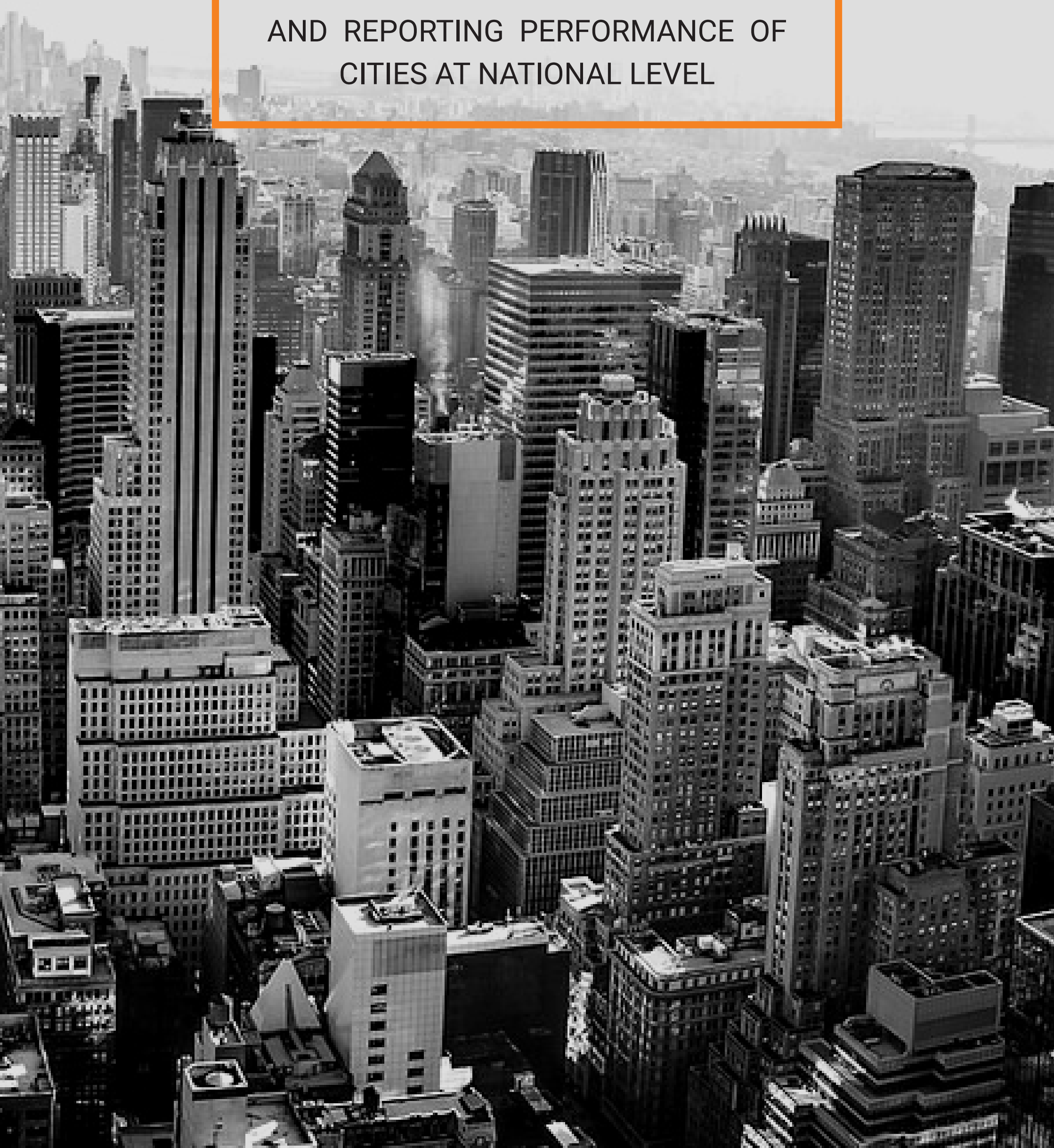
NATIONAL SAMPLE OF CITIES

A MODEL APPROACH TO MONITORING AND REPORTING PERFORMANCE OF CITIES AT NATIONAL LEVEL



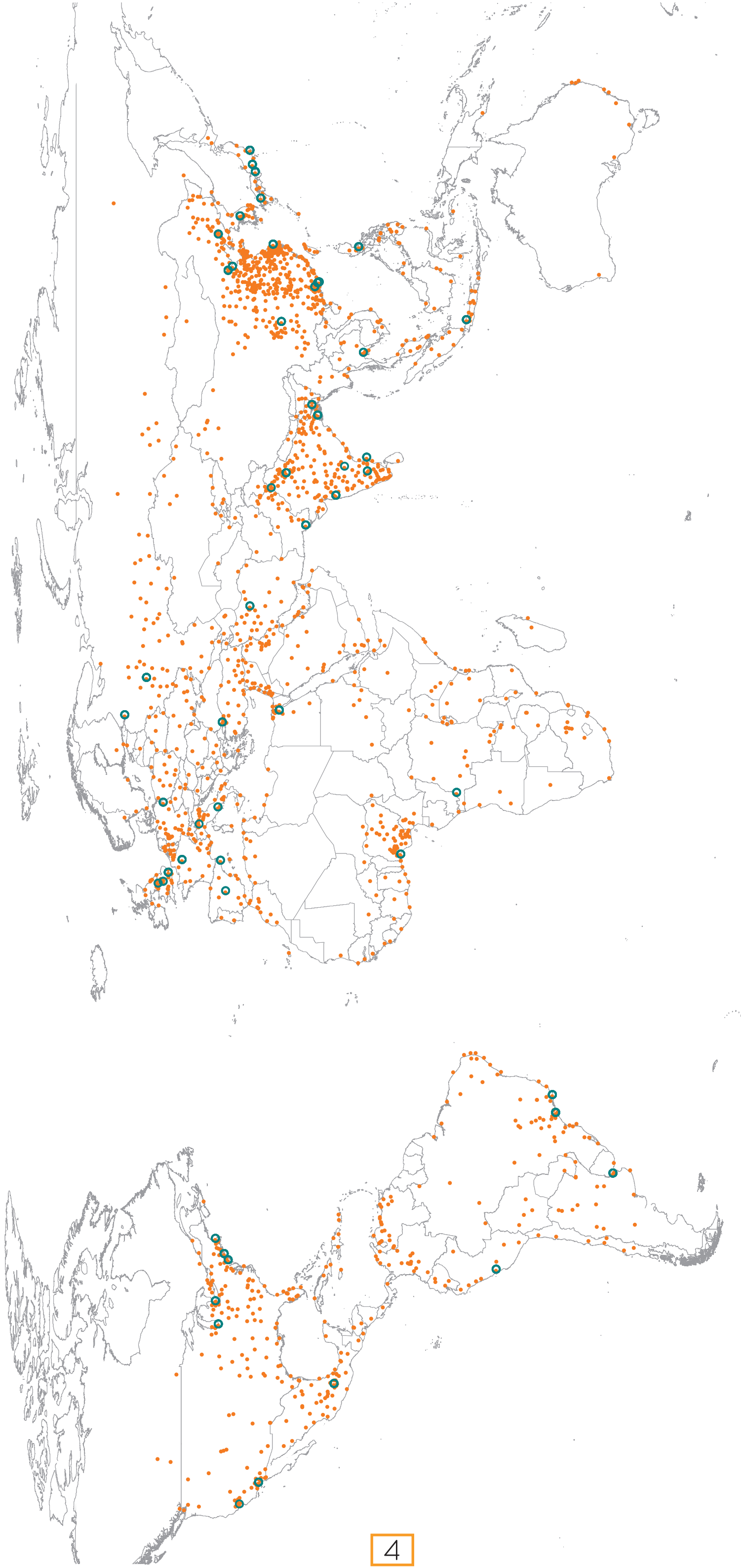
INTRODUCTION

The 2030 Agenda for Sustainable Development gives a prominent role to urbanization and cities with the inclusion of a stand-alone goal for cities and human settlements – Goal 11 "make cities and human settlements inclusive, safe, resilient and sustainable". The role that cities can play in sustainable development is reinforced by the fact that 80% of the SDG indicators have an urban component and around one third of indicators can be measured locally and therefore have a direct connection to urban policies and clear impact on cities and human settlements. There is therefore recognition that cities are central to achieving several other SDG targets going beyond what is covered in Goal 11.

However, SDG 11 monitoring and implementation presents unique challenges unlike the other SDGs. First, some of the indicators have to be collected / computed at city level although the reporting will be done at the national level. This is the case with various Goal 11 indicators such as convenient use of public transport (11.2.1), land consumption (113.1), solid waste (11.6.1), air quality (11.6.2), and public space (11.7.1), as well as with other indicators with a strong urban component such as secure tenure rights (1.4.2) and basic services (1.4.1) for Goal 1. This means that it is important to agree on an operational definition of a city that can be applied worldwide, allowing for global comparison. Secondly, without a standardized method of measurement and clear techniques of aggregation, countries will face serious problems to create a consistent set of cities that is representative of their territory, geography and history as well as facing difficulties to report on national (urban) progress in a systematic manner. Indeed, National Governments and Statistical Offices recognize that it is not possible, and perhaps not necessary, to study each and every city in the country to monitor national trends on SDGs urban indicators, especially in countries with many cities/urban centers. Third, there are other global monitoring challenges related to cities such as the need to use and apply geospatial data for some indicators, putting in place local data coordination, collection and reporting teams, and handling and applying appropriate data disaggregation and aggregation techniques.

It is against this background that UN-Habitat's Global Urban Observatory (GUO) developed the "national sample of cities" approach to facilitate reporting at regional and global levels on locally produced/collected urban SDGs indicators data. This approach allows countries to derive from a complete listing of all their urban centres/cities a representative sample of cities that reflects their systems of cities and ensure that they take into account sub-regional and city specific characteristics and variances. Using this approach, UN-Habitat and partners will assist countries in creating conditions to monitor and report on a consistent set of cities that enable them to produce time series analysis to measure national progress in a more systematic and scientific manner. In addition, the national sample of cities would facilitate an economical way of targeting and setting up appropriate monitoring and reporting systems for cities in countries where resources are a big constraint.

This technical document aims to provide the necessary guidance on how to draw out a national sample of cities by national governments, city leaders and various stakeholders in support of their efforts to monitor and report on urban sustainable development goals/targets. This work is part of UN-Habitat's efforts to provide the necessary technical support to countries and is in line with the numerous requests from national governments to UN-Habitat to assist them in preparing conditions to monitor nationally on indicators that are collected at city level.



WHAT IS A NATIONAL SAMPLE OF CITIES (NSC)?

The national sample of cities (NSC) is a carefully constructed representative sample of cities that takes into account sub-regional and city specific characteristics and variances to monitor the dominant pattern in the country's cities in an aggregated manner in any given country. The NSC will be drawn using sound statistical and scientific methodologies based on a number of relevant city-specific criteria/characteristics that capture the specific contexts of countries, ensuring that the sample is consistent and representative of a given country's territory, geography, size, history, etc. The adoption of NSC approach is a choice that a country must make after weighing the options available for national level monitoring of all cities to report for SDG indicators. Hence, countries that have the resources and means to monitor all their urban centres/cities will be able to continue with that option while those with constraints can adopt this NSC approach.

The NSC is one of the mechanisms that will create conditions to monitor and report on a consistent set of cities that can enable them to produce time series analysis to measure national progress in a more systematic and scientific manner. Otherwise, data produced on various random cities and with inconsistent number of cities in different years will make it difficult, if not impossible, to generate national aggregates in a systematic manner. This will in turn make it problematic to produce national averages and the expected reporting on cities performance.

The flexibility of the NSC allows for national Governments to possibly review the systems of cities over years and add additional cities to ensure that representativeness still reflects the national picture. Also such adjustments could be matched with the need to address other national interests, while at the same time ensuring that national reports are based on the same number of cities and conditions i.e. national representation. Once a NSC is agreed, national surveys and other data collection mechanisms will factor in their design the inclusion of cities from the sample to ensure that data collected in subsequent years is valid and available for these cities in a more continuous manner. Efforts from the private sector and the academia can also converge in the collection of data for the sampled cities, including the production of spatial data and non-conventional forms of data collection.

The NSC approach has a history. It is modelled after the 'Global Sample of Cities' that UN Habitat launched as a tool to measure global and regional urbanization and analyse the effects of urban sprawl on a global scale. UN-HABITAT released the work on the 'UN Sample of Cities' in advance of the Third UN Conference on Housing and Sustainable Urban Development (Habitat III). The global sample of cities was tested and applied in collaboration with New York University's (NYU) Urban Expansion Program, and the Lincoln Institute of Land Policy. The 'UN Sample of Cities' is also used to track trends related to air and water quality, housing affordability, access to enjoyable public space, physical proximity to employment and time to travel from home to work, etc.

The adoption of a NSC by Member States will bring the following advantages:

1. Offers an integrated low cost option for monitoring cities with the possibility to assess city performance in a more systematic manner.
2. Integrate cities of all sizes, functions and types as part of a national system of cities that can help to amalgamate the disjoined energies and potential of urban centres.
3. Assist in the aggregation of locally produced city indicators for national monitoring and reporting, and for the production of regional and global reports and analysis.
4. Provide a platform for collecting different layers of data with a unified methodology that can be used to report on national progress on the SDGs or other elements of the urban agenda. Data collected for all cities can be generalized to produce regional and global estimates and reports.
5. Calculate an un-weighted national average as well as weighted national averages on the overall urban SDGs indicators.
6. Facilitate a systematic disaggregation of information at national, sub-national and city levels along key SDGs indicators and dimensions of development.
7. Create baseline data and information for selected cities of the national sample and redefine local and national targets, propose strategies for improvement, identify setbacks, and monitor progress over time in a more consistent manner.
8. Establish benchmarks and national targets with the same technique of standardization that will enable for comparisons of indicators and city measurements.
9. Articulate a regional and territorial perspective to the monitoring and reporting of the SDGs.
10. Produce consistent data and information that can be used to prioritize activities, ensure strategic investments, monitor coverage of plans and measure their impact.

HOW TO CONSTRUCT A NATIONAL SAMPLE OF CITIES?

Below is a description of the relevant steps that countries could follow in the journey towards adopting the NSC approach or global monitoring;

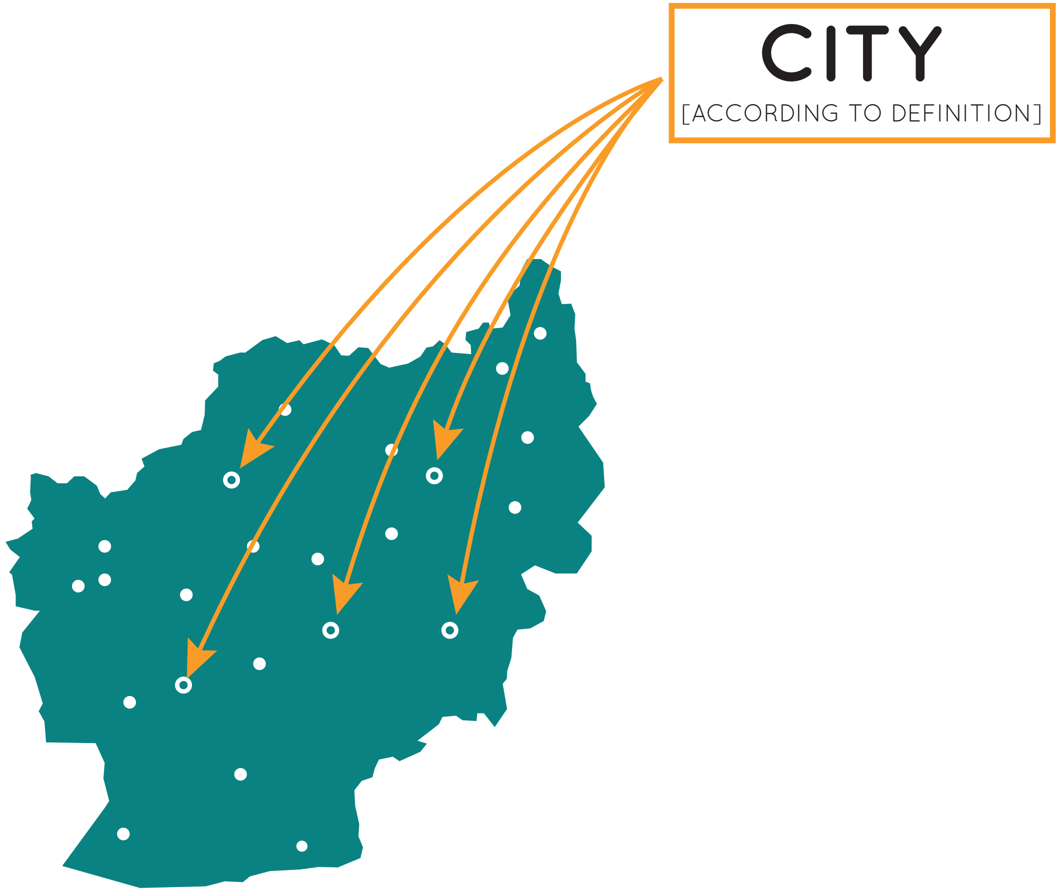
STEP 1
Compiling the national sampling frame of cities

The first step is to identify and compile a complete listing of all the cities in a given country. This identification of all cities requires a definition of what constitutes a city. Given that many urban related SDGs require global monitoring with the 'city' as the unit of analysis, it is necessary to agree on a global/common definition of what constitutes a 'city'. A standard city definition will assist in the monitoring of the SDGs by ensuring that the study areas for the spatial urban SDGs are standardized and easily reproducible, and will add clarity to the methodologies and approaches to the collection of data to support national urban policy related indicators. UN-Habitat in collaboration with New York University, European Commission's Joint Research Centre, and other partners recommend the following two definitions of cities:

1. City as defined by its urban extent (built-up and urbanized open space) and

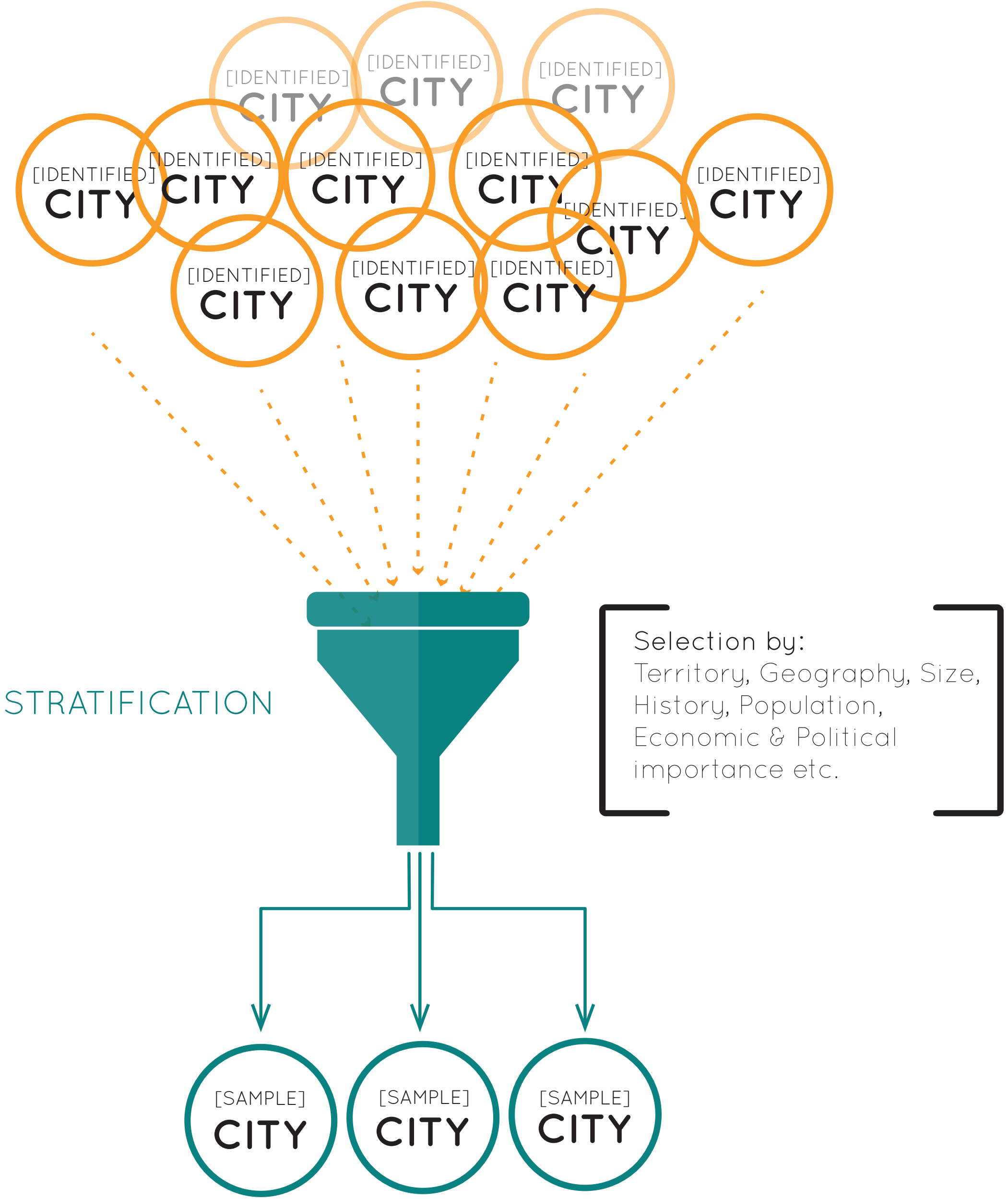
2. City as defined by its Degree of Urbanisation.

Annex 1 provides further details on these definitions. It is expected that these will guide countries in defining the list of all cities. Note that the definition of cities includes urbanized centres which sometimes maybe locally referred to as towns or urban centres. In this case, the definition of towns and urban areas will be subject to the local administrative definition as applied in the country.



STEP 2
Defining and localizing the selection criteria

Once all the cities are listed, it is important to agree on a selection criteria for choosing the representative sample of cities. This should factor in relevant stratification characteristics that will be used for the sample selection, ensuring that the final sample is consistent and representative of a given country's territory, geography, size, history, and systems of cities. In general, the national sample of cities will be drawn using sound scientific methods based, but not limited to the following recommended criteria: city population size, city area sizes, geographical location, city functionality, economic and political importance, etc. Other relevant factors may be added depending on the specific context of countries and decided by national governments . These various stratification characteristics are described as follows:



a. Population Size: This is the total urban population living in each city often obtained from the most recent census, population registers or population projections from relevant government agencies such the National Statistical Offices. The cities in the national sampling cities frame identified in STEP 1 will thus be divided in a number of categories. The number of categories and their ranges (e.g. 20,000- 35,000) depend on the total size of the urban population in a given country and should be determined in such a way that each category has a sufficient and meaningful number of cities.

For example, the number of categories or classes should be determined such that the total urban population in each size class was approximately equal. For example, if the total urban population in a given country X was 5.6 million, the universe of cities may be divided into four categories whose ranges are determined such that each category contains cities that represent approximately 1.4 million people. It is important to note that the division into ranges may result in a highly skewed distribution of the number of cities in each range: smaller cities may be over-represented while larger cities may be under-represented or vice-versa. A practical decision may be taken to ensure the sample is not too biased towards smaller cities or large cities. Table 1 below shows an example of categorization by population size in a given country X.

Table 1: Cities by population size in Country X

Population size	Number of cities	%
Less than 20,000	150	15
20,001 – 50,000	305	30.5
50,001 – 100,000	254	25.4
100,001 – 500,000	186	18.6
More than 500,000	105	10.5
Total	**1000**	**100**

b. City size: Refers to the total surface area of the urban land occupied in a city. Like for the population size category, the number of categories and their ranges depend on the total city size in a given country and should be determined in such a way that each category has a sufficient and meaningful number of cities. For example, the number of categories or classes should be determined such that the total urban population in each size class is approximately equal. For example, if the total population in cities in the given country X was 5.4 million, the cities may be divided into 3 categories whose ranges are determined such that each category contains cities that represent approximately 1.8 million people. Table 2 below shows an example of categorization by city size in a given country X.

Table 2: Cities by City size in Country X

City Area size (km^2)	Number of cities
1-999	376
1,000-1,999	204
2,000-4,999	174
5,000-10,000	146
10,000+	100
Total	**1000**

c. Geographic location: This represents the position of the city within a given country's boundaries. For the purpose of the NSC the geographical location of the cities will be taken to mean the relative position of cities within the countries boundary. Unlike the two preceding characteristics, this criterion is often predetermined in a given country through the regional classification defined by national authorities. For example, a country like Nigeria is classified into six geographical zones: Middle-Belt, North-East, North-West, South-East, South-West and South-South. However, for practical reasons to ensure good representation across the country, national governments may revisit this criterion by creating new categories of regions solely for the purpose of the selection of the cities (e.g. regrouping 2-3 categories into one new category or separating one category into several new categories). Table 3 provides an example of categorization by city geographic location in a given country.

Table 3: Cities by geographic location in Country X

Geographic location	Number of cities	%
North-East	250	25.0
South- East	175	17.5
South-West	246	24.6
South-South	174	17.4
Middle Belt	155	15.5
Total	**1000**	**100**

d. City function: Cities perform various functions that involve production, distribution and consumption of goods and services. The role and extent of these functions varies according to the historical and socio-economic context of each city consequently involving some form of specialization leading to the emergence of cities with specific specialization and functions. Cities in the NSC will be grouped depending on their specific functions. Cities may have the following functions among others: financial centre, commercial centre, manufacturing/industrial centre, administrative centre; entertainment centre (offering sporting attractions, shopping areas, restaurants), knowledge/education centre, cultural/tourist centre; religious centre or place of pilgrimage; transport hub or route centre; residential areas. Unlike the two preceding characteristics, this criterion is often predetermined in a given country but may also vary over time. However, for practical reasons to ensure unbiased representation across the country, national governments may revisit this criterion by creating new categories of city functions (e.g. regrouping 2-3 categories into one new category or separating one category into several new categories). Table 4 provides an example of categorization by city function in a given country.

Table 4: Cities by function in Country X

City function	Number of cities	%
Administrative	340	36.4
Financial	260	23.6
Trade	300	27.3
Entertainment	100	12.7
Total	**1000**	**100.0**

e. Economic and Political importance: Cities do play an important role in economic development. They provide economies of scale, agglomeration and localisation as well as providing efficient infrastructure through concentration in transportation, communication, power, human interactions, water and sanitation services as well as attracting talents and skilled labour that allow the specialization in knowledge, skills which translate to having an important economic and political significance. It is therefore suggested that various cities within a given country be categorized based on their economic and political significance. Economic importance of cities may be captured through the contribution of the city to the national gross domestic product or city income per capita, the amount of foreign direct investment they have attracted; the concentration of corporate headquarters; the number of particular business niches they dominate; road/air connectivity (ease of travel to other cities); financial services; etc.. Some of these characteristics which may not be easily obtained. The economic/political categorization may be defined by key stakeholders given their knowledge of the country's context. However, it is important that such categorization ensures unbiased representation across the country. Table 5 provides an example of categorization by city economic or political importance in a given country. In many cases, this criteria and the one on city function may be combined into one criterion given their relative proximity.

Table 5: Cities by economic or political importance in Country X

Economic/Political importance	Number of cities	%
Category A (Low importance)	300	30.0
Category B (Medium importance)	400	40.0
Category C (High importance)	300	30.0
Total	**1000**	**100.0**

To note, this is not an exhaustive list of criteria; it is rather meant to guide countries in determining a NSC that will help them in monitoring and reporting on urban related SDGs. It is expected that in all countries, vast consultations involving all relevant stakeholders will lead to defining a number of criteria that will be used to produce a national sample that is most representative of the national sets of cities they have. In addition to these six proposed criteria that may be retained or not, other relevant criteria may be identified by the stakeholders based on the country's specific historical, economic and political context.

STEP 1 and STEP 2 should lead to a complete database of all cities with their characteristics recorded as per the defined criteria .

STEP 3:
Selection of the Sample of Cities

a. Defining city clusters/combinations

The next step after building a complete database of cities with all the relevant characteristics is to derive a random sample that is a result of applying the selection criteria adopted by a country similar to what has been described above.

In practical terms, cities will be regrouped in clusters or groups by creating different combinations of the selection criteria. Depending on the number of categories identified for each criteria, all the cities in the universe will be put in boxes or cells such that each box/cell will be representing a combination of each category for all the criteria. So if (C_1, C_2, ….C_n) are the n criteria identified with the n criteria having respectively t_1, t_2 …..and t_n categories, the total number of cells or boxes will be equal to the total number of possible combination between each of their categories, i.e, the product of all categories.

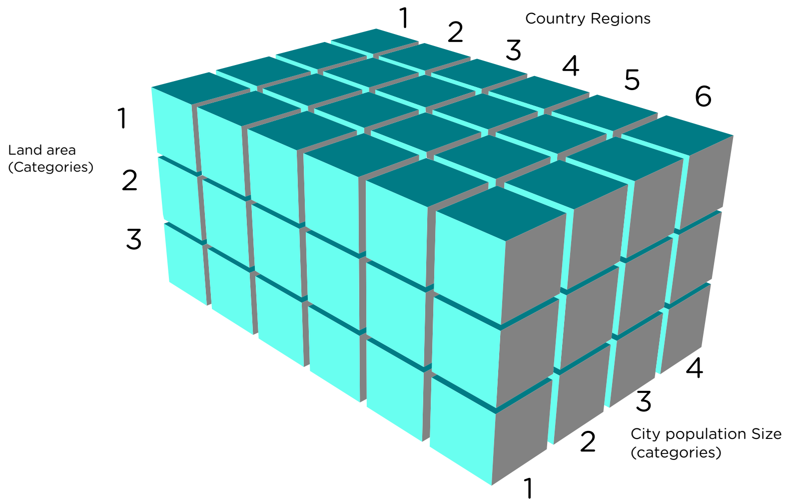
$$C = \prod_{(i=1)}^{n} t_i$$

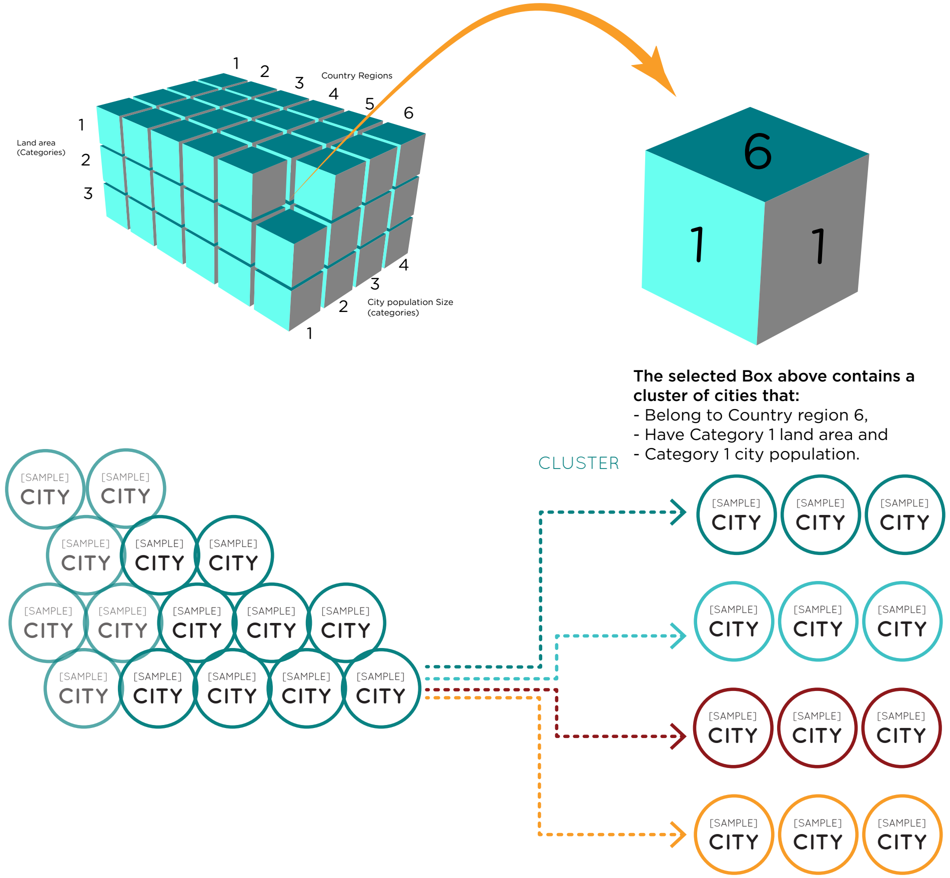
Each box or cell will therefore contain a certain number of cities that correspond to a certain combination.

For example, if for Country X where 3 criteria have been determined (geographic location, city population size, and city area size), with geographic location having 6 categories (Middle-Belt, North-East, North-West, South-East, South-West and South-South), city area size having 3 categories (Less than 15000 km², 15000-50000, and More than 50000), and city population size having 4 categories (Less than 10,000, 10,000-49999, 50,000-99999, At least 100,000), the number of boxes/cells will be: 72 (=6 x 3 x 4).

The simplest way to visualize these combinations (boxes) is to consider these characteristics as dimensions: geographic location along the x-axis, city area size ranges along the y-axis, and city population size along the z-axis. Each city in the country's universe of cities (or in the sample, for that matter) could then be seen as belonging to a box in three-dimensional space, identified by a three-digit number, its geographic location (1– 6), its city area size range (1–3), and city population size (1–4) (see Figure 1).

Figure 1: Visualization of the list of cities combined into 72 boxes, each box corresponding to one of six country regions, one of three city-area-size ranges, and one of four city-population-size ranges (6 x 3 x 4 = 72)





The selected Box above contains a cluster of cities that:
- Belong to Country region 6,
- Have Category 1 land area and
- Category 1 city population.

α) Random sampling within clusters

From the national cities list and from the different clusters identified as described above, a simple random sampling will be applied to select the final list of cities in proportion to their weight in sampling frame in each box or cell. This will be done as follows:

i. Determine the total population in each box/cell in absolute terms

ii. Determine the percentage of the population in each box as a percentage of the total population in universe

iii. Determine the total number of cities in each box/cell

iv. Determine the size of the sample to be drawn in each box/cell, in rough proportion to the total population in each box (as determined in (b)).

v. For each box, randomly pick the desired number of cities

Let us denote S_i as the box corresponding to the combination i, with i taking values 1 to N (N being the total number of boxes/cells, P is the total urban country population, P_i is the total population for the combination/box i, C_i is the total number of cities in the combination/box i, the total number of cities to be randomly selected in the combination/box i will be:

$$S_i = \left\{\frac{P_i}{P}\right\} * C_i$$

Where i=1, 2, …..N corresponding to each of the possible combinations as determined in STEP 3.1.

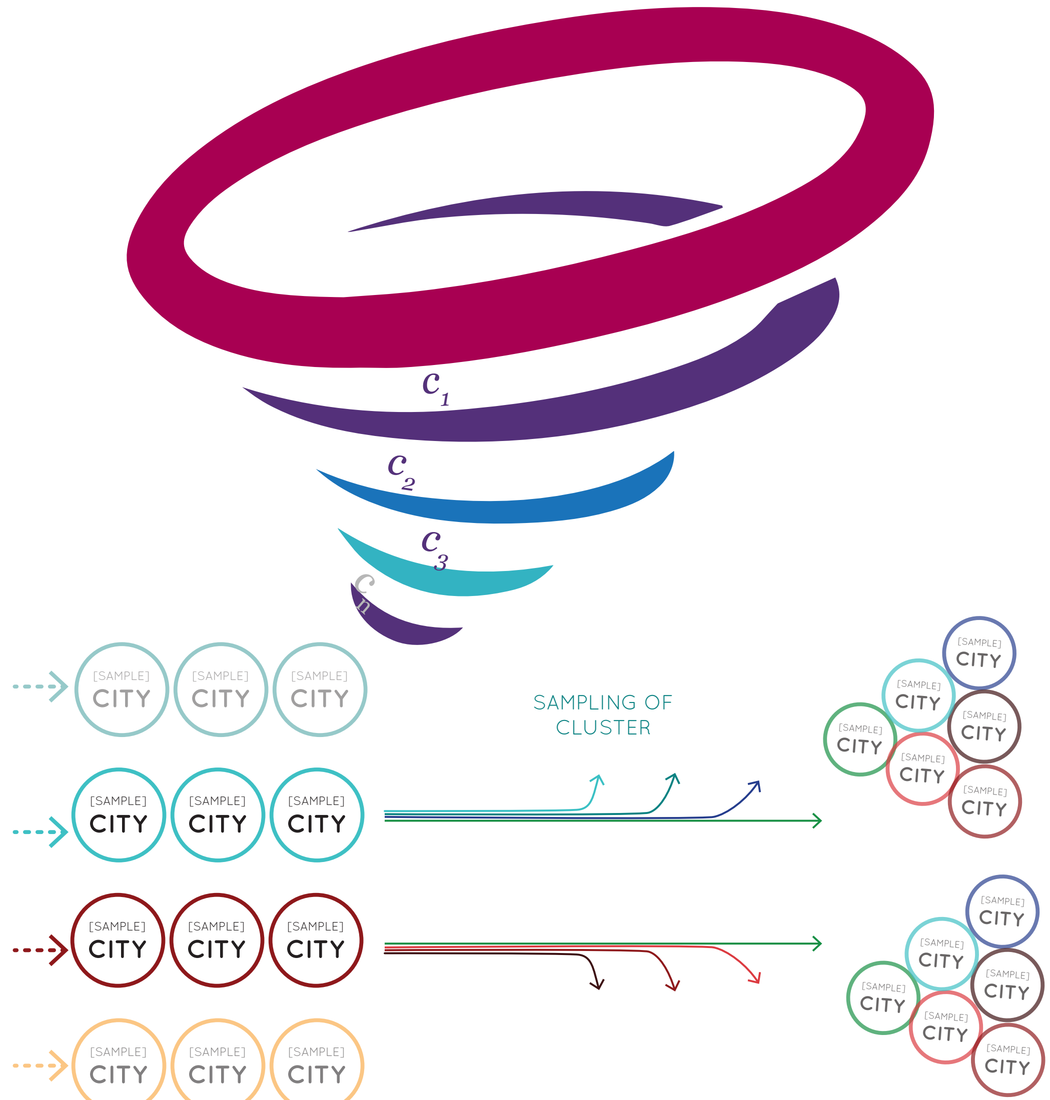
The total number of sampled cities will then be:

$$\sum_{i=1}^{N} S_i$$

To note, it is possible that not all the boxes/cells will have cities; some of them may not have cities, i.e. you may not find cities that will belong to a combination to certain categories. For example, you may not find cities that are in Region 1, with a population of more than 500m and with an area size of 20,000 km^2 or more. So if some boxes are empty, or have only very few cities then they will be merged with the nearest box consequently adjusting the classifications to ensure that each box possess the same characteristics i.e. similar population band sizes, same area size category, and the same geographical region. After the adjustment where for a fairly equal distribution, cities will be selected randomly from each box in rough proportion to the total population in the box.

Table 6: Example of how to calculate number of cities to be randomly selected

Parameter	Calculation
Population in Box 611 (A)	14,992,779
Total Population in Universe (B)	829,516,078
% of Box 611 in total population (C)=(A)/(B)*100	2%
Total cities in Box 611 (D)	320
Number of cities to be randomly sampled from Box 611 (E)= (D)*(C)	6

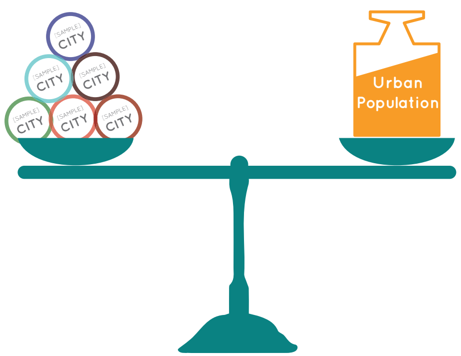


STEP 4:
Weights calculation and representativeness of the sample

It is important to ensure that measures obtained using the final sample are accurate and can be extrapolated to the universe of cities. In a stratified sample, each city in the sample represents a group of cities in the universe and is given a weight that is proportional to the share of the population of this group in the total population of the universe. The weight given to each city in the sample is then used in calculating global measures of SDG 11 indicators and other urban attributes of interest, e.g. access to public open spaces, the availability of public transport, air quality in the sample of cities, among others.

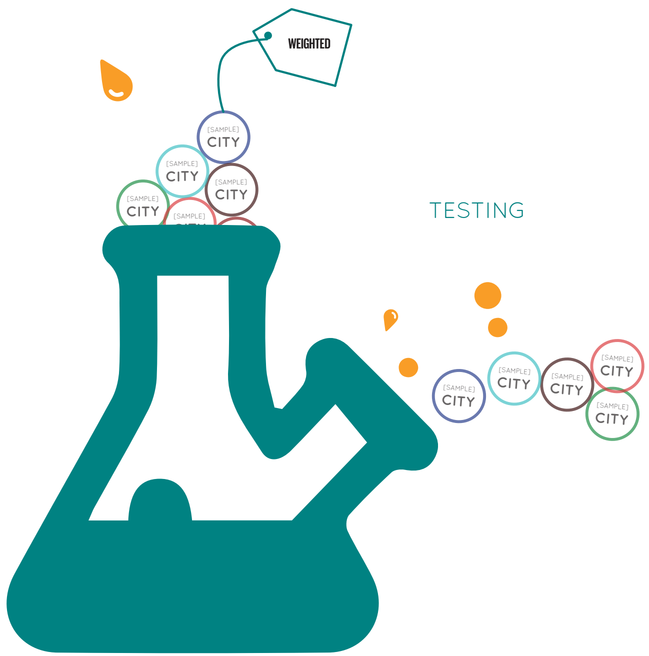
In the example above, 6 cities were randomly sampled out of 320 cities in Box 611, suggesting that 1 city in the sample represented some 53 cities in the universe of cities in the Box 611. Similarly, there are about 15 million in the cities in Box 611, and 1.5 million in the 6 selected cities in the box, suggesting that every resident in the cities in the sample in Box 611 represented 10 residents in the universe of cities in Box 611. The values 53 and 10 can be thought of as city-based and population-based weights respectively that can be used to calculate weighted averages for the universe.

After the sample is constructed, it is important to examine whether it is representative of the universe of cities in the country. For example, on could look at population growth rate as an indicator to test the representativeness of the sample. In this case, one can compare the average population growth rates during a certain period in all the cities in the universe with both the city-based and population-based weighted averages of the cities in the sample during the same period. If they are not different from each other at a certain level of significance (e.g. 95% confidence level), it can be concluded that the national sample of cities is indeed representative of the universe of cities in the country.



STEP 5:
Testing of the National Sample of Cities

Once the sample of cities has been identified, it will be tested in an example that involves monitoring and reporting using SDGs Indicators. This will involve collecting and analysing data pertaining to all the relevant indictors to be monitored and reported by countries. As for the previous stages, all relevant stakeholders will be involved to ensure all views are considered while collecting and analysing the data. This process can also benefit from UN-Habitat's technical assistance. The Agency has prepared a number of tools and guides that could be used during this process. For example, UN-Habitat's City Prosperity Initiative (CPI) can serve as the national framework to monitor the country's urban transformation as it integrates indicators for urban SDGs to address in a single framework the environmental, social and economic components of city sustainability. It also incorporates new analytical tools based on spatial indicators that facilitate a systematic disaggregation of information along the key dimensions of urban development in any given country.



STEP 6:
Preparation of regional and global reports

The final step is the preparation of regional and global reports aggregating data and information produced by the NSC to prove the feasibility and suitability of the method. This process can also benefit from UN-Habitat's technical assistance. As the main custodian agency for SDG 11 indicators, the Agency has prepared a number of tools and guides that could be used during this process.

CONCLUSION

This technical document provides guidance on how to construct a NSC that will help countries in monitoring and reporting on urban related SDGs, providing clarification on the key steps that need to be taken. It is expected that countries go through vast consultations involving all relevant stakeholders during the process of developing a NSC. The steps need to be adapted to the specific context of countries to ensure the final sample is a TRUE representation of the universe of cites in countries. In particular, it is strongly encouraged to define a number of selection criteria to be used to produce a national sample that is most representative of the country's urban space and pattern. UN Habitat will provide other necessary tools that will be used along with this document during the process of developing a NSC.

National statistical systems need to coordinate with local authorities and service providers to collect information at city level, using conventional i.e. data from municipalities, service providers and local communities) and modern forms of data collection (i.e. satellite imagery and ICT), including the integration of spatial data. Efficient capacity building efforts will be necessary as the use of innovative geospatial tools in data collection systems, including census and surveys to measure and to track performance of cities is new for many national statistical agencies and local institutions. The aggregation of the city level data and information at sub-national and national level would be a challenge that requires appropriate tools and techniques to ensure comparability and proper systematization.

Monitoring and reporting using the NSC will allow for better comparability, the production of time series analysis, and the possibility to connect consistent urban data and information to national policies. Member States can aggregate or disaggregate information at national and sub-national level for the refinement of analysis and the formulation of more appropriate policies. The NSC can be seen as an approach that will help cities set up and maintain appropriate monitoring system to support the formulation of more informed policies, as well as evaluate policy outcomes and the impact of specific plans and actions.

It is important to keep in mind the following limitations while developing a NSC:

1. The adoption of NSC can reduce but not to eliminate the lack of consistency and comparability in the use of indicators.
2. A combination of data sources at different administrative levels could make it difficult to homologate information and aggregate values. Monitoring progress on urban SDGs requires a focus on cities as the unit of analysis. There is a need of a common understanding of

what is the definition of the city and its limits. A global operational definition of the 'city' will be fundamental in guiding national statistical systems in the compilation of the list of cities or urban areas and in the collection of information.

3. In many countries, it is possible to find a mismatch between city boundaries and urban data associated to municipalities, metropolises or urban agglomerations. National level guidance is crucial in identifying the number, boundaries and sizes of cities. Countries with a large number of cities are expected to experience more complications in the selection of cities than cities with few cities. The methodology will mostly apply if a country has more than 10 cities to select a representative sample. Countries with less than 10 cities may not need to apply a NSC.

ANNEX

CITY DEFINITION

Many urban related SDGs require global monitoring with the 'city' as the unit of analysis. In order to monitor the urban SDGs, it is necessary to agree on a global/common definition of what constitutes a 'city'. A standard city definition will assist in the monitoring of the SDGs by ensuring that the study areas for the spatial urban SDGs are standardized and easily reproducible, and will add clarity to the methodologies and approaches to the collection of data to support national urban policy related indicators. UN-Habitat in collaboration with New York University, European Commission's Joint Research Centre, and other partners recommend the following two definitions of cities:

a) **City -- defined by its Urban extent (built-up and urbanized open space)**

The definition of **urban extent** described below was developed to facilitate the study of a global sample of 200 cities in the production of the *Atlas of Urban Expansion: 2016 Edition*. It relies on the analysis of satellite imagery to define the boundary of the city morphologically – based on the density of structures, not on the density of population, which we know to be highly variable in different contexts. It supposes that non-residential zones should be thought of as part of the city, along with open spaces such as parks and small amounts of undeveloped land, in addition to residential areas that report populations for the census.

Urban extent is defined as the total area occupied by the built-up area and the urbanized open space. The built-up area is defined as the contiguous area occupied by buildings and other impervious surfaces.

Landsat imagery[1] is used to identify and classify the built-up pixels into 3 types depending on the share of built-up density (urbanness) in a 1-km^2 circle of a given building:

- **Urban built-up area:** pixels where the walking distance circle has a built up density greater than 50%.
- **Suburban built-up area:** pixels where the walking distance circle has a built up density between 25%-50%. It also includes subdivided land, whether it is wholly unbuilt or not.
- **Rural built-up area:** pixels where the walking distance circle has a built-up density of less than 25% and that are not on subdivided land.

The urbanized open space *(mainly refers to unbuilt areas including open countryside, forests, crop fields, parks, unbuilt urban areas, cleared land)* is classified into 3 types:

1 Landsat Imagery is made up of several spectral bands that can be used to identify impervious surfaces roughly corresponding to built-up areas, making it possible to classify them by human-assisted algorithms into several classes with a high degree of accuracy.

- **Fringe open space** consists of all open space pixels within 100 meters of urban or suburban pixels;
- **Captured open space** consists of all open space clusters that are fully surrounded by urban and suburban built-up pixels and the fringe open space pixels around them, and that are less than 200 hectares in area; and
- **Rural open space** consists of all open spaces that are not fringe or captured open spaces.

The fringe open space and captured open space together, make up the urbanized open space in a given study area. In other words, the urban extent consists of all the buildings and the small open space areas (<200 ha) that are surrounded by buildings and the open space fringe that is within 100 meters of urban and suburban areas (i.e where built up area is more than 25%).

b) City -defined by its Degree of Urbanisation (DEGURBA) - European Commission

The Degree of urbanisation (DEGURBA) is a classification that indicates the character of an area. Based on the share of the local population living in 3 different types of clusters, local administrative units (LAUs) are classified into three types of area: thinly populated area (rural area); intermediate density area (towns and suburbs/small urban area), and densely populated area (cities/large urban area) following a 2-step procedure.

In a first step, grid cells of 1 km^2 are classified into one of the three following clusters, according to their population size and density:

- **High-density cluster/urban centre**: contiguous grid cells of 1 km^2 with a density of at least 1 500 inhabitants per km^2 and a minimum population of 50 000;
- **Urban cluster**: cluster of contiguous grid cells of 1 km^2 with a density of at least 300 inhabitants per km^2 and a minimum population of 5 000;
- **Rural grid cell:** grid cell outside high-density clusters and urban clusters.

In a second step, local administrative units are then classified into one of three types of areas:

- **Densely populated area** (alternative names: **cities or large urban area**): at least 50 % live in high-density clusters; in addition, each high-density cluster should have at least 75 % of its population in densely-populated LAUs; this also ensures that all high-density clusters are represented by at least one densely-populated LAU, even when this cluster represents less than 50 % of the population of that LAU;
- **Intermediate density area** (alternative name: **towns and suburbs or small urban area**): less than 50 % of the population lives in rural grid cells and less than 50 % live in high-density clusters;**Thinly populated area (**alternative name: **rural area**): more than 50 % of the population lives in rural grid cells.

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