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Measuring Urbanization Using Global Human Settlement Layers and Gridded Population Data

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Introduction

Globally, urbanization has been considered a key indicator of development, because it is strongly linked with economic growth, per capita income, and quality of life (Henderson, 2010; UN-Habitat, 2016). Thus, achieving high economic growth is possible through rapid growth at sub-national urbanization levels, since urbanization and growth go hand in hand (Chen et al., 2014). It is evident that nearly all middle-income countries have more than half their population in urban areas, while all high-income countries have three-fourths of their population in urban settlements (Spence et al., 2009). However, the definition of urban varies across countries. It has been impossible so far to establish a single global definition of urban due to diverse socio-economic settings across countries. In addition, estimation methods vary across countries.

The primary source of data on urbanization is the country's official census data collected at certain intervals. Most often, the census datasets are not available in a timely manner. For example, in India, it is a decadal census, and the last census was conducted 14 years ago. In this context, alternative measures for urbanization are essential. It could help policymakers monitor the rapid urbanization process in a timely manner and make evidence-based decisions.

The advancement of geo-spatial technologies and methods could be the key to addressing these issues. Using these techniques and spatial data, it has become easy to quantify economic and demographic dynamics over space and time (Kummu et al., 2018; Pesaresi et al., 2016; TReNDS & UN-SDSN, 2020). Hence, this study aims to measure the level of urbanization using Global Human Settlement Layers (GHSL) and grid-

KEY RESULTS

- GHSL and gridded population data could be alternatives to examine the spatio-temporal dynamics of the population when timely census datasets are not available.
- The country-level estimate of the urban population only considering the population size and density parameters using GHSL and gridded population data is found to be close to the Census estimate, especially for countries like India (at the sub-national level), Pakistan, Afghanistan, and Bangladesh.
- The urbanization level was underestimated for Bhutan, while it has been overestimated for Nepal and Sri Lanka.
- Compared to traditional data, these datasets could be useful for identifying areas that are rapidly transforming into urban settlements or cities.

Table 1: Description of datasets used in this study

Data	Data description	Time	Resolution	Source
GHS-SMOD	Global Human Settlement Model	2010 & 2020	1 kilometer	Global Human Settlement Layer https://ghsl.jrc.ec.europa.eu
Gridded Population	Grid-wise population data	2010 & 2020	0.1 kilometer	World Pop Hub (https://hub.worldpop.org/)
Urbanization level	World Urbanization Prospects (WUP)	2014		https://population.un.org/wup/Publications/
Census population data	Census of India, 2011	2011	-	(https://censusindia.gov.in)

Table 2: Defining criteria of different types of settlements

Settlement type	Settlement classification criteria
Urban centre (1)	4-connectivity cluster, population size at least 50,000, density at least 1500 per km^2 or built-up surface share at least 50%
Dense urban cluster (2)	4-connectivity cluster, population size at least 5,000, density at least 1500 per km^2 or built-up surface share at least 50%
Semi-dense urban cluster (3)	4-connectivity cluster, population size at least 5,000, density at least 300 per km^2 or built-up surface share at least 30%
Rural cluster (5)	4-connectivity cluster, population size 500 to 5,000, density at least 300 per km^2
Sub-urban or peri-urban grid cells (4)	Cells that belong to an urban cluster but are not part of an urban centre
Low-density rural grid cells (6)	Population density at least 50 per km^2 and not part of a rural cluster
Very low-density rural grid cells (7)	Population density of fewer than 50 inhabitants per km^2

ded population data for countries in South Asia and verify the estimate with census estimates. The same has been measured at the sub-national level taking the case of India to verify the sub-national representativeness of the measure.

Data and Method

The exercise is based on the GHS-SMOD settlement model data provided by the European Commission and gridded population data from WorldPop. To verify the results, this study has used the level of urbanization from the World Urbanization Prospects and the Census of India. Table 1 (on Page 2) describes the four datasets.

The Global Human settlement model is used to identify various types of settlements based on the criteria given in Table 2.

The gridded population data has been used to estimate the population count within those settlements. The gridded population data uses microdata from the Census and simulate the population based on the geo-spatial covariates (distance to different land uses and land covers, restricted areas, major road intersections, major roads, night-light, elevation, slope, etc.). These datasets contain settlement characteristics and population counts at the grid level.

The analysis has considered the first three groups, i.e., urban center, dense urban cluster and semi-dense urban cluster, as urban settlements. Sub-urban or peri-urban grid cells have been used to estimate sub-urban or peri-urban population. The other settlements are considered rural. In the first section, the analysis has been restricted to countries in South Asia. The study aimed to compare urbanization estimates across countries that have different definitions of urban. Further analysis has been done considering India as a case study.

The spatial analyst tool (zonal statistics) has been used to compute the statistics from raster gridded-population layers. The Intersect tool in the GIS application has been used to examine the settlement transition pattern. The analysis has been performed using ArcGIS Pro (https://www.esri.com/en-us/arcgis/products/arcgis-pro/overview).

Results

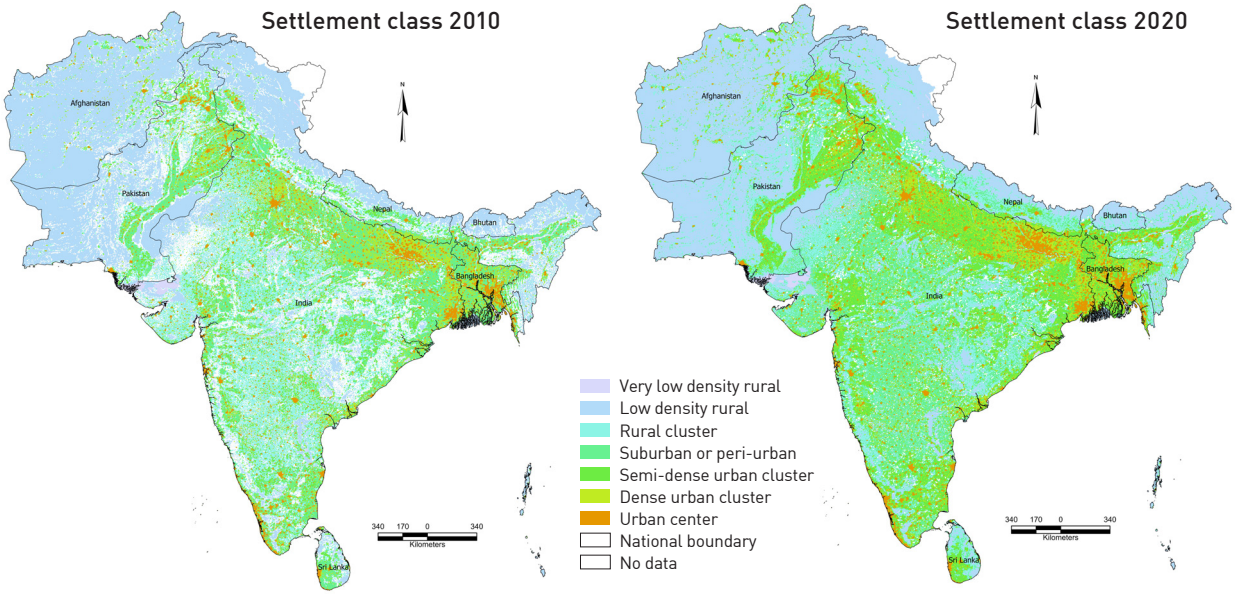
The results of the country-wise analysis are presented in Table 3 and Figure 1.

1. The gridded data-based estimate slightly underestimated the level of urbanization compared to World Urbanization Prospects (WUP). WUP reported the level of urbanization in South Asia as 32.7 in 2010 and 37.1 percent in 2020, whereas this study reported the urbanization level at 30.1 percent in 2010 and 34.6 percent in 2020.

Table 3: Comparison of gridded data-based estimates of population share in urban, sub-urban or peri-urban, and rural areas with urbanization levels provided in WUP

	Gridded data-based estimates						Urban (WUP)	
	2010			2020			2010	2020
	Urban	Sub or peri-urban	Rural	Urban	Sub or peri-urban	Rural		
Afghanistan	29.5	12.3	58.2	32.1	13.1	54.8	24.7	28.9
Bangladesh	36.5	48.0	15.5	45.4	43.6	11.1	30.5	38.0
Bhutan	12.6	3.5	83.9	13.0	5.9	81.2	34.8	42.2
India	28.7	22.7	48.6	33.0	28.2	38.8	30.9	34.8
Nepal	23.7	28.4	47.9	39.9	28.0	32.1	16.8	20.6
Pakistan	34.2	21.4	44.5	35.4	29.8	34.7	36.6	41.2
Sri Lanka	40.2	35.7	24.1	41.2	38.1	20.7	18.3	18.8
Grand Total	30.1	24.9	45.0	34.6	29.6	35.9	32.7	37.1

Figure 1: Change in spatial pattern of different types of settlements in South Asia, 2010-20.



2. The country-wise estimates show that the measured urbanization level is close to the estimates given in WUP for countries like India. However, it overestimates the urbanization level for Sri Lanka and Bangladesh and underestimates it for Bhutan and Pakistan (Table 3).

3. Sub-urbanization or peri-urbanization is growing in South Asian countries. The results portray the scenario of sub-urban or peri-urban growth (24.9 percent to 29.6 percent during 2010–2020). Most countries in South Asia, except for Afghanistan and Bhutan, have nearly one-third of the population living in sub-urban areas.

In some states, the estimated value of the urbanization level matches with the urbanization level of the 2011 census (states like Assam, Chandigarh, Odisha, and Uttar Pradesh). In Bihar and West Bengal, there is overestimation; the Census places the level of urbanization in Bihar at 11.3 percent, while the gridded measure shows 29.3 percent urbanization, primarily due to economic factors. Even though several areas in the state fulfill the criteria of population size and density, they did not meet the Census criteria of engagement of 75 percent of the male main workforce in the non-agricultural sector.

Several states, such as Maharashtra, Kerala, and Tamil Nadu, show underestimated urbanization levels compared to the Census data. For instance, Tamil Nadu has 48.4 percent population living in urban areas, according to the Census, while the gridded data shows 34.7 percent.

Sub-urban areas are rapidly converting to urban settlements (Table 4). During 2010–2020, around 12.4 percent of sub-urban or peri-urban settlements were converted into urban units. However, some settlements experience downward movements, too. For instance, more than one-third of semi-dense urban clusters are transformed into sub-urban or peri-urban areas, and the same has happened to several rural clusters.

Research Design Lessons

Population size and density have remained key components in global definitions of urban populations. A third indicator, which is the socio-economic indicator, is also used in several countries to adjust for socio-economic disparity across countries. For instance, the Census of India has provided three criteria to convert a rural settlement into an urban one: a population size of >5000 persons, a density of 400 persons per km2, and at least 75% of male main workers are engaged in non-agricultural activity.

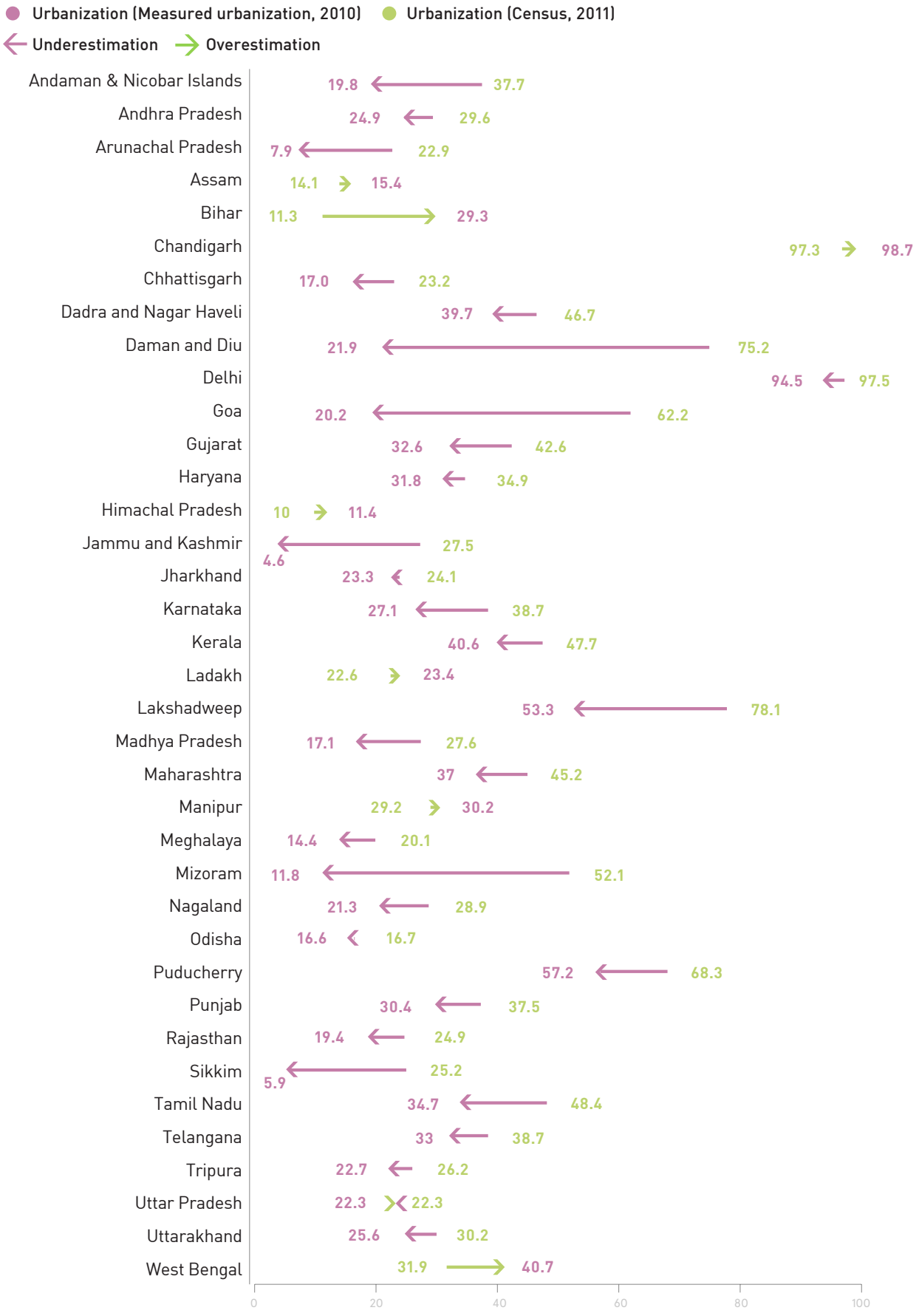
The definition of 'urban' varies significantly across

Table 4: Transition matrix of population share across various types of settlements in India during 2010–2020.

2010 ↓ / 2020 →	Urban centre	Dense urban cluster	Semi-dense urban cluster	Sub-urban or peri-urban grid cells	Rural cluster	Low-density rural grid cells	Very low-density rural grid cells
Urban centre	98.3	0.7	0.0	1.0	0.0	0.1	0.0
Dense urban cluster	14.0	77.4	0.5	7.5	0.1	0.3	0.1
Semi-dense urban cluster	0.0	2.3	51.8	35.6	2.8	5.7	1.7
Sub-urban or peri-urban grid cells	7.1	4.9	0.4	84.3	0.1	2.6	0.6
Rural cluster	0.0	0.7	9.4	22.5	59.6	5.9	1.8
Low-density rural grid cells	1.0	0.4	1.7	27.5	2.9	62.2	4.2
Very low-density rural grid cells	0.4	0.2	0.3	4.1	0.8	15.8	78.5

Note: Settlement type as outlined in Table 2.

Figure 2: Verifying sub-national estimates using gridded data with Census estimates.



countries, but this study helps us examine urbanization patterns across countries in South Asia following a uniform scale. The estimates are very close to the census estimates for some countries, while in some cases it varies; for instance, the measured urbanization is found to be underestimated for countries with complex urban definitions, such as Bhutan.

Additionally, the methods used in this study are useful in identifying the spatial concentration of the population and identifying high-density zones. They are also useful in tracing the temporal dynamics of the settlements, the contributions of different types of settlements in urban growth and the potential areas likely to be converted into urban areas in the near future.

This study highlights the usefulness of the settlement model-based (density and population cluster) estimates of urbanization level over the traditional measures since it can be used as a universal tool to measure urbanization and understand the global urbanization dynamic. The measurement of urbanization level using GHSL and gridded population data could be very useful in cross-country comparisons and when the census data is outdated. Further, the method has great potential to examine different dimensions of urbanization and could advance the urbanization measurement process.

Policy Influence

The sustainable management of urban populations is crucial in an era of rapid urban transformation, especially for countries in the global south. The proposed methods and the findings of the study could help in efficient urban planning and management. Advanced planning and appropriate measures could be taken for areas more likely to transform into urban areas. Attention should be given to an area's potential for future urban development with a high population concentration and equip it with better infrastructure and facilities for better outcomes in terms of economics and development.

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