
NL005	Eindhoven	97.1%	99.4%	95.0%
NO001	Oslo	98.9%	100.0%	97.9%
PL001	Warsaw	84.8%	100.0%	65.5%
PL004	Wroclaw	80.5%	100.0%	24.1%
PL006	Gdansk	82.6%	99.9%	53.1%
PT001	Lisbon	80.2%	84.9%	56.4%
SE001	Stockholm	98.7%	99.7%	95.6%
SE002	Goteborg	97.0%	98.9%	94.8%
SE003	Malmo	97.0%	99.2%	92.5%
SI001	Ljubljana	61.5%	99.2%	17.6%
UK001	London	99.3%	99.8%	97.5%
UK002	West Midlands urban area	99.1%	99.8%	94.5%
UK003	Leeds	99.0%	99.8%	95.8%
UK004	Glasgow	99.4%	99.8%	98.1%
UK006	Liverpool	99.8%	99.9%	98.5%
UK007	Edinburgh	99.2%	99.9%	98.3%
UK008	Greater Manchester	99.4%	99.9%	96.4%
UK009	Cardiff	98.9%	99.2%	98.6%
UK010	Sheffield	99.7%	99.8%	98.7%
UK011	Bristol	99.0%	100.0%	98.2%
UK012	Belfast	57.1%	79.0%	22.9%
UK013	Newcastle upon Tyne	98.6%	100.0%	95.3%
UK014	Leicester	97.3%	99.0%	95.0%
UK023	Portsmouth	79.0%	72.8%	98.1%
UK029	Nottingham	98.8%	0.0%	98.8%

Benchmarking Accessibilty in Cities

This report presents a new urban accessibility framework. It identifies which destinations can be reached on foot, by bicycle, public transport or car within a certain time (accessibility). It then measures how many destinations are close by (proximity). The comparison between accessible destinations and nearby destinations shows how well each transport mode performs (transport performance). These three indicators are calculated for destinations such as schools, hospitals, food shops, restaurants, people, recreational opportunities and green spaces in 121 cities in 30 European countries.

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