MODULE 6

PUBLIC SPACE

UN-HABITAT
FOR A BETTER URBAN FUTURE

PUBLIC SPACE

TARGET 11.7: *By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities*

Indicator 11.7.1: *Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities*

SECTION 1: INTRODUCTION

1. Background

Streets and public spaces define the character of a city. From squares and boulevards to neighbourhood gardens and children playgrounds, public space frames city image. The connective matrix of streets and public spaces forms the skeleton of the city upon which all else rests. Public space takes many spatial forms, including parks, streets, sidewalks and footpaths that connect, playgrounds of recreation, marketplaces, but also edge space between buildings or roadsides, which are often important spaces for the urban poor. Public space forms the setting for a panoply of activities - the ceremonial festivities of the multi-cultural city, trade for the commercial city, the movement of goods and people, provision of infrastructure, or the setting for community life and livelihoods of the urban poor–e.g. street vendors or waste-pickers. Having sufficient open public space allows cities and towns to function efficiently and equitably.

The network of open public space not only improves quality of life but also mobility and functioning of the city. Well-designed and maintained streets and open public spaces can help lower rates of crime and violence, make space for formal and informal economic activities, and avail services and opportunities to a diversity of users; particularly for the most marginalized, where public space is 'the poor man's living room' and important for recreation, social, cultural and economic development. Public space as a common good is the key enabler for the fulfillment of human rights, empowering women and providing opportunities for youth.

Investments in streets and public space infrastructure improve urban productivity, livelihoods and allows better access to markets, jobs and public services, especially in developing countries where over half of the urban workforce is informal.

It is the role of local governments to ensure adequate provision of these spaces, particularly because the private sector, which plays a key role in urban development, has little incentive to provide them. As cities and urban areas all over the world continue to grow at unprecedented rates (often diversifying beyond the formal operational sphere), there is a need to continuously support local and national governments in developing legislation, policy, and norms and practices, which support them to adopt a holistic and integrated approach to the planning, design, development, creation, protection and management of public spaces. Ideally, urban planning systems should have the requirement of adequate public space as part of local and municipal plans. Local governments should be able to design the network of public space as part of their development plans and work with communities to foster social inclusion, gender equality, incorporate multiculturalism and biodiversity, and enhance urban livelihoods; which would in turn contribute to sustainable, productive and prosperous urban systems/ communities.

However, many local governments are relinquishing this role. As a result, rapid urbanization is proceeding in an uncontrolled manner, yielding settlement patterns with dangerously low proportions of public space. Even the planned areas of new cities have sizably reduced allocations of land for public space. To ensure adequate foundation for a well-functioning and prosperous city, UN-Habitat recommends an average of 45 - 50% of urban land be allocated to streets and open public spaces, which includes 30 - 35% for streets and sidewalks and 15 - 20% for open public space.

Public spaces – including streets – are, and must be seen as, multi-functional areas for social interaction, economic exchange and cultural expression among a wide diversity of people. It is for urban planning to establish and organize these public spaces, and for urban design to facilitate and encourage their use, in the process enhancing a sense of identity and belonging.

Safety and security are important dimensions to be considered in any such design, together with vital infrastructure (water, energy and communications). Important conditions for such planning to be successful are the contextual existence of good governance and management arrangements, as well as viable mechanisms to redirect part of the value gains into the nurturing of better quality public space.

Global Public Space toolkit, Pg 4.

City park @ D-Mark /Flickr

2. Rationale for Monitoring

Public space is a vital part of everyday urban life: the streets urban residents pass through on the way to school or work, the places where children play, the local parks in which urban residents enjoy sports and sit at lunchtime. Public space is an open-air living room for city dwellers. Ensuring good quality, multi-functional and well connected public space which reflects class, gender, age and ethnic differences in how people use these spaces is crucial. Some groups, such as women, children, people with disabilities, undocumented migrants or the poor, may be excluded from public spaces if they are unsafe.

Therefore, a good city should foster social cohesion and build social capital, engaging the community in design, management and maintenance of public space. Public space creation, protection, management and enjoyment are ideal opportunities for the involvement of all citizens, ensuring that individual and differentiated interests are transformed into collaborative practices. It is important to tap into the collective wisdom of those who know the community best–its citizens/inhabitants.

Good public spaces can play a decisive role in this regard by:

1. Allowing for orderly and rational development (i.e. street connectivity).
2. Attracting investment, uses and activities.
3. Increasing property values, thus generating additional municipal revenue.
4. Providing opportunities for economic development and consequent enhanced livelihood opportunities, while generating tax revenue for local governments.
5. Contributing value added to a city's cultural, historical and architectural endowment, thus enhancing urban attractiveness and promoting tourism.
6. Providing room for social and cultural interaction, which foster a sense of belonging.
7. Enhancing safety: Well-designed and well-maintained streets and public spaces can help to reduce fear of crime and violence and contribute to improving safety.
8. Improving public health: a good network of public spaces can help to improve our physical and mental health by encouraging us to walk and play, making walking more attractive, reducing stress and providing a calming environment.
9. Increasing mobility: One of the fundamental functions of public space is that it allows us to move around from our homes to work, schools and other amenities – on foot, by bicycle, by car, motorbike or public transport.
10. Improving the environment: Green and open public space brings many important environmental benefits such as, the cooling of air and the absorption of atmospheric pollutants.
11. Promoting inclusion – which is achieved through creation and/or improvement of spaces to be friendly to women, children, youth and the elderly

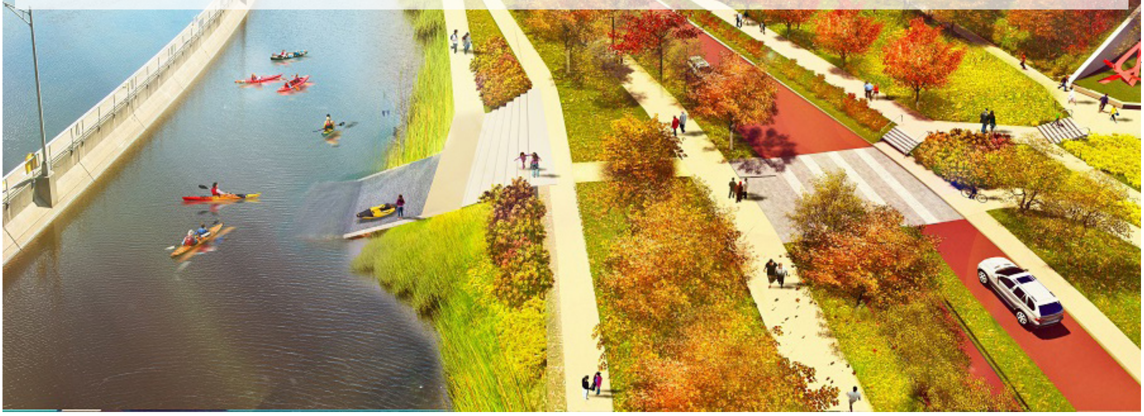
The creation, rehabilitation, protection and management of public space is most often the prevalent responsibility of local governments. This requires the active collaboration of citizens, civil society and the private sector.

As such, the purpose of monitoring progress against the SDG 11 Target 11.7 (Indicator 11.7.1) is to provide necessary and timely information to decision makers and stakeholders in order to make informed decisions and accelerate progress towards providing universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities. Regular monitoring and reporting will be done every 5 years, allowing for 3 reporting time points until the year 2030.

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 are able to make appropriate decisions on the best policies and actions to adopt, whilst systematically documenting their performance at the outcome and impact levels.

Minneapolis, USA, is known throughout the USA as a city with a high quality of life, with 14.9 percent of its land area dedicated to public green space and 94 percent of residents are within a ten-minute walk of a park . One of the reasons for this is the abundance of open spaces and parks. The city has sparkling lakes, a dynamic riverfront, quiet creeks and gushing waterfalls all linked by the Grand Rounds National Scenic Byway. In addition, multitudes of neighbourhood parks provide important gathering and recreation space. Several parks and trails in Minneapolis are also part of the premier Regional Parks System. Envisioned 125 years ago, the Minneapolis Park and Recreation Board (MPRB) managed park system delights Minneapolis' residents and visitors. Minneapolis residents also benefit from the presence of other open spaces such as school facilities, greenways, gardens, and plazas. Open spaces and parks make up a collection of formal and informal landscapes used in numerous ways by a diversity of residents.

http://www.ci.minneapolis.mn.us



Minneapolis park render @ Minneapolisparks.com

3. Monitoring and reporting of the indicator

- National Statistical Offices (NSOs) have the sole responsibility of ensuring that data on public space is made available. Additionally, National governments and local governments are encouraged to work together, which will entail enhancing their statistical capacities, tapping into the potential of new and non-traditional data sources for spatial analysis.

- UN-Habitat and its partners will work closely to provide capacity building and quality assurance support for the various components of the indicator.

- NSOs are responsible for national level reporting. Global and Regional level reporting will be conducted by, the custodian agency.

Monitoring of the indicator will be repeated at regular interval every 5 years, allowing for 3 reporting time points until 2030.

Following recommendations by the Inter-Agency Expert Group on the SDGs (IAEG-SDGs), the methodology for computing this indicator relies 80% on analysis of satellite imagery and use of population grids.

3.1. Concepts and Definitions

Indicator 11.7.1 has several concepts whose definitions require global consultations and consensus. These include, among others, built-up area, cities, and open spaces for public use. As the main custodian agency for SDG 11, UN-Habitat has engaged many partners and held several expert group and consultative meetings to come up with globally applicable and acceptable definitions. This section presents the variety of emerging definitions, as well as the working definitions used to measure the indicator.

a) City:

This indicator adopts a functional as opposed to administrative boundary-based delimitation of a city. The recommended functional definition follows the concept of "urban extent" developed by New York University and applied on a global sample of 200 cities. This definition views a city as an operational entity that incorporates both built-up areas and open spaces, which often extend beyond official/ formal administrative boundaries (refer to a manual titled "city definition using built up area density: GIS workflow").

b) Built up area

This is the contiguous part of a city occupied by buildings and other impervious surfaces. However, built up area as used in the indicator denominator means the same thing as the functional city area (see definition of city).

c) Public Space :

The Charter of Public Space defines Public Spaces as "all places publicly owned or of public use, accessible and enjoyable by all for free and without a profit motive". This definition favours public ownership because "such ownership guarantees more stable access and enjoyment over time. The charter further distinguishes between four typologies of public spaces: a) **streets**, b) **open public spaces**, c) **public facilities** and d) **markets**. Over the last 3 years, UN-Habitat through the Global Public Space Programme has been working with cities to undertake assessments of public spaces across these four typologies. For computation of indicator 11.7.1

i) **Streets** are defined as thoroughfares that are based inside towns, cities and neighborhoods; and are commonly lined with houses or buildings and offer an essential urban function for both pedestrians and vehicles – mobility. They are public spaces by virtue of their being publicly-owned and maintained, accessible and enjoyable by all, mostly without charge and at all hours. Streets are versatile in the nature of activities they host, which range from social and economic to cultural and political uses. The main elements included within the street-space are avenues and boulevards, squares and plazas, pavements, passages and galleries, bicycle paths, sidewalks, traffic islands, tramways and roundabouts. Elements excluded from street-space include plots (built-up or unbuilt up), open space blocks, railways, paved space within parking lots and airports and individual industries.

ii) **Public Open Spaces** Refer to undeveloped land or land with no buildings (or other built structures) that is accessible to the public, and that provides recreational areas for residents and helps to enhance the beauty and environmental quality of neighborhoods. Types of open public space vary across cities and can broadly include parks, gardens, playgrounds, public beaches, riverbanks and waterfronts. These spaces are also available to all without charge and are normally publicly owned and maintained. In many cases, however, they are accessible during daylight hours only. Box 1 summarizes hierarchies of public open spaces based on their size and coverage area .

Box 1: Categorization of public open spaces based on size and coverage area

Public open spaces can be categorized into four broad levels, based on their individual sizes and catchment (how far a user might travel to visit them);

1. **Local/pocket open public spaces** – These are small parklets that service the recreation needs of the immediate residential population within a walking distance or 400meters (5 minutes walk). Their average areas range from 0.03 to 0.04hectares and are often used for recreation purposes. In some places, these may include small areas of nature space.

2. **Neighbourhood public open spaces** – these are larger spaces which serve the recreational and social needs of a community. Their areas range from 0.04 and 0.4hectares, and can easily be accessed within 400meters walking distances from households. They can accommodate a variety of activities, such as recreation, sporting, and natural features conservation.

3. **District/city open spaces or city open spaces** – these spaces are mainly designed to provide for organized formal sport. They include substantial recreation areas and some nature spaces. They serve several neighbourhoods with players and visitors traveling from surrounding districts. The size of the spaces range from 0.4 to 10 hectares, and are designed to serve populations within 800 meters or 10 minute walking distance

4. **Regional open space/Larger city parks** – these are substantial facilities for organised sport, play, social interaction, relaxation and enjoyment of nature. They serve one or more geographical or social regions and are likely to attract visitors from outside any one local government area. Their areas range between 10 and 50 hectares.

5. **National/metropolitan open public spaces** – these are large spaces whose areas range from 50 and 200 hectares. They support concurrent uses, and contain such services as recreational, sporting, and basic amenities.

Source: UN-Habitat, City-wide public space strategies: Guide for local governments, draft report 2018

iii) **Public facilities** comprise high maintenance amenities/places that are publicly owned and maintained and are accessible to users without any charge, such as public libraries, civic/community centres, municipal markets and public sports facilities. In many cases, these facilities are only accessible during daylight hours or operating hours. Studies conducted in four countries by the Global Public Space Programme at UN-Habitat have established that, while the management of public facilities could be complex in terms of free access (as some services attract a charge), the non-built up parts of the facilities are an important open space that is freely available to citizens, and that it should be included as part of a city's public open space

iv) **Public commercial spaces** are areas which host markets and accessible commercial activities in fixed premises, public venues and other services (collective and not, public and private), in which the socio-economic dimension of the city is always expressed.

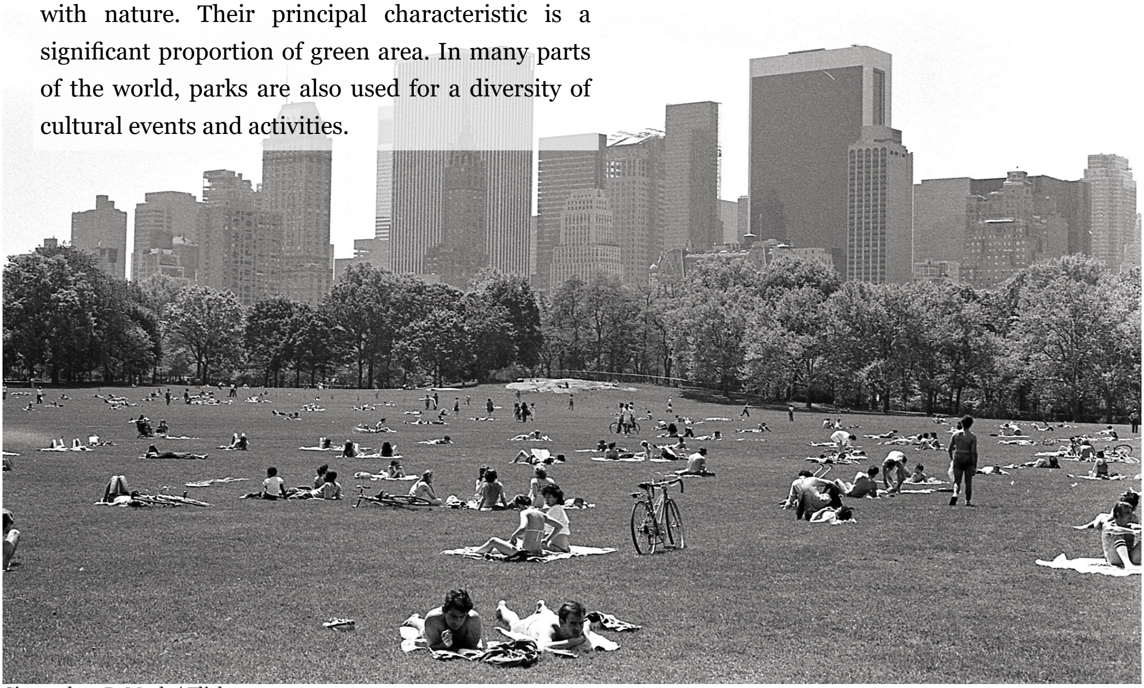
For the purpose of monitoring and reporting on indicator 11.7.1, **public space is defined as all places of public use, accessible by all and comprises streets and public open spaces. It excludes the non-built up parts of public facilities and public commercial spaces**. Cities are however encouraged to collect information on all the four components of public space.

e) Land allocated to streets:

This refers to the total area of urban surface consumed by all forms of streets. This includes land occupied by the actual thoroughfare, walkways, as well as any green area that is officially identified as part of the street space within the target city This indicator only measures networks available at the time of data collection and excludes proposed networks.

Parks

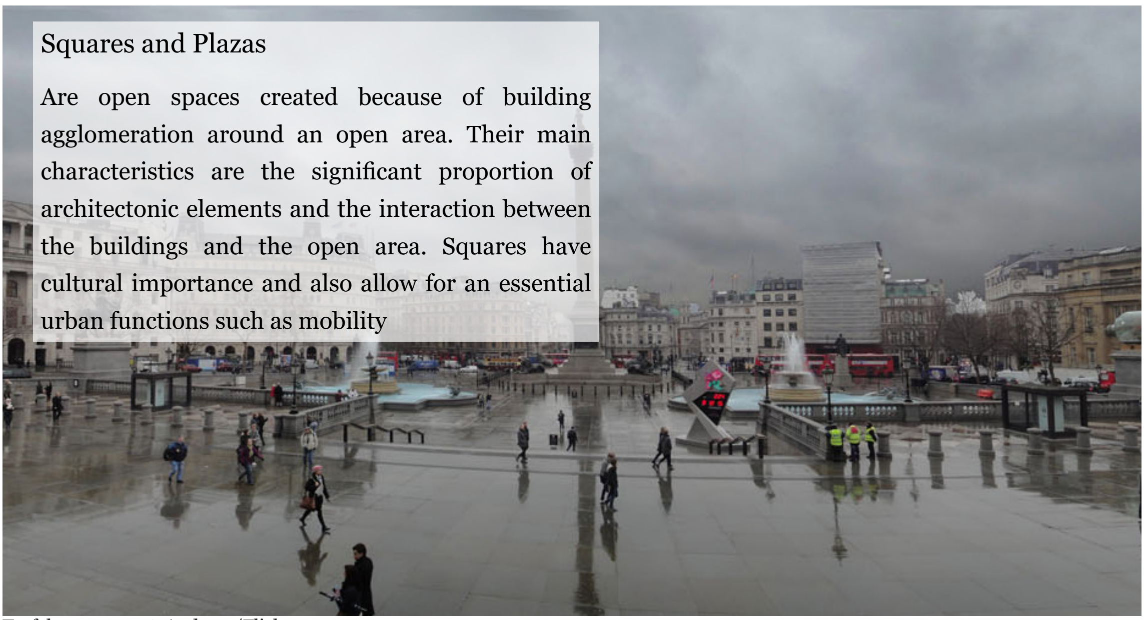
are open spaces inside a municipal territory. Their objective is to provide free air recreation and contact with nature. Their principal characteristic is a significant proportion of green area. In many parts of the world, parks are also used for a diversity of cultural events and activities.



City park @ D-Mark / Flickr

Squares and Plazas

Are open spaces created because of building agglomeration around an open area. Their main characteristics are the significant proportion of architectonic elements and the interaction between the buildings and the open area. Squares have cultural importance and also allow for an essential urban functions such as mobility



Trafalgar square @ Andrew /Flickr

SECTION 2:
HOW TO COMPUTE THE INDICATOR

This section focuses on the procedure for computing indicator 11.7.1: Part 1 identifies the tools required for computation of the indicator, as well as some potential data sources; Part 2 provides a step by step guide on alternative methods of calculating/estimating the amount of land allocated to both open public spaces and streets; and part 3 describes how to estimate the share of the population with access to the public open spaces. .

Part 1: Tools and potential data sources

Tools

- Desktop GIS – commercial (e.g ArcGIS/ ArcMap) or open source (e.g QGIS)
- Image processing software (e.g ErdasImagine – commercial; GRASS, ILWIS, Saga GIS – open source)
- Technical expertise on spatial analysis
- Input data

Data sources

City open space and streets database – this is the most important, and perhaps the most accurate source of data for computation of the indicator. Each country, city and/or urban jurisdiction keeps some or all records on the roads, walkways, public parks and other public spaces, be it in terms of project documents and land use plans or as well constructed databases. While some cities/countries may have this information scattered in different departments, and the data may be old and un-updated, the information contained therein is key to assessing this indicator.

Local knowledge – local knowledge such as that from community leaders, opinion shapers, NGOs working on the ground, etc. is a key source of data, particularly that related to the location and use of open public spaces. In many cities, open public spaces often get converted to other uses such as commercial services, often making them hard to track based on old and outdated city databases and satellite imagery. This information source is particularly also important for identifying open public spaces which can aid primary data collection, as well as helping create a good understanding on disaggregation elements such as safety, usability, provisions for different groups (gender, age), walkability of streets, etc.

Open source datasets –a diversity of open source databases exist at the global and regional levels, which provide relevant information ranging from simple metrics such as presence of streets and their hierarchy to presence and use of various public spaces. Some of the key datasets usable for computation of this indicator include:

i) OpenStreetMap (OSM) – a global database containing information on streets and their hierarchies as well as some key interest areas (including places of public use such as major public transport stations, parks, gardens etc.). Data is freely available through multiple channels and can be downloaded in database and GIS compatible formats. This is a major resource for understanding (urban) street layouts and can be used to compute street lengths (www.openstreetmap.org)

ii) Landsat and Sentinel Missions – these are earth observation satellite missions which perform terrestrial observations of the earth, and produce imagery that can be used to monitor land cover changes. The United States Geological Survey (USGS) and the European Space Agency (ESA) are in charge of the missions, respectively. While Landsat offers imagery with a spatial resolution of 30 meters, sentinel (2) imagery has a 20 meter resolution. Both imagery can be downloaded from the USGS website (https://landsat.usgs.gov/). Sentinel imagery can also be accessed from the Copernicus Open Access Hub (https://scihub.copernicus.eu/dhus/#/home).

iii) Google Earth – is a searchable resource that represents the earth in 3D based on satellite imagery. This resource offers high resolution imagery access that can be downloaded as pictures. It also allows users to measure distances and digitize elements into the map, which features can be downloaded in GIS compatible formats. This resource is particularly important for computation of this indicator, as it can be used as a baseline for initial identification and digitization of open public spaces, to estimate widths of streets as well as to check completeness of street data from OpenStreetMap (where such is the preferred data source option).

iv) Analytical databases – a diversity of databases which offer analytical content on some components on the indicator exist. Key among them is the Atlas of urban expansion (http://www.atlasofurbanexpansion.org/) which has information directly related to the indicator for 200 cities. Other databases include the Gridded Population of the World (GPW - http://sedac.ciesin.columbia.edu/data/collection/gpw-v4) and the Degree of Urbanization Global Human Settlement Grid (http://cidportal.jrc.ec.europa.eu/ftp/jrc-opendata/GHSL/GHS_SMOD_POP_GLOBE_R2016A/).

Part 2: Computing the indicator

The method described in the next sections describes how to measure the share of cities occupied by streets and public open spaces ad defined in part 1. Effectively, the presented steps show how to measure;

- Amount of land occupied by streets (LAS)
- Amount of land occupied by public open spaces – including the non-built up parts of public facilities
- Total share of city that is built up, which in this indicator is used to imply the functional city area as defined through analysis of built up areas

Delimitation of the functional city boundaries should always be the first step in the computation of this indicator, since it helps identify the denominator value and in turn narrows down the scope of data collection. The logic and procedure for achieving this is provided in a separate manual titled **"city definition using built up area density: GIS workflow"** The following sub-sections provide guidelines on how to measure LAS and land occupied by public open spaces; as well as how the data from the three components is put together to compute the core indicator: Average share of the built-up area of cities that is open space for public use for all.

Since this module is designed to be a source of information on the general indicator computation process, as well as help city technical staff to undertake the task, it provides two layers of detail for each computation alternative: a) generic steps and b) analytical instructions in GIS software. The generic steps are designed to give a broad understanding of the method by non-technical GIS personnel, while the analytical instructions are formulated for GIS technical staff as a step-by-step do-it-yourself manual.

> Delimitation of functional city boundaries should be the first step in computation of the indicator as it helps narrow down scope of data collection.

Unit 1:
Estimation of the land allocated to streets (LAS)

The estimation of land allocated to streets can be achieved through various methods, all of which involve some level of spatial analysis. Use of GIS technology and software is thus paramount.

Input data

1. Functional city boundaries file generated through the method described in the manual titled "city definition using built up area density: GIS workflow". GIS compatible format is preferred (e.g. shapefile)

2. Roads data covering the entire functional city boundary area, including both length and width where possible – some of this data can be sourced from city databases or downloaded from OpenStreetMap in GIS compatible format. It however should be noted that OSM data only includes the road centre-lines (no length and width) and is incomplete for some areas.

Computation option 1:
For cities with streets data containing length and width

Some cities have detailed spatial databases (geodatabase) containing information on all their streets – some of whose features could include the shape of the streets (street lines in a GIS compatible format such as shapefile), names, lengths, widths, location of stops or barriers, etc. If such data is available, the following steps can be followed to compute LAS.

1. Generic steps

If the street data has the width and length specified, the following methodology can be used:

i) Select only the streets included in the urban area (or clip streets to the working city boundary)

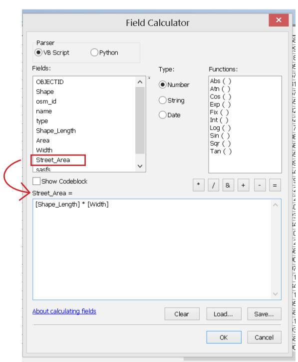
ii) From GIS software, calculate the total urban surface allocated to the streets by multiplying the length with width using field calculator (this is the figure needed for computation of the indicator)

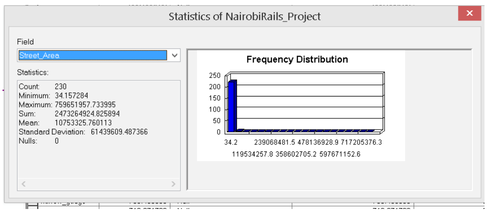
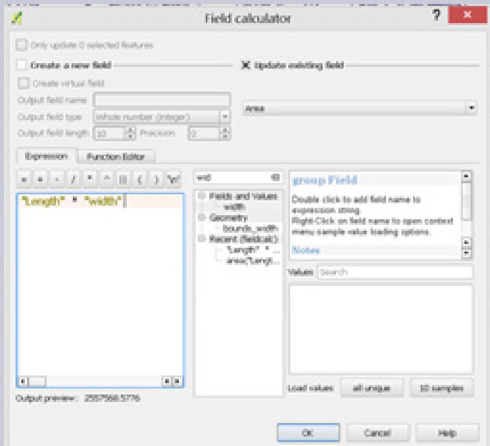
iii) To get the percentage share of city land allocated to streets, divide the total area of streets by the total city area (ensure the units are similar); and multiply the result by 100

$$\text{Land allocated to streets} = 100\left[\frac{\text{Total surface of urban streets}}{\text{Total surface of urban area}}\right]$$

2. Analytical steps

The steps described below are based on the use of two GIS softwares, ArcGIS/ArcMap (commercial GIS software) and QGIS (free and open source software).

Steps in ArcMap	Steps in QGIS
Assumption: The assumption in the steps below is that streets data is in projected coordinate system.	
1. Open a new ArcMap window and add the functional city boundary layer	Open a new QGIS window and add the functional city boundary layer
2. Add the shapefile containing the streets layer	Add the shapefile containing the streets layer
3. If the streets extend beyond the functional city boundary, clip them to the city boundary as follows - Geoprocessing > ArcToolbox >Analysis > Extract > Clip - Select streets layer as your input feature and the functional city boundary as the clip feature. Define location and name of clipped streets. In this example let's call it **City_X_Streets**. Leave the xy tolerance tab to default and click OK. Once the geo-process is complete, add the clip layer to the map. This will be our working file	If the streets extend beyond the functional city boundary, clip them to the city boundary as follows (for all QGIS tools, the easiest method is to open the "processing toolbox" and search for each function from the toolbox search bar)
4. Right click on the City_X_Streets layer and open attribute table. This opens the layer geo-database. Among other things, there should be two columns with the length and width of each street. Some databases could also have the area for each street section.	Processing Toolbox > Clip > Select streets layer as your input feature and the functional city boundary as the clip feature. Define name and location to save the clipped streets layer and click Run. Check the box on "open output file after running algorithm". In this example, let's call it City_X_Streets. This will be our working file.
5. If the area column is not existent, click on the dropdown menu under "Table Options" and select "Add Field". Create a new field called "Street_Area", and select "Double" under Type, then OK. A new column with the defined name will be appended to the end of the attribute table.	Right click on the City_X_Streets layer and open attribute table. This opens the layer geo-database. Among other things, there should be two columns with the length and width of each street. Some databases could also have the area for each street section.
6. Calculate the **street area** by multiplying the length and width. Right click on the menu bar of the Area column and select "Field Calculator". In the window that opens, add the expression: Street_Area = [Length]*[Width] as shown in figure below. The outcome is the area of each street section 	If the area column does not exist, click the tab on "Toggle Edit Mode" to enable editing, then new field to it. Create a new field called "Street_Area", under type select "Decimal Number (real)", define the number length and precision and click OK. A new column with the defined name will be appended to the end of the attribute table.

7.	To get the total area occupied by streets, right click on the Area field at the menu and select "Statistics". A window with a summary of the field will appear, showing the total area (sum) as well as other statistical measures (measures of central tendencies) such as number of items included in the field, mean area, standard deviation etc as shown below. You can also export the entire attribute table into different database formats, or copy and paste the data in MS-Excel and calculate the total area of the streets.  	Calculate the street area by multiplying the length and width. Open field calculator > update existing field and select Area field created in 5 above > from the Fields and Values row number listing, add the length and width and multiply them ("Length"*"Width") under Expression tab > click OK. The outcome is the area of each street section 
8.	In the event that the streets database contains the width of the streets but does not have the length field, such can be calculated automatically in ArcMap through the following steps. Create Length field as per step 5 above > right click on the field and select "Calculate Geometry" > select "Length" under property > define your preferred working units (e.g Meters, Km) and click okay. The area of each street segment with be updated automatically. Repeat steps 5 – 7 above. When the streets are clipped from the original size in step 3 above, the new street length should get updated automatically, although it is good to cross-check by re-calculating the street length.	To get the total area occupied by streets, open the show statistical summary tab (Ƹ). A panel opens below the table of contents. Select the layer to calculate area for > enter "sum ("name f area field created in 5 above")" then click on the Ƹ sign to the right. The total and other measures of central tendencies will be displayed in the aggregates table.
9.	If data on street area is available in the attribute table, repeat step 7 to get the total area allocated to streets.	Automatic calculation of the street length can be achieved by utilizing the geometry "$Length" command in field calculator

Note: For accurate results, make sure to use a projected coordinate system for your streets layer. There are varied ways to re-project data in each software, with different outcomes on the data accuracy. The most important condition is to understand the metrics to use in each re-projection to achieve minimum spatial shift and data error.

To calculate the share of city land occupied by streets, divide the total area occupied by streets by the total city area, and multiply by 100. The units of measurement for both components should be the same (e.g. meters, kilometers, hectares, etc.)

$$\text{Share of city land allocated to streets} = 100\left[\frac{\text{Total surface of urban streets}}{\text{Total surface of urban area}}\right]$$

Computation option 2:
For cities without streets data

Most cities across the world do not have spatially referenced streets data containing length and width fields, which can be used to compute the indicator as per method 1. This creates the need to develop an alternative method to not only generate data on the location of the streets themselves, but also establish their lengths, widths and areas. While this method assumes that such data should be generated from scratch, it also acknowledges that some patches of information are available in cities; and proposes that such data should be fed into the computations proposed in the following sections.

For small cities, it is possible to manually digitize all streets and measure their lengths and widths, which data can be used to compute LAS using method 1. For large cities, this is not possible, something that requires adoption of spatial sampling methods to collect the data. The steps below can be applied by large cities to define representative samples, collect data in the sampled areas and to aggregate this data for computation of city level LAS

Generic steps

i) Using the functional city area outline, create a sampling frame in GIS software. While many methods exist for spatial sampling, the proposed method is the Halton Sequence of Points approach. The preference for this method is based on its ability to generate more evenly spread points across space, as well as its ability to return the same points for the same area when applied repeatedly. Based on experiments done by New York University in a global sample of 200 cities, using the city area to determine the density of sampling points can create a good balance between data accuracy and efficient resource use. In this stage, sampling points proportional to the city size are randomly identified using Halton sequence.

ii) Buffer each sampling point to a radius of 178.4 meters, so as to attain a circle with an area of 10 hectares (1,00,000 m^2) around each sampling point. These are the areas where data will be collected and each is called a locale.

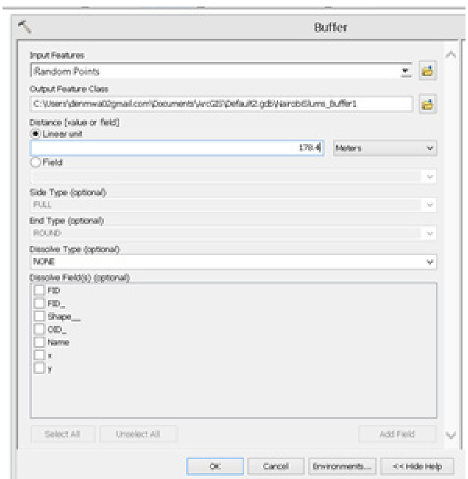
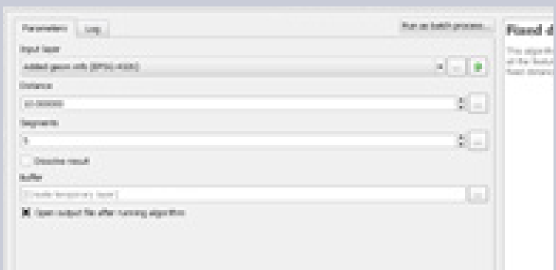
iii) In GIS software, manually digitize the land occupied by all forms of streets within each locale. An alternative is to: a) clip any available streets data (particularly lines drawn at the centre of each street, commonly known as centrelines) to each locale, b) measure the width of each street section from satellite imagery or google earth, c) buffer the centreline using the street width to define the actual area occupied by the particular street section, and d) calculate the area of all buffered street sections.

iv) In GIS software, calculate the area covered by the streets in all locales and compute the proportion of land allocated to streets in all locales using the formula below:

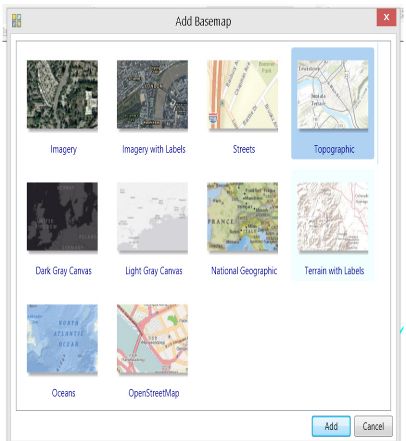
$$\text{LAS in all Locales} = 100\,\frac{\text{Total area of streets in all locales}}{\text{Total area of all locales}}$$

v) The resultant figure is the proportion of land allocated to streets in the target city.

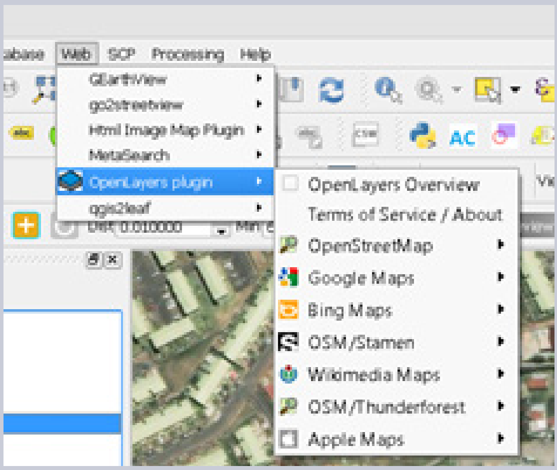
Analytical steps

Steps in ArcMap	Steps in QGIS
A: Sampling	
Use the Halton sampling matrix supplied by UN-Habitat to generate random points for city based on the functional urban extent boundaries. This is an Microsoft excel sheet which generates geo-referenced points based on the areas' input coordinates. The matrix is distributed with a brief training manual.	
B: Data generation and computation of indicator	
1. Add the randomly generated points in A above to ArcMap and buffer them to a radius of 178.4 meter by following the steps below: - Under the geoprocessing tab, open the Buffer tool (you can also access this from ArcToolbox > Analysis > Proximity > Buffer). Use the random points layer as your input features, define the output folder and file name and input the 178.4 as a Linear Meter under the Distance tab. Under Dissolve tab select NONE then click OK.  2. Once the geo-process is complete, the "City_X_Locales" layer will be updated to reflect a circle covering an area of 10 hectares. Each circle will represent the unit of data generation in the subsequent steps.	1. Add the randomly generated points in A above to QGIS and buffer them to a radius of 178.4 meter by following the steps below: 2. Create a new shapefile named "City_X_Locales". Define the coordinate system to be the same as those of the points layer (which should in projected coordinate systems). 3. Under Vector select Geoprocessing Tools > Fixed Distance Buffer > and set randomly geListnerated points as the input layer. Set Distance as 178.4 meters, input "1" under segments and click on dissolve results. Set "City_X_Locales" as the buffer layer and click run. The assumption here is that the working units are meters  Once the geo-process is complete, the "City_X_Locales" layer will be updated to reflect a circle covering an area of 10 hectares. Each circle will represent the unit of data generation in the subsequent steps

3. If a high resolution satellite image is available for the city, add it to the map. Open source imagery such as Landsat and Sentinel which can be used to delimit the city area will not be ideal for the next steps. Instead, if no high resolution city image exists, ArcMap offers a wide range of basemaps which can be added to an active map from the "Add" button dropdown tab. You can choose any of these 5 layers: *imagery, imagery with labels, streets, topographic and openstreetmap.* Compare the characteristics of each of these layers to determine which works best for you. Note that you need an internet connection to use these basemaps in your active project.



3. If a high resolution satellite image is available for the city, add it to the map. Open source imagery such as Landsat and Sentinel which can be used to delimit the city area will not be ideal for the next steps. QGIS offers a diversity of high resolution open source base maps such as OpenStreetMap and Bing maps. These are available through the installable OpenLayers Plugin. You need an internet connection to use these base maps in your active project.



4. Once you have added the satellite image/ basemap, each locale will encompass a mix of built up areas, streets, open spaces and other land uses. Our interest is the streets network within the locale boundaries.

4. Once you have added the satellite image/ basemap, each locale will encompass a mix of built up areas, streets, open spaces and other land uses. Our interest is the streets network within the locale boundaries.

5. Create a polygon layer called "Street_Area". You can manually digitize all the streets areas (polygons) for each locale, or you can draw centerlines for each street, measure individual street section widths and use these to buffer the centerlines using the procedure described in 1 above (using the Street_Area as the template). You can also download streets data for almost all cities from the OpenStreetMap website, which you can use as the centerlines.	5. Create a polygon layer called "Street_Area". You can manually digitize all the streets areas (polygons) for each locale, or you can draw centerlines for each street, measure individual street section widths and use these to buffer the centerlines using the procedure described in 1 above (using the Street_Area as the template). You can also download streets data for almost all cities from the Openstreetmap website, which you can use as the centerlines.
6. Once the street polygons are generated, open the layer attribute table, add a new field called area and calculate the area from "Calculate Geometry" tab as described in method 1.	6. Once the street polygons are generated, use the geometry function "$Area" under "Field Calculator" to calculate the street areas for all locales and calculate the total as described in method 1.
7. Calculate the total area of streets in all locales from the Statistics tab (right click on the area menu bar and select statistics)	

To calculate the share of city land occupied by streets, divide the total area occupied by streets in all locales by the sum area of all locales, and multiply by 100.

$$\text{LAS in all Locales} = 100 \left[\frac{\text{Total area covered by streets in all locales}}{\text{Total area of all locales}} \right]$$

The resultant figure is the average of LAS in all locales, which in turn represents the proportion of land allocated to streets in the target city. Similar results can be achieved by computing individual LAS per locale, then getting the average value from all locales.

Unit 2:
Estimation of the share of land allocated to public open spaces

Unlike the sub-indicator on land allocated to streets which can be calculated exclusively based on satellite imagery and spatial analysis, collection of data on the share of urban areas that is allocated to open public spaces uses a mix of image interpretation and expert or ground validation. Open public spaces in the context of this indicator comprise the undeveloped land or land with very minimal or no buildings (or other built structures) that is accessible to the public, and that provides recreational areas for residents and help to enhance the beauty and environmental quality of neighborhoods.

Input data

- Functional city boundaries file – a GIS compatible format is preferred (e.g shapefile). This should be the same area as used for computation of the LAS.
- High resolution imagery covering the same area as the city boundary. In the absence of such imagery, google earth or basemaps available in GIS software such as ArcMap and QGIS can be used.
- City public spaces database, land use plans, cadastral maps or any other official documents.
- OpenStreetMap data on land use and place names

Generic steps

i) If city has an up-to-date database of its public open spaces, use the information to plot such spaces in GIS software and compute their areas. Where necessary, clean data to remove components which are not applicable in the computation of this sub-indicator (e.g. market spaces).

ii) 13. In the absence of such data, undertake image analysis to extract information on open spaces (areas that are not built up). High resolution satellite imagery or google earth imagery can be used in this analysis.

iii) 14. Undertake validation to remove spaces which are not open for public use (e.gs private non-built up land within the urban area), or to add new spaces that might have been omitted during the extraction stage. This can be achieved through analyzing the character of spaces (e.gs size, shape, land cover, etc), comparison of identified spaces with known recreational areas within the city or with data from OpenStreetMap, or consultations with city leaders, local civil society groups, community representatives among others. UN-Habitat has developed a tool for ground validation of the spaces which is openly available for cities. The validation approaches which require primary data collection are capital intensive and may not be feasible for most countries in the short run. Validation based on existing city-level data and continuous stakeholder engagement will produce reliable results at low costs.

iv) 15. In GIS or other database management software, compute land allocated to public open spaces from the final validated data.

v) 16. The proportion of land allocated to public open spaces can be calculated using the formula

$$\text{Share of city land allocated to OPS} = 100\left[\frac{\text{Total area covered by OPS}}{\text{Total city area}}\right]$$

Unit 3:

Computation of core indicator: Average share of built up area of cities that is open space for public use for all

In units 1 and 2, we have learned how to compute the two elements which constitute open public spaces for measurement of indicator 11.7.1. The formula below is used to calculate the core indicator: *Average share of built up area of cities that is open space for public use for all*

$$\text{POPS} = \left[\frac{\text{Total surface of open public space+Total surface of land allocated to sreets)}}{\text{(Total surface of built up area)}}\right] \times 100$$

Unit 4:
Computing share of city population with access to public open spaces

The identification of populations with access to the public open spaces identified in units 1 to 3 is based on the generic argument that, people living within **a pre-defined walking distance** to a given space can easily access and use it without any restrictions.

To help define what an **"acceptable walking distance"** to public open spaces" is, UN-Habitat organized a series of consultations with national statistical officers, civil society and community groups, experts in diverse fields, representatives from academia, think tanks, UN-agencies, regional commissions among other partners. These consultations, which were held between 2016 and 2018 concluded that a walking distance of 400 meters - equivalent to 5 minutes walk, was a practical and realistic threshold. Based on this, a street network based service area is drawn around each public open space, using the 400 meters access threshold. All people living within the service areas are in turn identified as having convenient access to public open spaces. The following key assumptions are made;

- Equal access to each space by all groups of people – i.e children, the disabled, women, elderly can walk a distance of 400 meters (for 5 minutes) to access the spaces (in actual sense, these will vary significantly by group)
- All spaces are open for use by all – i.e there are no limitations to space access
- All streets are walkable – where existing barriers are known (e.g un-walkable streets, lack of pedestrian crossings, etc), these can be defined in the delimitation of the space service area
- All public open spaces have equal area of influence – which is measured as 400 meters along street networks. In real life situations, bigger spaces have a much larger area of influence (see Box 1 on categorization of spaces based on their size and coverage area)
- All buildings within the service area are habitable, and that the population is equally distributed in all buildings/ built up areas

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

1. **Use of high resolution data from national statistical offices (NSOs)** – In this option, population with access to a given public open space is computed by extracting, from high resolution population data, the number of people living within the service area of a given space. Data attained from this source can easily be disaggregated by age, sex and disability. This is the best data source for the indicator computation, but data security laws in various countries prohibit release of such high resolution information.
2. **Use of gridded population** - In this option, a population grid is made by distributing population to each built up pixel/cell (or other classes) and aggregating/disaggregating to the required level of analysis. 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 with total population at 1km2 and 250m grids are available (e.g GPWv4,

GHS-POP). This approach is proposed for the indicator computation in the absence of high resolution data from national statistical offices.

3. 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 with access to an open public space. This approach results in huge generalizations about the population distribution, often assuming that large tracks of unbuilt up land are habited.

Input Data

- GIS layer containing the public open spaces defined in unit 2
- GIS layer containing streets data from unit 1
- Population at the lowest administrative unit – this can be block level, Enumeration Area level, ward level, etc based on country/ city data architecture
- ArcGIS software with Network Analyst Extension is required for this analysis

Generic steps

- Create network dataset using streets data
- Convert public open space polygons to points – where entrance to spaces are known, use this as the space reference point. Create multiple points around the space polygon for spaces which can be accessed from any location
- Using the defined points, create service area for each space. Merge all spaces to create one service area
- Estimate the number of people living within the service area either from high resolution population data from the statistics office or population grids. Calculate the shares of population per indicator requirements – share of women, youth, elderly, persons with disability with access to public open spaces

Detailed steps

The workflow described here uses the Network Analyst Extension in ArcGIS 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 prep 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).

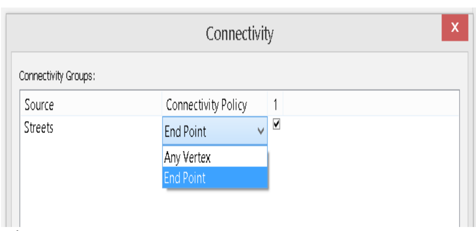


Figure 4.1

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

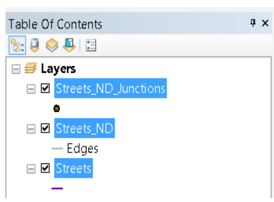


Figure 4.2

3. Convert all open public space polygons into multi-points. For public open spaces where the entrances are known, create a points layer and digitize the entrances as points. In absence of this data, and for spaces which can be accessed from any direction, convert the public open space polygons to a point layer.

– In ArcToolbox, open Data Management Tools > Features > Feature Vertices to Points. Select the public open spaces polygon as your input and define the location and name of output point layer. Select ALL under point type (you can use any of the other options depending on your input data structure and local context). Click okay.

– Add the resulting layer to the map and assess output. Clean the points if required. These points will be your input for the definition of the service area in the next step

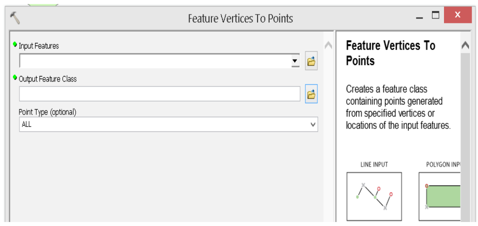


Figure 4.3

4. Activate the network window and select "New Service Area". This creates a new window in the map table of contents (fig 4.4).

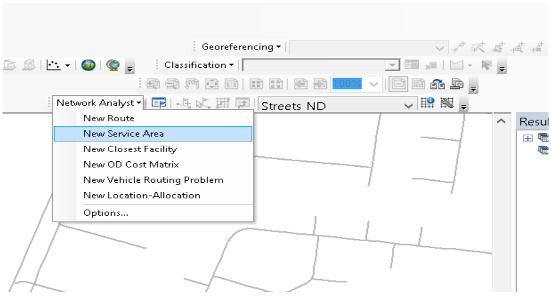


Figure 4.4

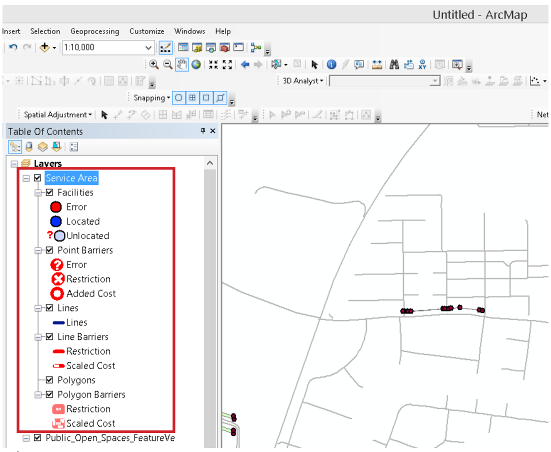


Figure 4.5

5. Click on the Network Analyst Window at the network analyst toolbar. This opens a new window next to the table of contents (fig 4.6). From this window, right click on facilities and select load locations.

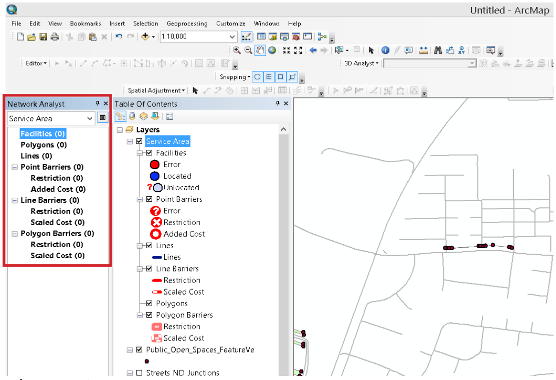


Figure 4.6

6. Select your public open spaces points defined in step 3 above 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 a point of entry to the public open space. In essence, this will mean that if an entry point to a park is more than 100 meters to a street, then that point will not be accessible. The logic here is that for a park to be accessible there should be at least one street within 100 meters of its entrance.

7. Once finished, the loaded facilities 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 (fig 4.7)

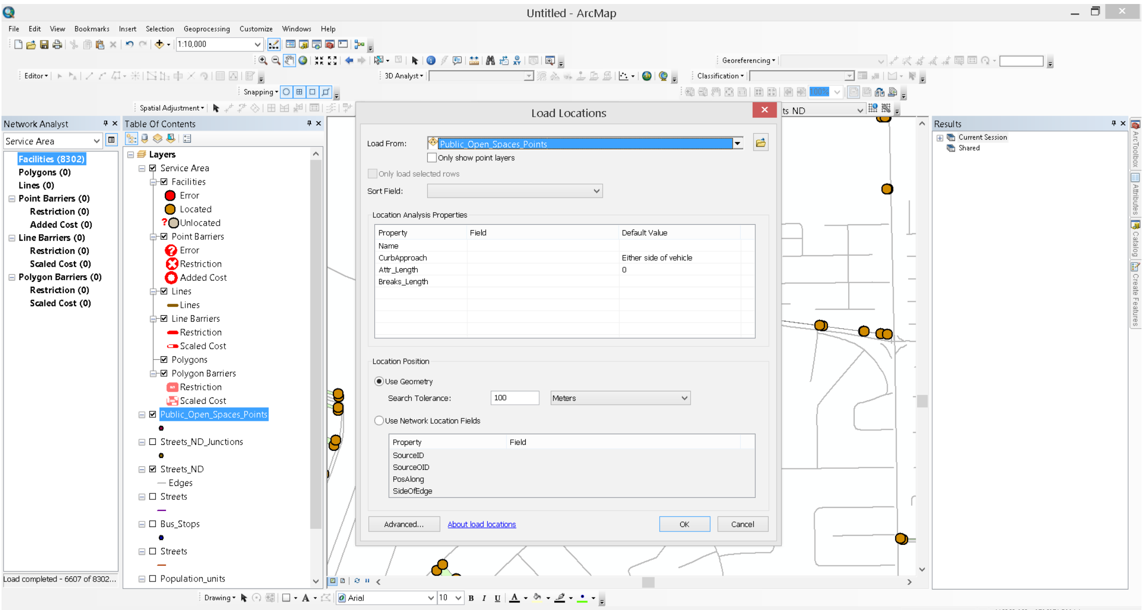


Figure 4.7

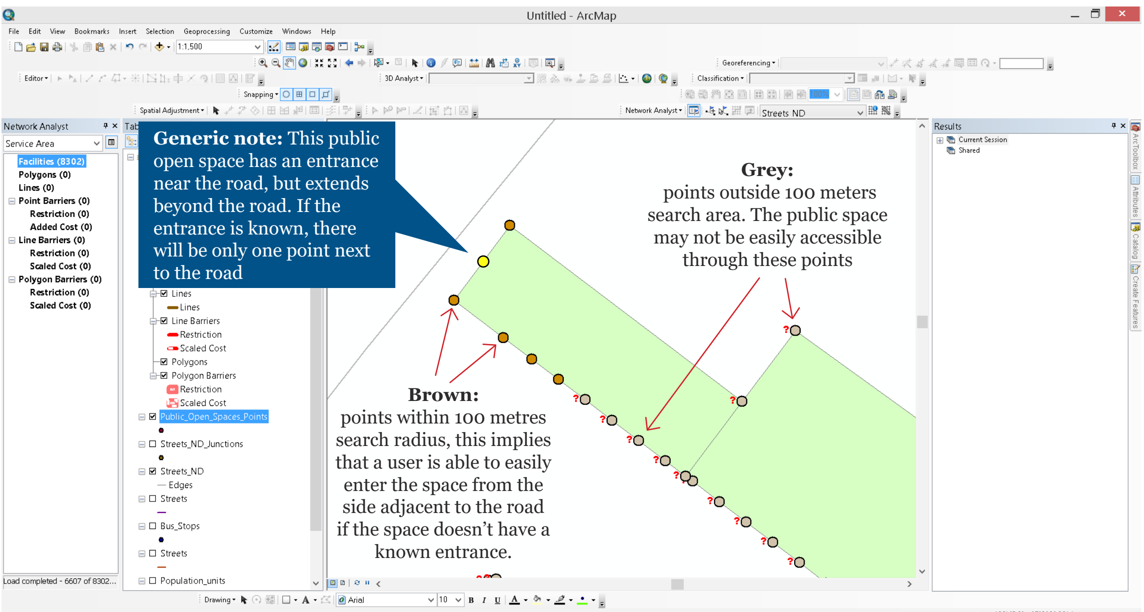


Figure 4.8

8. From the Network Analyst window open Service area properties. Under analysis settings, set length (meters) as the impedance input and add 400 (meters) as the default break value. This is the 400 meters walking distance discussed at the beginning of this unit. 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

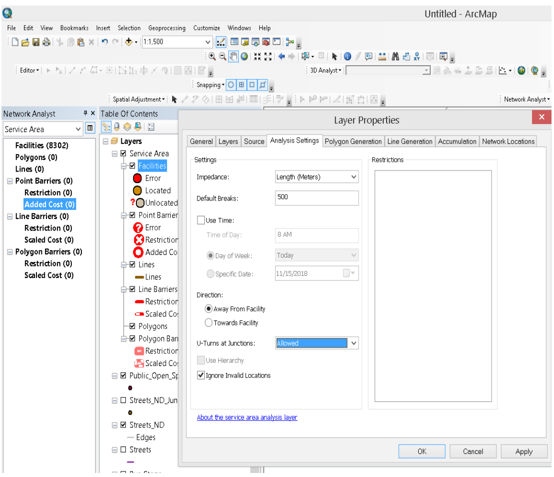


Figure 4.9

9. 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

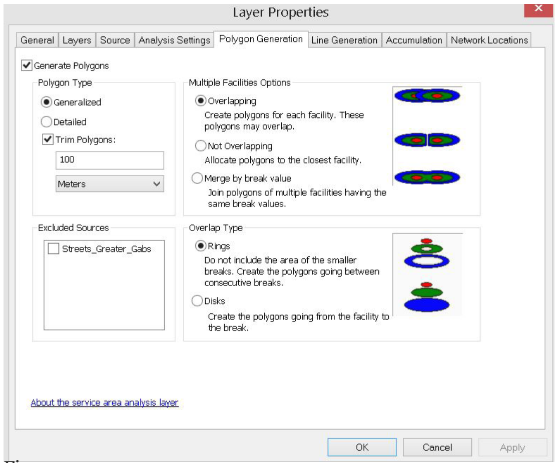


Figure 4.10

10. Under the polygon configuration window, check “generate polygons” and ”select “overlapping” under multiple facilities options. Under polygon type, choose generalized and trim polygons by 100 meters. Click okay. The outcome from selecting overlapping polygons per facility is that a service area will be created for each facility. These service areas will be merged to create a single service area (step 12 below), which will ensure that no double counting of population in areas where the service areas overlap

11. 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 several minutes depending on the number of input points. The resulting service area will resemble what is provided in figure 4.12 below

12. Export the resulting layer by right clicking on the "polygons" layer under the service area layers group. Add the exported "polygon" to the map and start editing. Select and merge all features in this layer. The result is a layer that shows areas which are served by the public open spaces within 400m walking distance. This is the service area for all the open public spaces in that city (figure 4.12).

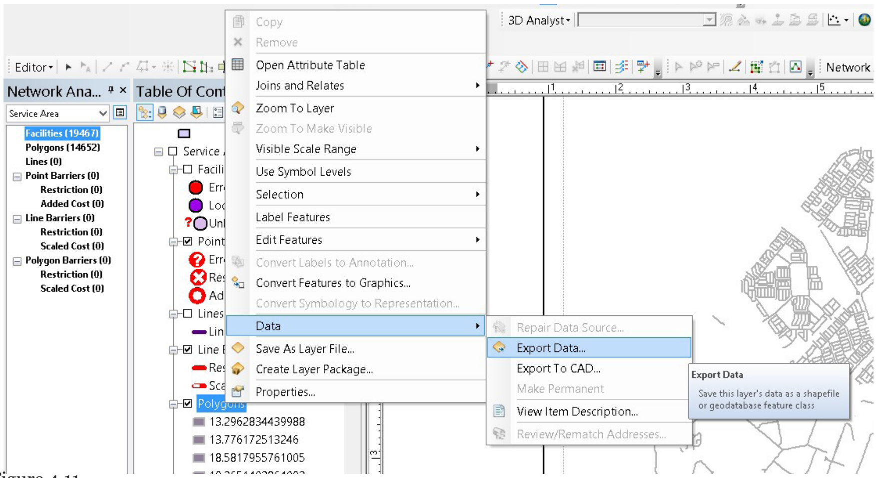


Figure 4.11

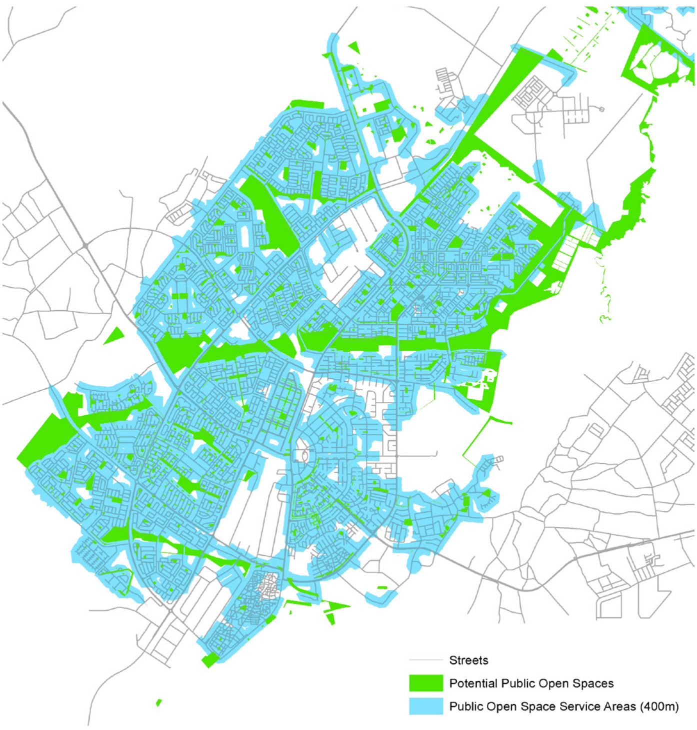


Figure 4.12

Estimating populations with access to public open spaces

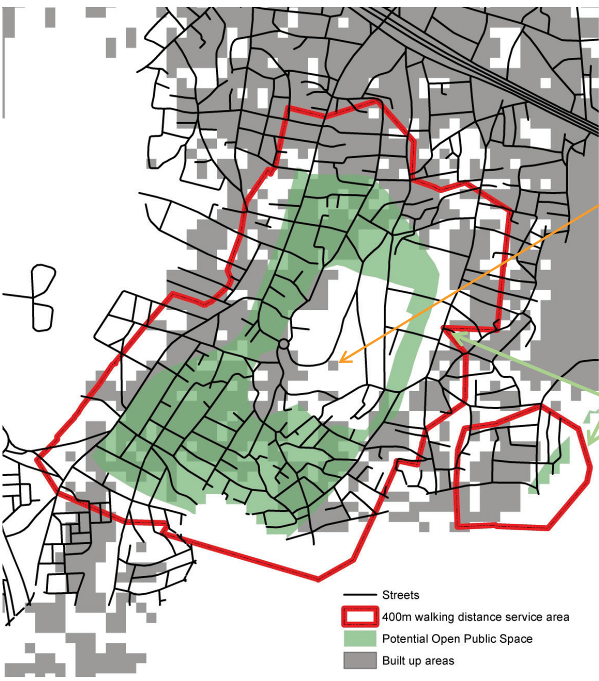
After defining the service areas for all the public open spaces, the next step is to estimate the number of people living within them, which in turn represents the population with access to open public spaces in the city.

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 open spaces 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, infrastructure, social services, etc.
- **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 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 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 the open public spaces.

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 with population data at the smallest statistical unit (individual households, enumeration area etc) and sum up the number of people living within the enclosed 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 open public spaces for each population group (egs women, children, the elderly, persons with disabilities etc).



For example

Number of people per single building = x
People aged < 15 = y
Women in building = w
People aged between 15 > d < 60
People aged > 60 = z
Persons with disabilities = d

Total population with access to OPS = **total no. of people in all buildings within serviced area (x)**

$$\text{Share of age x} = \frac{\text{Total population of age x within service areas}}{\text{Total population of age x within urban area}}$$

$$\text{Share of age d} = \frac{\text{Total population of age d within service areas}}{\text{Total population of age d within urban area}}$$

$$\text{Share of age z} = \frac{\text{Total population of age z within service areas}}{\text{Total population of age z within urban area}}$$

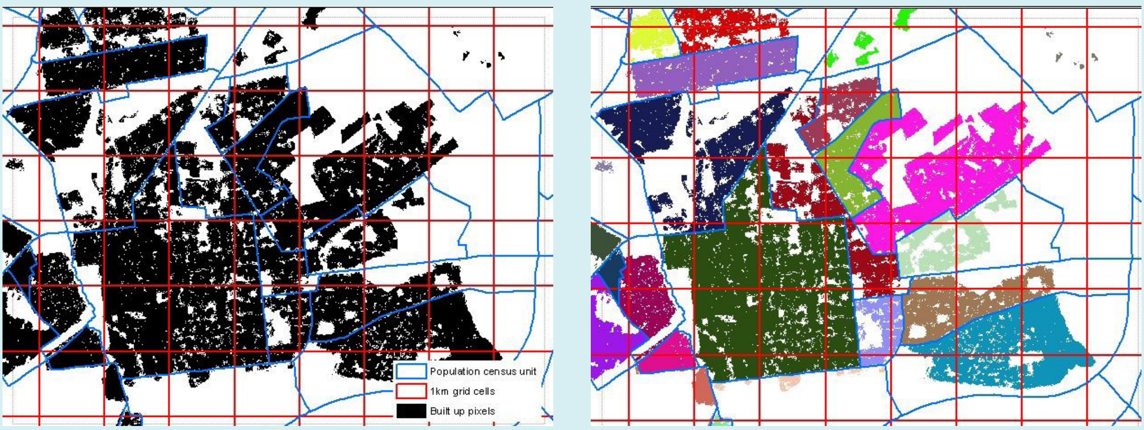
$$\text{Share of women w} = \frac{\text{Total population of age w within service areas}}{\text{Total population of age w within urban area}}$$

$$\text{Share of persons with disabilities d} = \frac{\text{Total population of PWD d within service areas}}{\text{Total population of PWD d within urban area}}$$

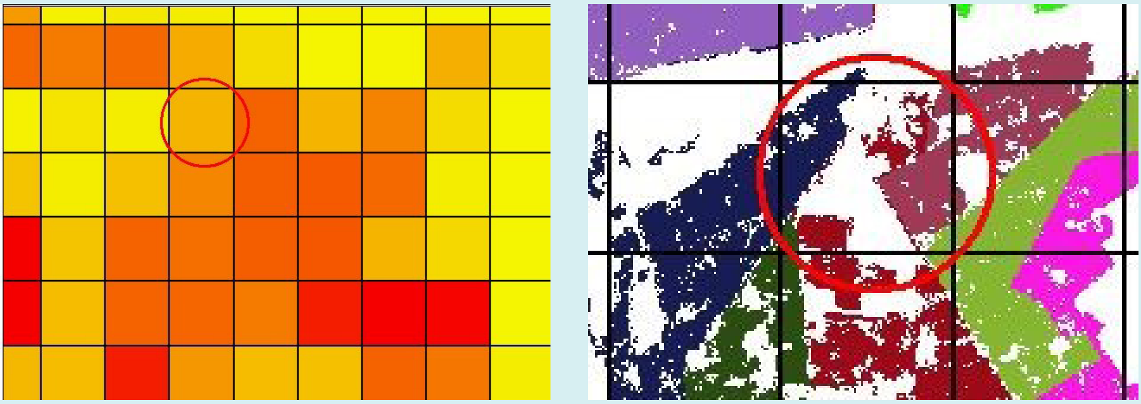
Figure 4.13

2. In the absence of this high resolution data from the statistics 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 4.14).

Figure 4.14: 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, children or the elderly 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 open spaces, 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 such spaces 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 public open spaces, 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.

5.General Limitations

Cities vary considerably in size, history, development patterns, designs, shapes and citizen's attitudes towards public spaces. Measuring how much public space a city has is only one part of measuring whether residents actually benefit from the space.

Gaps in the currently available data for monitoring target 11.7, along with some recommendations of upcoming opportunities for filling them are summarized below:

- As a new and innovative indicator, data availability may be scarce. Many cities lack an inventory of public space, or have one that is not up-to date.
- Efforts should be done to expand the availability of data in the developing world. UN-Habitat has developed tools, programmes and guidelines to assist cities in measuring, and expanding the availability of public space in cities.
- Some cities in the developing world lack formal recognized public spaces that are publicly (freely) accessed and used. Innovative tools like the use of satellite imagery, and community-based mapping can support the identification of potential open spaces in public use.
- The indicator quantifies the amount of open space in public use in cities, but does not capture the quality of the space that may impede its proper use.
- An additional indicator may be helpful to measure some of the limitations to the current one, such as the accessibility of public green spaces. This could serve as a component of a greater indicator for cities on accessibility to destinations, including access jobs, goods and services.

6.References

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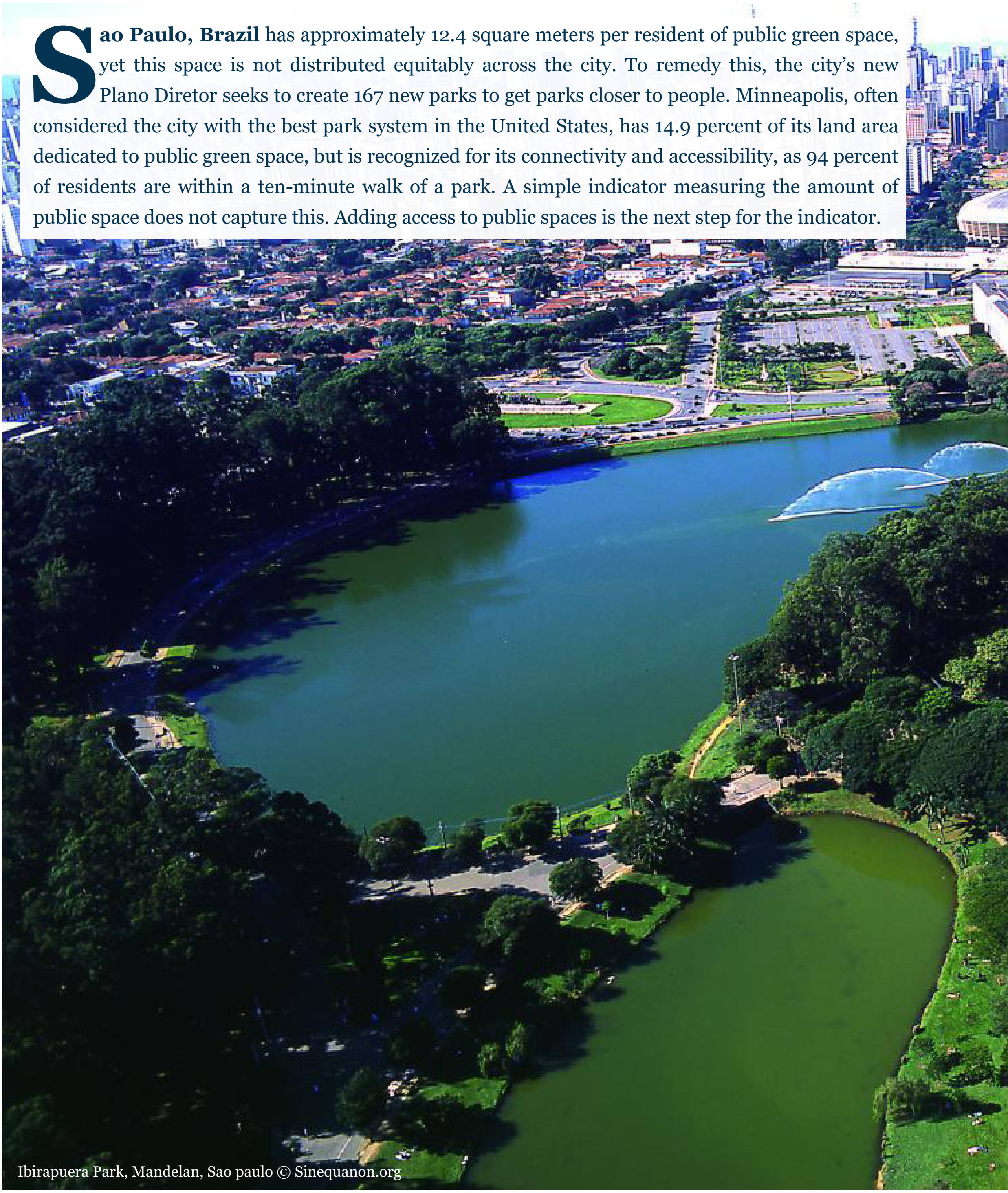
Sao Paulo, Brazil has approximately 12.4 square meters per resident of public green space, yet this space is not distributed equitably across the city. To remedy this, the city's new Plano Diretor seeks to create 167 new parks to get parks closer to people. Minneapolis, often considered the city with the best park system in the United States, has 14.9 percent of its land area dedicated to public green space, but is recognized for its connectivity and accessibility, as 94 percent of residents are within a ten-minute walk of a park. A simple indicator measuring the amount of public space does not capture this. Adding access to public spaces is the next step for the indicator.



Ibirapuera Park, Mandelan, Sao paulo © Sinequanon.org

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