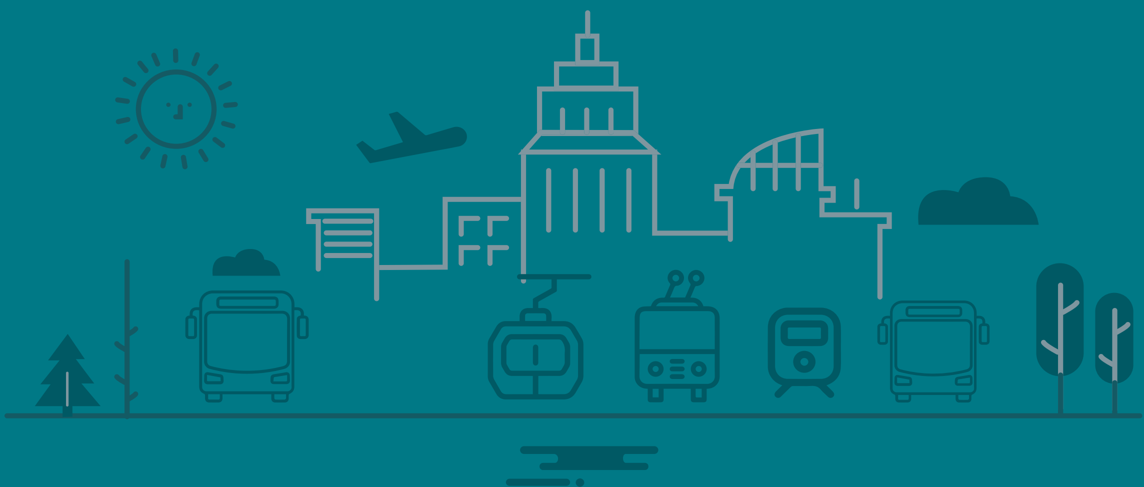
MODULE 2

PUBLIC TRANSPORT SYSTEM



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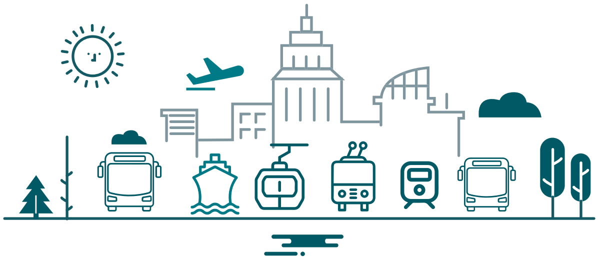

PUBLIC TRANSPORT SYSTEM

__TARGET 11.2:__ By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons

__Indicator 11.2.1:__ Proportion of the population that has convenient access to public transport by sex, age and persons with disabilities

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SECTION 1:

INTRODUCTION

1.1 Background

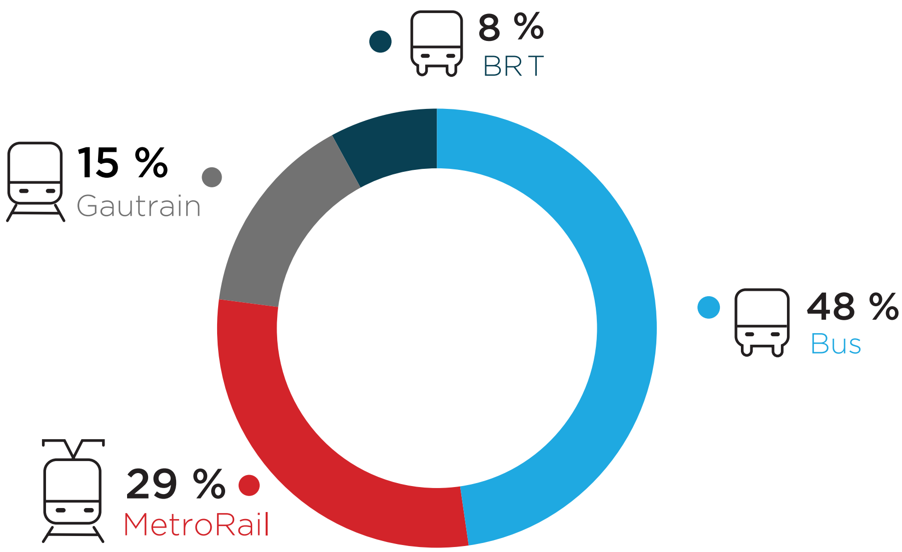
Accessibility to urban mobility paradigm critically needs good, high-capacity public transport systems that are well integrated in a multi-modal arrangement with public transport access points located within comfortable walking or cycling distances from homes and jobs for all.

Achieving SDG 11 target 11.2 requires a fundamental shift in the thinking on transport with the focus on the goal of transport rather than on its means. With accessibility to services, goods and opportunities for all as the ultimate objective, priority is given to making cities more compact and walkable through better planning and the integration of land-use planning with transport planning. The means of transport are also important but the SDG's imperative to make cities more inclusive means that cities will have to move away from car-based travel to public transport and active modes of transport such as walking and cycling with good inter-modal connectivity.

It is empirically proven that public transport makes cities more inclusive, safe and sustainable. Effective and low-cost transportation is critical for reducing urban poverty and inequalities and enhancing economic development because it provides access to jobs, health care, education services and other public goods

Improving public transport, improving lives

"South Africa faces pressing challenges as it aims to create an efficient inter-modal public transport sector that seeks to improve the lives of its citizens. Public transport is a challenge for the majority of users, but more so for the poor. More than 60% of households spend on average 20% of their income monthly on transport. It can be as high as 31% in rural areas.



The challenges faced by the transport sector range from high operating and social costs to inefficiencies within the different public transport modes. Additionally, the commuting distance from homes to the work places (many people live far away from their places of work) is highly influenced by planning of residential in pre-democracy days. Well planned transport systems that guide all public transport investments, need to be implemented for t South Africa to achieve a better transport system with the limited financial resources at hand. It should ultimately lead to an intermodal transport system aligning all the different modes of public transport in the country. This is the key for improving the passenger experience".

Malijeng Ngqaleni, Deputy Director-General: Intergovernmental Relations, speaking on the first plenary session of the 35th Southern African Transport Conference (SATC)

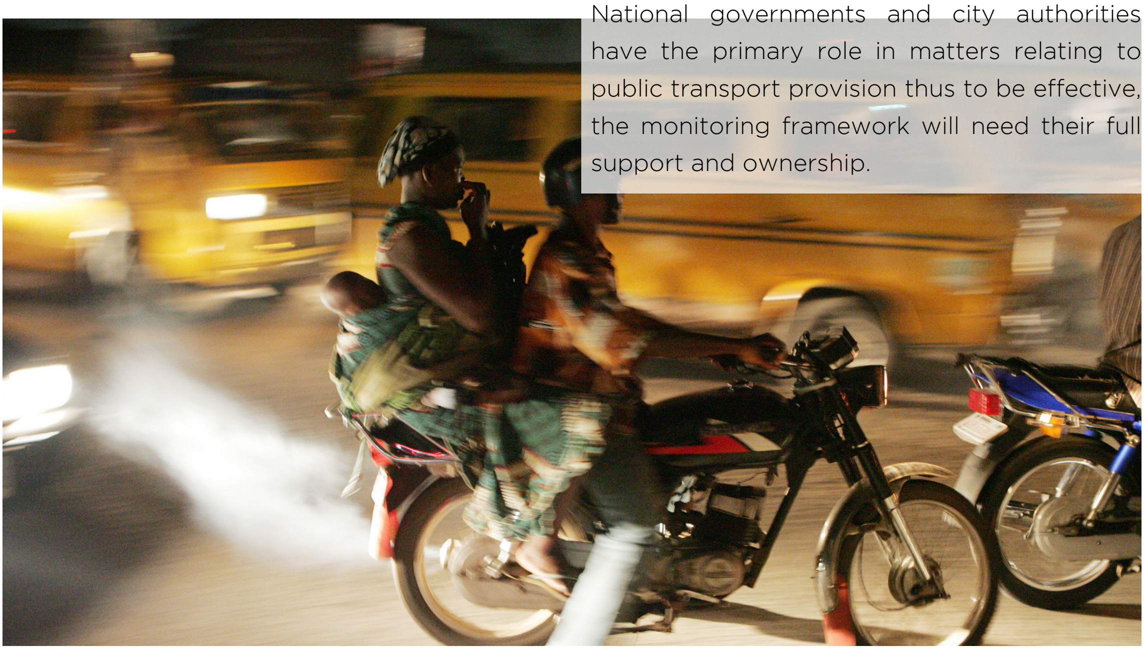
1.2 Rationale for Monitoring

Mobility contributes to quality of life. It is the pre-condition for economic growth, trade and creativity as well as for personal wellbeing. People who can easily move around in the city can enjoy more of life's opportunities. Mobility creates access to opportunities for advancement, for individuals and communities.

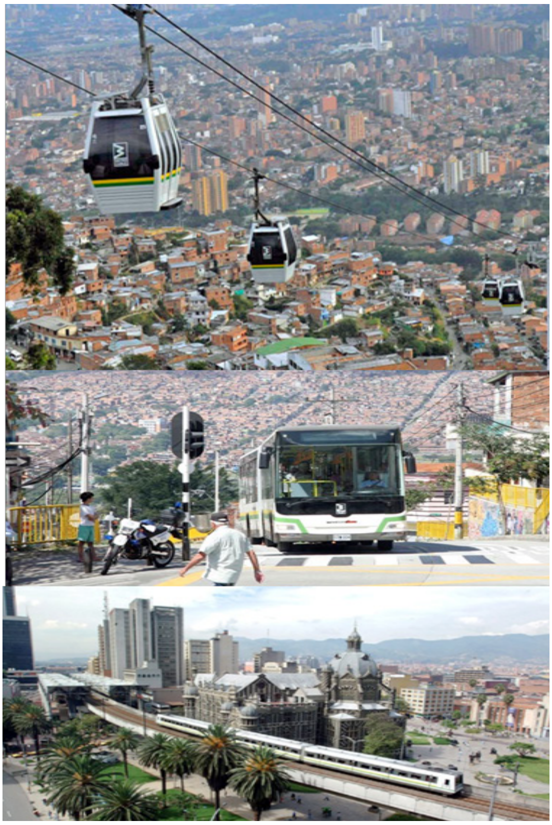
In general, monitoring promotes higher accountability, better performance assessment and strong coordination between central governments and the regional and local governments. It enables cities to collect accurate, timely, disaggregated data and information, adopting a systemic approach to the city, with clear policy implications that are based on evidence. This way, countries and cities can make appropriate decisions on the best policies and actions to adopt, whilst systematically documenting their performance at the outcome and impact levels.

The purpose of monitoring progress against the SDG target 11.2 is to provide necessary and timely information to decision makers and stakeholders in order to accelerate progress against the target and goal. The transport target emphasizes on a new paradigm of sustainable mobility with its emphasis on accessibility and inclusiveness recognizing that development of a sustainable transportation system begins with the organization of urban space. Therefore, every decision on transport infrastructure ultimately determines the cityscape for decades to come and has a long-term influence on the mobility behavior of residents. For this reason, it is imperative to include and integrate all relevant actors in the decision-making process. Transport will only become modern and sustainable when people have access to and start using these new mobility options.

National governments and city authorities have the primary role in matters relating to public transport provision thus to be effective, the monitoring framework will need their full support and ownership.



Public transport motorcyclist popularly known as Okada in Lagos, Nigeria © Julius Mwelu/UN-Habitat.



Medellin Colombia

With approximately 2.7 million inhabitants living in both mountain and valley zones, Medellin has been very innovative in the modes of public transportation the city offers to its citizens-which consists of an elevated rail system, a bus system and cable cars.

The priority in the planning and development of the traffic network is the inclusion of disadvantaged population groups, in order to provide equal access to transport services for all residents. The cable cars provide access to the poor neighbourhoods on the mountainsides of the city.

Public transport © Franklin Heijnen /Flickr.

1.3 Monitoring and Reporting Process

DATA COLLECTION

- National Statistical Offices (NSOs) are responsible for data collection.

CAPACITY DEVELOPMENT

- UN Habitat and its partner organizations and National Focal points will work closely to provide capacity building and quality assurance support

DATA RELEASE

- Survey data will be available every 2 to 5 years.
- Monitoring of the indicator will be repeated at annual intervals, allowing several reporting points until 2030.
- NSOs are responsible for national level reporting. Global and Regional level reporting will be conducted by custodian agency-UN-Habitat.
- Comprehensive reporting will be undertaken on a biennial basis.

1.4 Concepts and definitions

Public transport

Refers to shared passenger transport services that are available to the general public and which are provided for the public good. It may include cars, buses, trolleys, trams, trains, subways, and ferries that are shared by strangers without prior arrangement. It may also include informal modes of transport (para-transit) - but it is noted that these are often lacking in designated routes or stops.

However, it excludes taxis, car pools, and hired buses, which are not shared by strangers without prior arrangement.

Convenient access to public transport

Refers to 500m walking distance to the nearest public transport stop.

Public transport accessible to all special needs

Includes those who are physically, visually, and/or hearing- impaired, as well as those with temporary disabilities, the elderly, children and other people in vulnerable situations.

Frequent service

Public transport with frequent service during peak travel times with an average waiting time of 30 minutes.

Safe and comfortable stops

Public transport stops that present a safe and comfortable station environment.

Man on wheelchair boards a bus © Travelling with diabilities / visitnorway.com

SECTION 2:

HOW DO WE MEASURE ACCESS TO PUBLIC TRANSPORT?

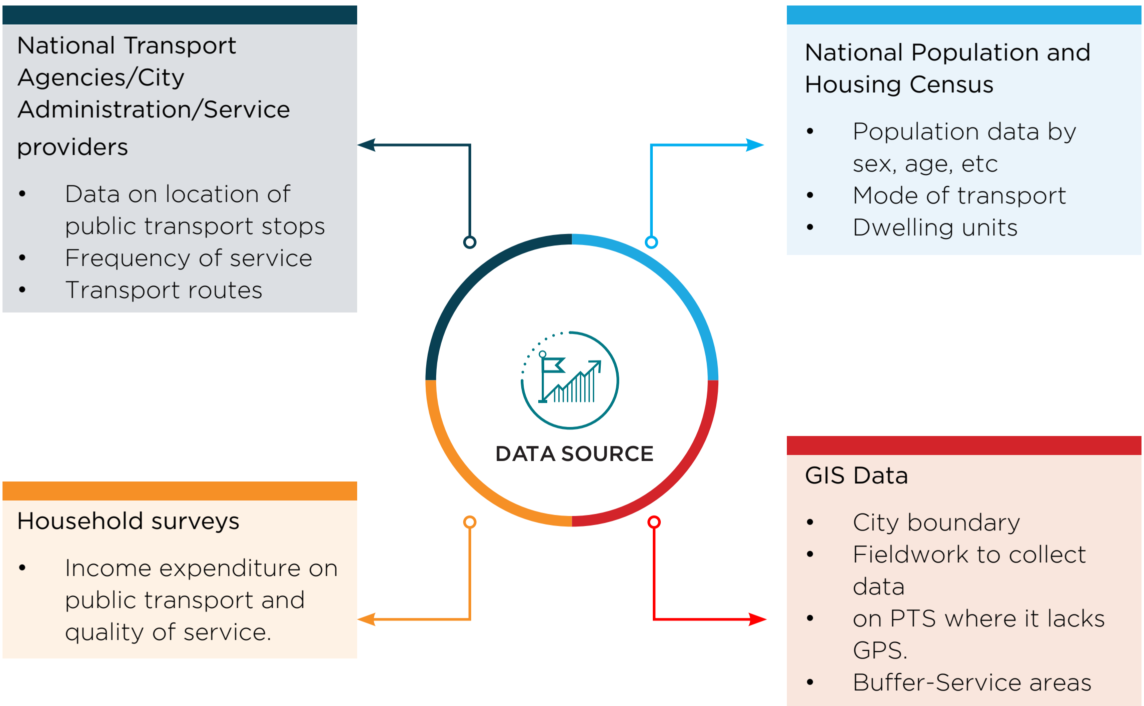
This section focuses on the potential data sources, software and stepwise criteria for assessing access to public transport. The section is divided into three parts; a) identifying public transport stops, b) creating service areas for each stop – which is defined as a walking distance of 500 meters to a public stop along a road/ street network, and c) calculating the number of people within the service areas by overlaying the service area with population data layers at the lowest data unit or as population grids.

This indicator requires data on two aspects of public transport, location of public transport stops and population data. Due to the complexity of public transport systems in different regions, countries / cities are encouraged to document, in a different column access to informal public transport stops. This will help them understand the nature of the available transport systems (shares of formal versus informal systems), and to in turn make informed decisions and investments to enhance access to public transport among populations.

In addition, the indicator acknowledges that mass transport systems such as rail and metro services, ferries, etc have a bigger area of influence than smaller capacity bus systems. In effect, this means that people can walk longer distances (up to 1000 meters) to access a railway or metro station/ stop. Countries / cities are thus also encouraged to collect data on the number of people within 1000 meters walking distances along street networks to these high capacity transport systems; and to present it as an additional data column.

2.1 Tools and potential data sources.

1. Desktop GIS
    - *Preferably ArcGIS / ArcMap*
2. Technical expertise in spatial analysis and use of network analyst extension in ArcMap
3. Input data
    - *Street and public transport*



2.2 Identifying public transport stops,

Data on public stops can be acquired from relevant ministries working in transport in cities / countries. In the absence of this data at the local level, high resolution imagery and open source data can be used to identify and map the location of public transport stops. OpenstreetMap has point data for some of the public transport stops, from where gaps can be filled through digitization from the high resolution satellite imagery.

2.2.1 Use of high resolution imagery to extract data on public transport stops

The unique design and physical character of public transport stops can be used to identify their location within human settlements and along streets. Bus stops, laybys, metro stations etc can easily be distinguished and mapped from high resolution imagery and/or from google earth (figures 2). The tile server service in QGIS which uses a diversity of basemaps as raster tiles (egs google streets, esri streets, openstreetmap, etc) can also be used to identify and map out public transport stops (figure 3).

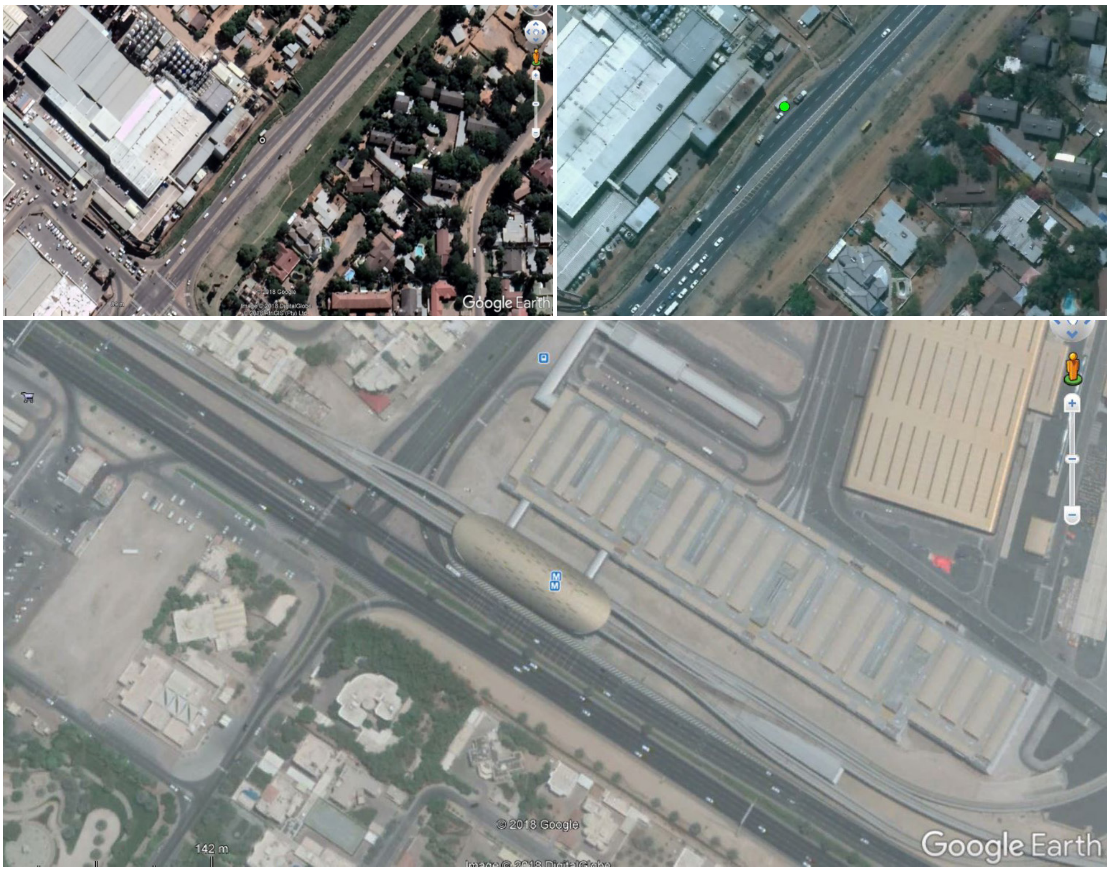


Figure 2: High resolution satellite imagery or Google earth can be used to identify location of public transport stops

Figure 3: Google streets tile server in QGIS can be used to identify location of public transport stops

2.3 Creating service areas for each public transport stop

Once all the public transport stops have been identified, the next step is to create 500 meters service areas around each stop. Prior to this, we need to create a street network dataset. Streets data is required for this step. This data can be acquired from the relevant ministries within the target country or from open sources such as Openstreetmap (Refer to UN-Habitat (2018) SDG 11.7.1 computation manual, for detailed guidelines on potential sources of streets data)

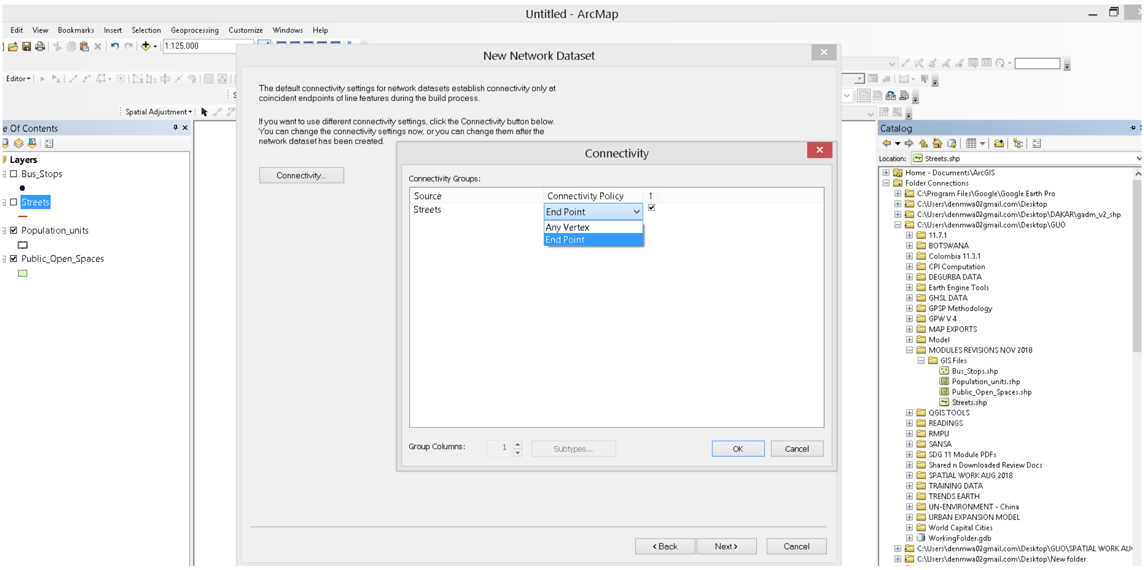
The workflow described here uses the Network Analyst Extension in ArcMap software.

1. Clean streets data to remove such problems as un-linked streets sections, missing junctions, etc. A detailed tutorial on how to clean data is available here: https://support.esri.com/en/technical-article/000012743. For this tutorial we are going to only fix small issues in the data using the Integrate tool in ArcGIS

- In ArcToolbox, open Data Management Tools > Feature Class > Integrate.
- Select your streets layer as the input features > leave the XY tolerance blank and click okay (see detailed explanations on why this is important in the data cleaning tutorial at the link provided above). An important thing to note is that the Integrate function makes changes to your original file, thus it is recommended that you run this tool on a copy of the data.
- Based on the quality of your original data, follow the ArcGIS network analyst data preparation tutorial to perform advanced data cleaning

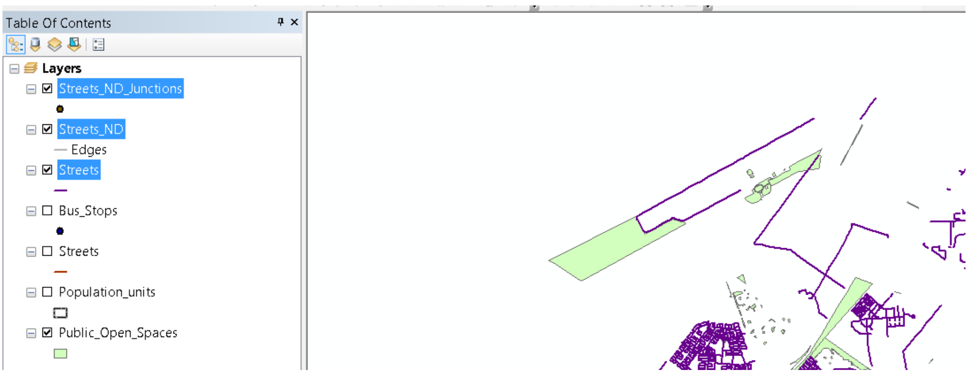
2. Create a network dataset from the cleaned streets layer. From ArcCatalog, right click on the streets layer and select Create Network Dataset. For this tutorial, we will create a very basic network dataset. Recommendations on more advanced options are provided where applicable.

   - Enter a name for your dataset in the first screen and click next
   - On the model turns select no and click next
   - On the next screen click on connectivity and change connectivity policy to Any Vertex, click okay then next. Here we are using any vertex to make it possible for someone to make a turn at any junction. If your data is well cleaned and all junctions properly set, you should use the end point option for more accurate results (refer to tutorial on cleaning streets for detailed explanations).

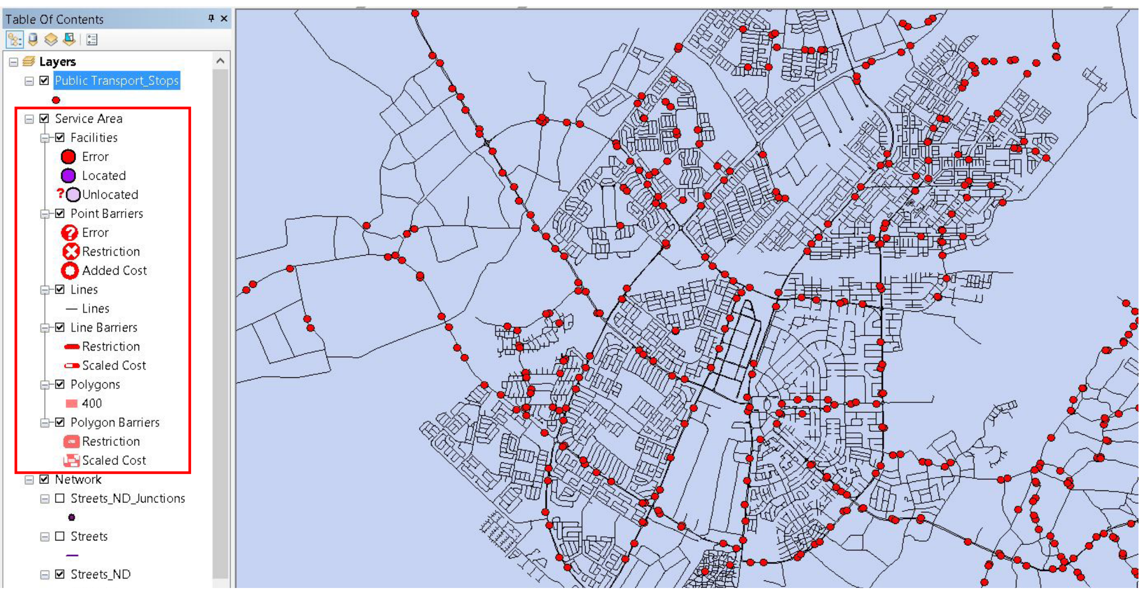


   - Do not model the elevation. On attributes for the network dataset select meters as the units. If you choose to use different units you will be required to also change the service area buffer units to similar units
   - Do not establish driving directions. Preview the input metrics and click finish. A window will appear stating that “The new network dataset has been created. Would you like to built it now?” Click Yes
   - Once the processing finishes, you will be asked whether you want to add all feature classes that participate in the network dataset to the map – select Yes.

- If your network data has errors, a window will also appear asking if you would like to view the error messages. You can review this as they will help you know which areas need further cleaning
- Three layers will be added to the display – a streets layer, a layer containing the street network junctions (points where two or more streets meet), and a layer with the edges (lines connecting junctions). These three constitute your network dataset. We will use this dataset to define our service areas
- We will use the resultant street network dataset to create service areas for each public transport point.

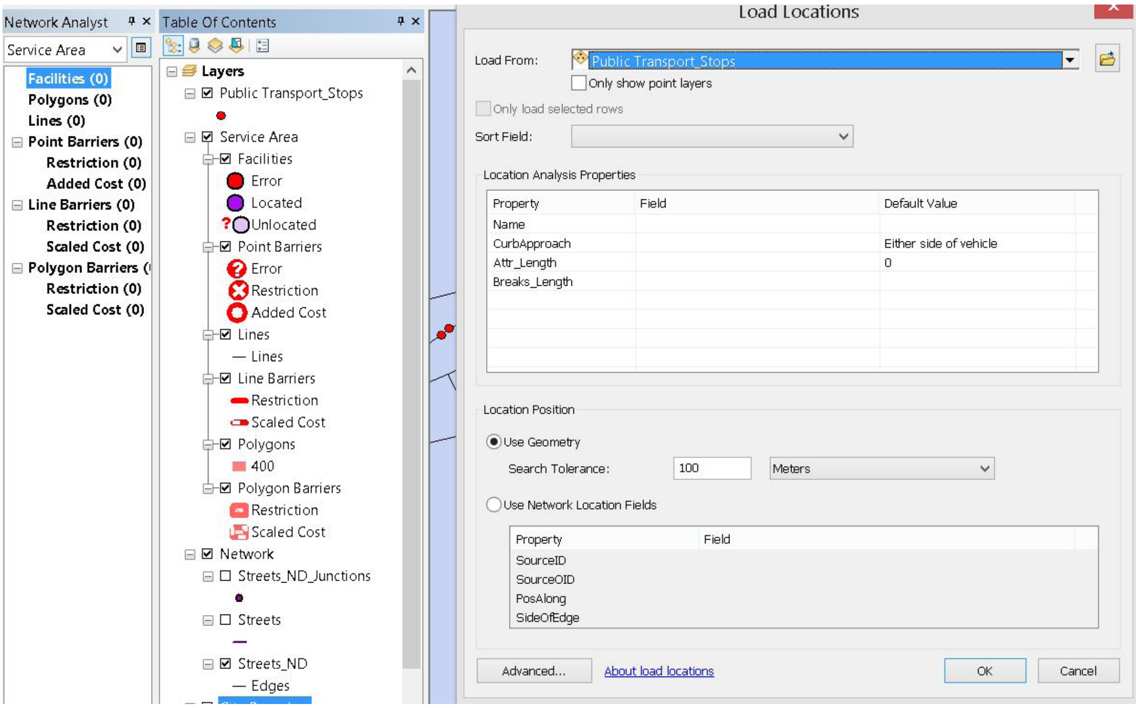


3. Activate the network window and select “New Service Area”. This creates a new window in the map table of contents

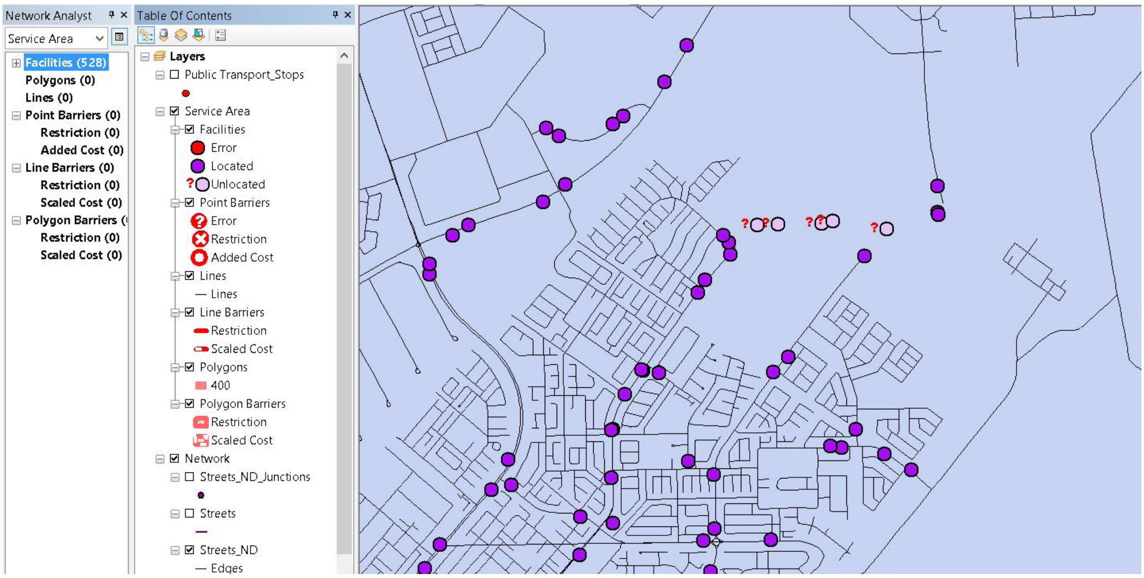


4. Click on the Network Analyst Window at the network analyst toolbar. This opens a new window next to the table of contents. From this window, right click on facilities and select load locations.

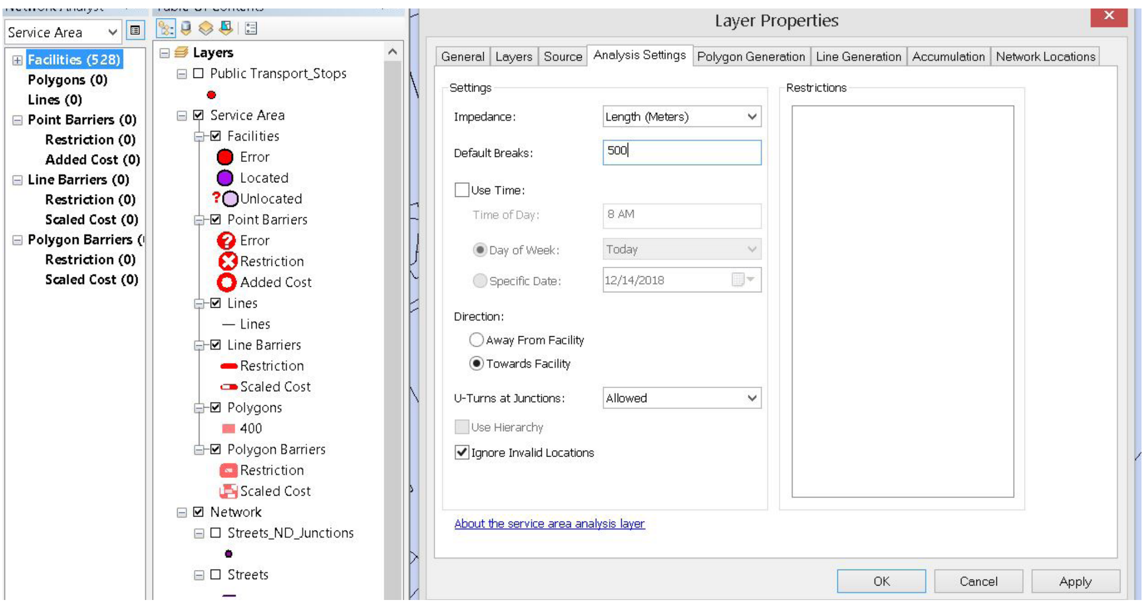
5. Select the public transport stops as the facilities source file, set 100 meters as the search tolerance then click okay. The search tolerance defines how far from the street network ArcGIS will search for the public transport stop. This will for example mean that if a bus stop is more than 100 meters from a street, that point will not be accessible.



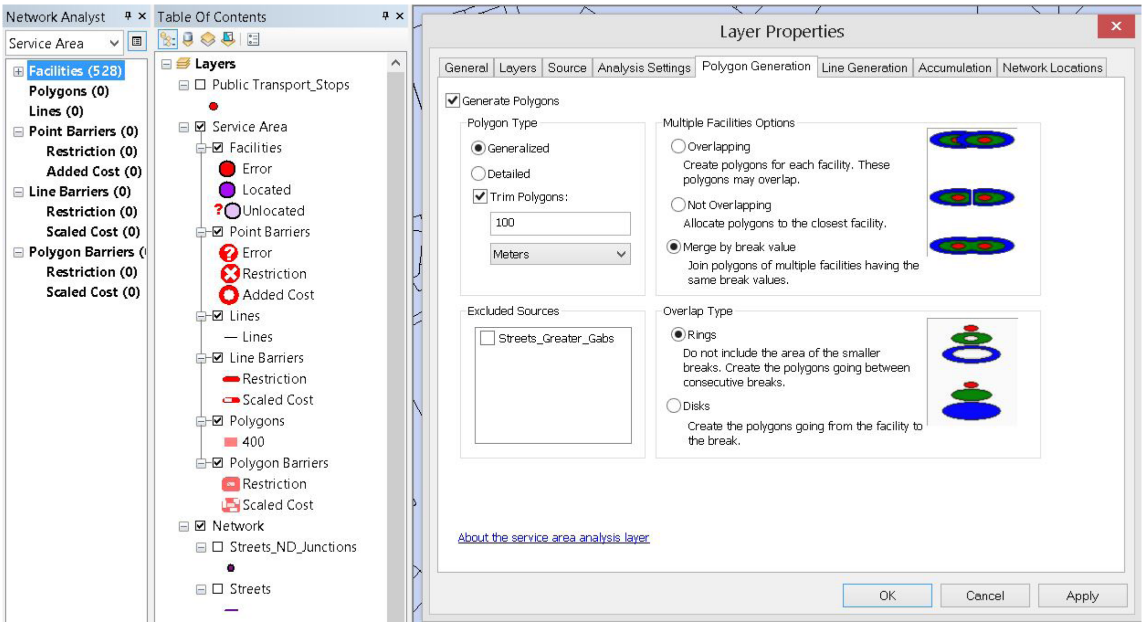
6. Once finished, the loaded stops will be added to the active map (the number of imported points will also be shown in parenthesis in network analyst window). The facilities tab in the table of contents will show the points within the defined and those outside the search area. In the map view, points which are outside the defined search area have a question mark.



7. From the Network Analyst window open Service area properties. Under analysis settings, set length (meters) as the impedance input and add 500 (meters) as the default break value. Under direction, select "towards facility", allow U-turns at junctions and check ignore invalid locations. Note that these parameters are only defined for this tutorial and will not apply uniformly for all countries – read more about global turns in the ArcGIS Network Analyst data prep tutorial



8. Under the polygon configuration window, check “generate polygons” and ”select “merge by break value” under multiple facilities options. Under polygon type, choose generalized and trim polygons by 100 meters. Click okay. The merging of polygons is key to ensure that no double counting of population in areas where the service areas overlap



9. Click the solve button in the network analyst window bar, or right click on the service area window under table of contents and click on solve. ArcGIS will process the service areas for a few minutes depending on the number of input points. The resulting service area will resemble what is provided in figure 4 below.

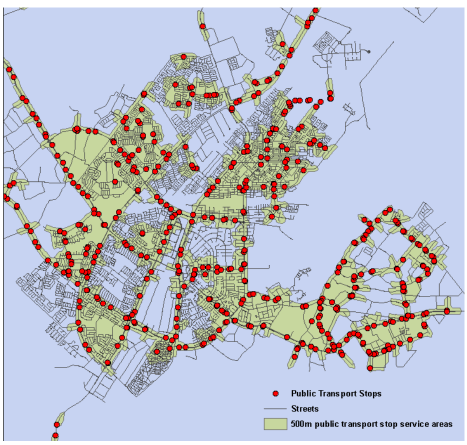


Figure 4: Created 500 meter service area to public transport stops

2.4 Estimating populations with access to public transport stops

After defining the service areas for all the public transport stops, the next step is to estimate the number of people living within them, which in turn represents the population with convenient access to public transport.

The following key assumptions are made;

- Equal access to each stop by all groups of people – i.e children, the disabled, youth, men, women can walk a distance of 500 meters to access the stops (in actual sense, these will vary significantly by population group)
- All streets are walkable – where existing barriers are known (e.gs non-walkable streets, lack of pedestrian crossings), these can be defined during creation of the stops' service areas
- All buildings within the service area are habitable, and the population is equally distributed across the built up areas and/or all habited land use classes
- Each stop has the necessary facilities to support access to all population groups e.g there are facilities for the disabled.

Primary data and field verification can be incorporated to reduce the margin of error associated with some of the above assumptions.

The estimation of the number of people living within each service area can be achieved through **three broad approaches**;

Use of high resolution data from national statistical offices (NSOs) –
In this option, census data is used to aggregate the number of people living in all households within the stops' service area. Population data obtained from this source can easily be disaggregated by age, sex and persons with disabilities as per the indicator requirements. This is also the best source of population data for the indicator computation, but implementation of the approach requires good collaboration and coordination between the national statistical offices and other actors involved in the indicator monitoring e.g ministries in charge of SDGs or transport.

Use of gridded population -
In this option, a population grid is made by distributing population to habitable land use classes at the cell/pixel level (such as built up cells) and aggregating the pixel population to a reasonable square grid cell (egs 100x100 meters, 250 x 250m, 1x1 km, etc). Each grid cell will have both habitable (e.g built up) and non-habitable cells (e.g non-built up cells); and a population density that will be equivalent to the total population of all habitable encompassed cells divided by its size. In the absence of high resolution data from NSOs, this option produces better estimates for population, although the production of the population grid requires multi-level analysis. Global datasets representing populations at 1km² and 250m grids are available (e.gs GPWv4, GHS-POP). This approach is proposed for the indicator computation in the absence of high resolution data from national statistical offices.

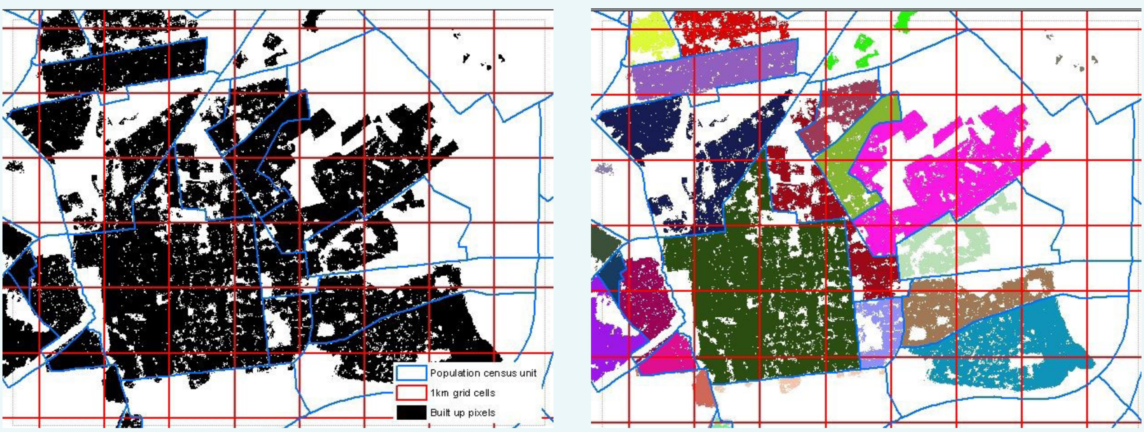
Use of population density variables –
in this option, density measures, which mimic conventional population density measurement (population/area) are used to estimate the number of people within the public transport stop service areas. This approach results in huge generalizations about the population distribution, often assuming that large tracks of unbuilt up land are habited. It is thus not recommended for the indicator computation.

The steps below summarize the process of estimating the number of people with access to convenient public transport based on the service areas created in sub-section 2.3

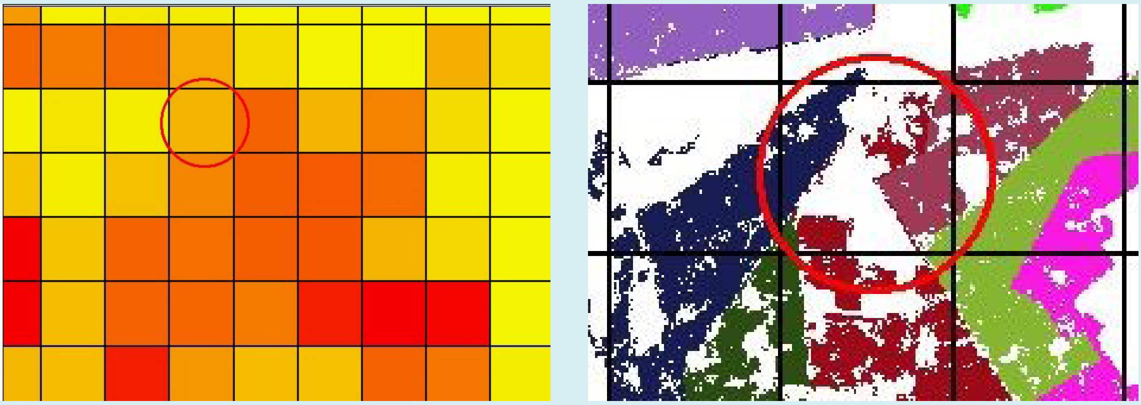
1. National Statistical Offices have high resolution data that can be used to accurately determine the total population within the service areas. To achieve this, overlay the service area created in sub-section 2.3 with population data at the smallest statistical unit (individual households, enumeration area etc) and sum up the number of people living within the service area. Census data and data from other surveys conducted by the NSOs is often disaggregated by sex, age, and sometimes by persons with disabilities. Use this data to estimate access to the public transport stops for each population group (egs women, children, persons with disabilities etc).

2. In the absence of this high resolution data from the statistical offices, you can create population grids using existing population data at the lowest unit it is available (e.g ward level, administrative area unit). This is achieved by distributing the entire census unit population to the habitable land use classes in that city – in most cities, this will be the built up areas class. The general concept is that the entire census unit population is divided by total built up area within the unit, to determine how many people live within a single built up pixel. Use of dasymetric mapping techniques is proposed to distribute the census unit data to the built up areas, particularly because these techniques acknowledge different population distribution aspects – e.g that high density settlements in a city account for a larger share of the population than low density settlements. The assumption here is that each building is habitable and hosts an equal number of people. In the resulting grid, each grid cell will have a unique value, which is dependent on the quantity of the built up areas, the total population and the contribution of each built-up area category to the urban population (figure 5).

Figure 5: Generic approach to creation of population grids



Left: Land use class data is overlaid with population data at the lowest unit; **Right** Dasymetric mapping techniques are used to allocate a population to every habitable land use class cell (in this case built up pixels within the same population enumeration area share a single value based on the assumption that population is equally distributed)



Cell population is aggregated to a reasonable grid cell (1km² in this case). Each grid has habituated and non-habited pixels and a single value that represents either the total population or the population density.

- Similar population grids can be created based on age, gender and disability data, although these will create more generalizations because the associated population traits are highly heterogenous – e.g equal distribution of persons with disabilities within a census unit is highly unlikely and thus a grid on the same may require more input data. If a city /country considers this option as an alternative to estimating access by the different groups, the two critical assumptions that should be considered are that, a) the population is uniformly distributed in all parts of the enumeration area/ census data area, and b) the population parameters follow the trend of the total population (i.e there is uniform distribution of population along the dimensions of age, gender, disability in all parts of the enumeration/census data area).

3. To estimate the number of people with access to public transport, identify all grids which lie within the service area, then sum up their individual populations. To get the percentage share of population with access to public transport in the city, divide the total population within the service areas by the total city population and multiply by 100. To estimate the share of women with access to convenient public transport, divide the total female population within the entire service area by the total female population in the city and multiply by 100. Apply the same method for other types of disaggregation.

2.5 General limitations

Data Limitations	Possible Solutions
The methodology described above covers public transport service solely based on proximity analysis to transport stops. It does not incorporate temporal dimension associated with the availability of public transport. Factors such as affordability, safety and universal accessibility may influence the usage of public means of transport.	• The temporal aspect is important in measures of accessibility, as a service within walking distance is not necessarily considered as available if waiting time goes beyond a certain threshold level that is required. Additional data is required to factor determine how quality impacts on use and access to public transport
Harmonized global/local data on urban transport does not exist, nor are they comparable at the world level.	• An open source software platform for measuring accessibility, the Open Trip Planner Analyst (OPTA) accessibility tool, will be available to government officials and all urban transport practitioners. • Expert Group Meeting to harmonize the tools and existing data to ensure a more uniform and standard format for reporting on this indicator.
The road segments should include attributes allowing for a selection of streets accessible to pedestrians; however, road network is not incorporated in the measurement of the target.	• To be able to quantify the ease of access stops; a comprehensive road network is needed. Additionally, calculating how easily people can walk to a public stop is important. • The walking distance could be calculated using a street network taking into account the density of the street network and obstacles such as rivers, steep slopes, highways or railroads, which cannot easily be crossed by walking.

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