Metadata on SDGs Indicator 11.3.1
Indicator category: Tier II

Goal 11: *Make cities and human settlements inclusive, safe, resilient and sustainable.*

Target 11.3: *By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries.*

Indicator 11.3.1: *Ratio of land consumption rate to population growth rate*

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1. Institutional Information

Organization(s): United Nations Human Settlements Programme (UN-Habitat)

2. Concepts and definitions

2.1 Definition:

The indicator is defined as the ratio of land consumption rate to population growth rate.

This indicator requires defining the two components of population growth and land consumption rate. Computing the population growth rate is more straightforward and more readily available, while land consumption rate is slightly challenging, and requires the use of new techniques. In estimating the land consumption rate, one needs to define what constitutes "consumption" of land since this may cover aspects of "consumed" or "preserved" or available for "development" for cases such as land occupied by wetlands. Secondly, there is not one unequivocal measure of whether land that is being developed is truly "newly-developed" (or vacant) land, or if it is at least partially "redeveloped". As a result, the percentage of current total urban land that was newly developed (consumed) will be used as a measure of the land consumption rate. The fully developed area is also sometimes referred to as built up area.

2.2 Rationale:

Globally, land cover today is altered principally by direct human use: by agriculture and livestock raising, forest harvesting and management and urban and suburban construction and development. A defining feature of many of the world's cities is an outward expansion far beyond formal administrative boundaries, largely propelled by the use of the automobile, poor urban and regional planning and land speculation. A large proportion of cities both from developed and developing countries have high consuming suburban expansion patterns, which often extend to even further peripheries. A global study on 120 cities shows that urban land cover has, on average, grown more than three times as much as the urban population [1]; in some cases similar studies at national level showed a difference that was three to five times fold. [3]. In order to effectively monitor land consumption growth, it is not only necessary to have the information on existing land use cover but also the capability to monitor the dynamics of land use resulting out of both changing demands of increasing population and forces of nature acting to shape the landscape.

Cities require an orderly urban expansion that makes the land use more efficient. They need to plan for future internal population growth and city growth resulting from migrations. They also need to accommodate new and thriving urban functions such as transportation routes, etc., as they expand. However, frequently the physical growth

Aerial image of Amsterdam, Netherlands © Flickr / European Space Agency.

of urban areas is disproportionate in relation to population growth, and these results in land use that is less efficient in many forms. This type of growth turns out to violate every premise of sustainability that an urban area could be judged by including impacting on the environment and causing other negative social and economic consequences such as increasing spatial inequalities and lessening of economies of agglomeration.

This indicator is connected to many other indicators of the SDGs. It ensures that the SDGs integrate the wider dimensions of space, population and land adequately, providing the framework for the implementation of other goals such as poverty, health, education, energy, inequalities and climate change. The indicator has a multipurpose measurement as it is not only related to the type/form of the urbanization pattern. It is also used to capture various dimensions of land use efficiency: economic (proximity of factors of production); environmental (lower per capita rates of resource use and GHG emissions); social (reduced travel distance and cost expended). Finally, this indicator integrates an important spatial component and is fully in line with the recommendations made by the Data Revolution initiative.

2.3 Concepts:

Population growth rate (PGR) is the change of a population in a defined area (country, city, etc) during a period, usually one year, expressed as a percentage of the population at the start of that period. It reflects the number of births and deaths during a period and the number of people migrating to and from the focus area. In SDG 11.3.1, this is computed at the area defined as urban/city.

Land consumption within the context of indicator 11.3.1 is defined as the uptake of land by urbanized land uses, which often involves conversion of land from non-urban to urban functions.

Land consumption rate is the rate at which urbanized land or land occupied by a city/urban area changes during a period of time (usually one year), expressed as a percentage of the land occupied by the city/urban area at the start of that time.

2.4 Comments and limitations:

The major limitation for this indicator lies in its interpretation. In each human settlement structure, there are many factors at play, that make it more difficult to generalize the implication of a single LCRPGR value to sustainable urbanization. For example, while a value less than 1 could be a good indicator of urban compactness and its associated benefits, intra-city analysis may reveal high levels of congestion and poor living environments, which is against the principles of sustainable development. On the other hand, a value of one may not mean an optimal balance between spatial growth of urban areas and their populations, since it would imply new developments with every unit increase in population. To help explain the values of the indicator, two secondary indicators have been proposed, which use the same inputs as the core indicator: built up area per capita and total change in built up area.

Another limitation in the indicator is where zero or negative growth get reported, such as where population over the analysis period decreases or a natural disaster results in loss of the built-up area mass. Without looking at the land consumption and population growth rates separately, it is difficult to correctly interpret the indicator and its meaning. To address this, it is recommended to understand the individual rates, and also use the proposed secondary indicators to explain the trends.

Aggregating the indicator values for more than one city may also make the interpretation ambiguous. For example, an average value for a country with two cities might be between 0 and 1 if both cities are record values within this range, or if one has a value above 1 and the other a value below 0. The use of the national sample of cities approach, which produces a representative sample for each country will help resolve this challenge.

In some cases, it is difficult to measure the urban expansion by conurbations of two or more urban areas that are in close proximity; to whom to attribute the urban growth and how to include it as one metric usually becomes a challenge. At the same time, data would not always coincide to administrative levels, boundaries and built-up areas. To resolve this, the use of a harmonized approach to defining urban areas and cities has been identified as helping to resolve this challenge.

In the absence of the GIS layers, this indicator may not be computed as defined. As a result, more alternative measures for land that is developed or consumed per year can be adequately used. Alternatively, one can monitor the efficient use of urban land by measuring how well we are achieving the densities in residential zones that any city plans or international guidance call for. Comparing achieved to planned densities is very useful at the city level. However, planned densities vary greatly from country to country, and at times from city to city. At the sub-regional or city levels, it is more appropriate to compare average densities achieved currently to those achieved in the recent past. While building more densely does use land more efficiently, high density neighborhoods, especially in and around urban centers, have a number of other advantages. They support more frequent public transportation, and more local stores and shops; they encourage pedestrian activity to and from local establishments; and they create lively (and sometimes safer) street life.

3. Methodology

3.1 Computation method

The method to compute ratio of land consumption rate to population growth rate follows five broad steps:

a). Deciding on the analysis period/years
b). Delimitation of the urban area or city which will act as the geographical scope for the analysis
c). Spatial analysis and computation of the land consumption rate
d). Spatial analysis and computation of the population growth rate
e). Computation of the ratio of land consumption rate to population growth rate
f). Computation of recommended secondary indicators.

a). Deciding on the analysis period/years

This step involves selecting the time period during which the measurement of the indicator will be undertaken. Since this indicator considers historical growth of urban areas, analysis can be done annually, in 5-year cycles or 10-year cycles. Cycles of 5 or 10 years are commended, especially where use of mid-to-high resolution satellite imagery is used to extract data on built up areas, which is used to compute the land consumption rate component of the indicator. UN-Habitat and partners have been creating a repository of some data on this indicator using 1990 as the baseline year. Countries can however compute the indicator as far as back as satellite imagery is available (1975 for Landsat free imagery) and can maintain the current/most recent year as the final reporting year.

b). Delimitation of the urban area or city which will act as the spatial analysis scope

Urban areas and cities grow in different ways, the most common of which include infill (new developments within existing urban areas resulting in densification), extension (new developments at the edge of existing urban areas), leapfrogging (new urban threshold developments which are not attached to the urban area but which are functionally linked) and inclusion (engulfing of outlying urban clusters or leapfrog developments into the urban area, often forming urban conurbations). Key to note also is that growth of urban areas is not always positive. Sometimes, negative growth can be recorded, such as where disasters (e.gs floods, earthquakes) result in collapse of buildings and/or reduction in the built-up area mass.

Understanding the spatial growth of urban areas requires two important pre-requisites: a) delimitation of an appropriate spatial analysis scope which captures the entire urban fabric (as opposed to just the administratively defined boundaries), and b) use of a growth tracking measurement that helps understand when both positive and negative growth happen. For the former, a harmonized urban area/city definition approach which allows for consistent analysis is recommended, while the use of built up areas is recommended for the latter since it allows for measurement of both positive and negative urban growth.

Following consultations with 86 member states, the United Nations Statistical Commission in its 51st Session (March 2020) endorsed the Degree of Urbanisation (DEGURBA) as a workable method to delineate cities, urban and rural areas for international statistical comparisons. Countries are thus encouraged to adopt this approach, which will help them produce data that is comparable across urban areas within their territories, as well as with urban areas and cities in other countries. More details on DEGURBA are available here: https://unstats.un.org/unsd/statcom/51st-session/documents/BG-Item3j-Recommendation-E.pdf

c). Spatial analysis and computation of the land consumption rate

Using the urban boundaries defined in step (b), spatial analysis is undertaken to determine the land consumption rate. To implement this, the three steps below are followed:

1. From satellite imagery, extract data on built up areas for each analysis year
2. Calculate the total area covered by the built-up areas for each of the analysis years
3. Compute the (annual) land consumption rate using the formula:

Land consumption rate (LCR):

$$LCR = \frac{(LN(Urb_{(t+n)}/Urb_t)}{(y)}$$

Where,

LN = Natural logarithm value

Urb_t = Total of all built-up areas within the urban area/ city in the past/initial year

$Urb_{(t+n)}$ = Total of all built-up areas within the urban area/city in the current year

y = The number of years between the two measurement periods

d). Spatial analysis and computation of the population growth rate

Using the urban boundaries defined in step (b), calculate the total population within the urban area in each of the analysis years where the land consumption rate is computed. Population data collected by National Statistical Offices through censuses and other surveys should be used for this analysis. Where this type of population data is not available, or where data is released at large population units which exceed the defined urban area, countries are encouraged to create population grids, which can help disaggregate the data from large and different sized census/ population data release units to smaller uniform sized grids.

The (annual) population growth rate is calculated using the total population within the urban area for the analysis period using the formula below:

Population Growth rate (PGR):

$$PGR = \frac{(LN(Pop_{(t+n)}/Pop_t)}{(y)}$$

Where

LN = Natural logarithm value

Pop_t = Total population within the urban area/city in the past/initial year

$Pop_{(t+n)}$ = Total population within the urban area/city in the current/final year

y = the number of years between the two measurement periods

Land use in Barcelona,Spain © Thegurdian.

e). Computation of the ratio of land consumption rate to population growth rate

The ratio of land consumption rate (LCRPGR) to population growth rate is calculated using the formula:

$$LCRPGR = \frac{(Annual\ Land\ Consumption\ rate)}{(Annual\ Population\ growth\ rate)}$$

The overall formula can be summarized as:

$$LCRPGR = \frac{\left(\frac{(LN(Urb_{(t+n)}/Urb_t)}{(y)}\right)}{\left(\frac{(LN(Pop_{(t+n)}/Pop_t)}{(y)}\right)}$$

The analysis years for both the land consumption rate and the population growth rate should be the same.

f). Computation of recommended secondary indicators

There are two important secondary indicators which help interpret the value of the main indicator - LGRPGR, thus helping in better understanding the nature of urban growth in each urban area. Both indicators use the same input data as the LCRPGR and will thus not require additional work by countries. These are:

1. **Built-up area per capita** – which is a measure of the average amount of built-up area available to each person in an urban area during each analysis year. This indicator can help identify when urban areas become too dense and/or when they become too sparsely populated. It is computed by dividing the total built-up area by the total urban population within the urban area/city at a given year, using the formula below:

$$Built\text{-}up\ area\ per\ capita\ (m^2/person) = \frac{(UrBU_t)}{(Pop_t)}$$

Where

$UrBU_t$ = The total built-up area/city in the urban area in time t (in square meters)

Pop_t = The population in the urban area in time t

2. **Total change in built up area** – which is a measure of the total increase in built up areas within the urban area over time. When applied to a small part of an urban area, such as the core city (or old part of the urban area), this indicator can be used to understand densification trends in urban areas. It is measured using the same inputs as the land consumption rate for the different analysis years, based on the below formula:

$$Total\ change\ in\ built\ up\ area\ (\% = \frac{(UrBU_{(t+n)}/UrBU_t\ )}{UrBU_t}$$

Where

UrBUt +n is the total built-up area in the urban area/city in time the current/final year

UrBUt is the total built-up area in the urban area/city in time the past/initial year

Detailed steps for computation of the core indicator and the secondary indicators are available in the detailed training module for indicator 11.3.1: https://unhabitat.org/sites/default/files/2020/07/indicator_11.3.1_training_module_land_use_efficiency_french.pdf

3.2 Disaggregation:

Potential Disaggregation:

- Disaggregation by location (operational urban area vs administratively defined urban area, urban wide vs intra-urban growth trends)
- Disaggregation by type of growth (infill, expansion, leapfrogging)
- Disaggregation by city type (large vs medium sized vs small)
- Disaggregation by type of land use consumed by the urbanization process

3.3 Treatment of missing values:

All countries are expected to fully report on this indicator more consistently starting in 2020 with few challenges where missing values will be reported due to missing base map files. Only limited cases of missing values are anticipated, which can emanate from situations where population growth figures are unavailable or where land consumption rates are inestimable due to lack or poor quality of multi-temporal coverage of satellite imagery. Because the values will be aggregated at the national levels from a national sample of cities, missing values will be less observed at national and global levels

3.4 Regional aggregates

Data at the global/regional levels will be estimated from national figures derived from national sample of cities. Regional estimates will incorporate national representations using a weighting by population sizes. Global monitoring will be led by UN-Habitat with the support of other partners and regional commissions.

3.5 Sources of discrepancies

Significant variations between global and national figures are anticipated where globally produced built-up layers are used to compute the indicator. This is largely due to the uniqueness of some local contexts and variations in image reflectance and land cover types, which make it difficult to accurately capture built up areas consistently. While the national figures will be used for reporting – resulting in less differences being observed, some countries may opt to use the globally available products, which may create some variations as locally generated data becomes available. UN-Habitat will be responsible for checking all figures to ensure that no inconsistencies are reported.

The second likely source of differences between figures is the approach used to define urban areas and cities for the purpose of the indicator computation. To resolve this, the use of the degree of urbanization approach to definition of urban and rural areas and production of comparable data is recommended. This approach was endorsed by the UN Statistical Commission in March 2020, and its incremental adoption by countries is likely to reduce any differences in the figures reported in future.

4. Data sources

Sources and collection process:

Population data required for this indicator is available from National Statistical Offices, UNDESA as well as through newly emerging multi-temporal gridded population datasets for the world. Historical built-up area data can also be generated for most countries and cities using mid-to-high resolution satellite imagery from the Landsat and Sentinel missions. Higher resolution data is available for several countries which have a rich repository of earth observation missions or partnerships with commercial providers of high to very high-resolution imagery. Other sources of data for this indicator include urban planning authorities and multi-temporal analytical databases on built-up area at the global level produced by organizations working in the earth observation field.

The production of data for this indicator requires some level of understanding of geospatial analysis techniques at the country level. Several tools have been developed to help with the indicator computation, including systems that allow for on-the-cloud analysis, but users still require some good level of understanding of the process and geospatial analysis to efficiently utilize these tools. Equally, access to internet is needed either to download the free satellite imagery or undertake analysis using existing cloud-based architecture.

National level capacity building initiatives will aim to balance the knowledge and understanding of the analysis, compilation and reporting of this indicator. Global reporting will rely on the estimates that come from the national statistical agencies, who should work collaboratively with mapping agencies and city data producers. With uniform standards in computation at the national level, few errors of omission or bias will be observed at the global/regional level. A rigorous analysis routine will be used to re-assess the quality and accuracy of the data at the regional and global levels. This will involve cross-comparisons with expected ranges of the values reported for cities.

UN-Habitat has developed a simple reporting template that allows countries to input data on the intermediate products (built-up area and population) then get the computed values for each analysis city and period. The template, which will be send to countries every year to report any new data is appended to this metadata and can also be accessed here.

5. Data availability

Description:

This indicator is categorized under Tier II, meaning the indicator is conceptually clear and an established methodology exists but data on many countries is not yet available. The indicator's rapid adoption by countries since 2015 has resulted in increased production of data at the local level, while activities of UN-Habitat and partners in the earth observation field are significantly contributing to availability of baseline data for the indicator. For example, using global datasets such as the Global Human Settlement Layer (GHSL), the World Settlement Footprint (WSF), the

Gridded Population of the World (GPW), WorldPop dataset, the High Resolution Settlement Layer (HRSL) among others can help attain global estimates for the indicator. While some of these datasets have limitations in their application to track city level trends, their wide coverage provides a useful resource for the indicator computation. Higher resolution data is continuously being produced by countries, which are supported by organizations working in the earth observation and geospatial information field of expertise. More than 1,500 cities from more than 80 countries have data at the right resolution required for the indicator computation.

Time series:

Available time series runs at the city and national level for selected countries

6. Calendar

Data collection:

The monitoring of the indicator can be repeated at regular intervals of 5 years, allowing for three reporting points until the year 2030. Since this indicator considers historical growth trends of urban areas, analysis can cover periods as far back as data allows.

Data release:

Updates will be undertaken every year, which would allow for annual updates in reporting at the global level.

7. Data providers

UN-Habitat and other partners such as the Global Human Settlement Layer (GHSL) team, the German Aerospace Center (DLR), partners in the Group on Earth Observations (GEO) and ESRI among others will support various components for reporting on this indicator. The global responsibility of building the capacity of national governments and statistical agencies to report on this indicator will be led by UN-Habitat. National governments/ national statistical agencies will have the primary responsibility of reporting on this indicator at national level with the support of UN-Habitat to ensure uniform standards in analysis and reporting.

8. Data compilers

UN-Habitat with the support of other selected partners will lead the compilation of data for this indicator.

9. References

URL:

- http://unhabitat.org/knowledge/data-and-analytics
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- http://atlasofurbanexpansion.org/file-manager/userfiles/ data_page/Methodology/ Understanding_and_Measuring_ Urban_Expansion.pdf?time=1476446554646

10. Related indicators as of February 2020

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

11.6.2: Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)

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

11.a.1: Proportion of population living in cities that implement urban and regional development plans integrating population projections and resource needs, by size of city

15.1.2: Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type

11.7.2: Proportion of persons victim of physical or sexual harassment, by sex, age, disability status and place of occurrence, in the previous 12 months

11.b.1: Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015-2030 [a]

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