Alternative SSPs urbanization projections based on the Degree of Urbanization data

Leiwen Jiang, Lewis Dijkstra, and Alessandra Carioli

Abstract

As a core component of new climate change scenarios, the SSPs urbanization projections have been widely used to guide long-term global strategies across climate, infrastructure, environmental protection, and social policies. However, the data used for the existing projections was from the UN WUP. It is based on national administrative definitions that vary across countries and change over time. To make the projections more spatially compatible and temporarily consistent, this paper uses a newly developed Degree of Urbanization (DOU) data to generate an alternative set of SSPs urbanization projections for the climate change research communities. Adopting an improved urbanization projection model, we project urbanization trends for all countries and regions till the end of the century. The projection results are more robust and reflect a larger range of uncertainties in urbanization trends, embodied in the DOU data compared to the WUP dataset. While it does not aim to replace projections based on national definitions, the output provides an alternative set of projections that are more useful for comparative analysis. Moreover, DOU data is geocoded. It can provide spatial data across geographical scales, and produce consistent urbanization projections for territories at global, continental, national, and subnational levels.

Extended Abstract

1. Introduction

As a global demographic megatrend, urbanization contributes to future climate change mitigation and adaptation challenges. Consequently, the most recent IPCC socioeconomic scenarios - the Shared Socioeconomic Pathways (SSPs) - for the first time included urbanization projections as a core component of climate change scenarios, along with projections on population, economic growth, and technological advancements in energy and land use. Since the first set of SSPs urbanization projections was published in 2013, it has been widely used as a critical tool for guiding long-term global strategies across climate, infrastructure, environmental protection, and social policies.

In a recent effort, the most recent available UN World Urbanization Prospects (WUP) 2018 Revision dataset was used to update SSPs urbanization projections for all countries and regions. The adoption of the UN WUP dataset for urbanization projections was because of its global coverage with long historical records which are fundamental data requirements for projections. However, the WUP records on urban population are based on national administrative definitions, which vary across countries and change over time. The variations in urban definitions and incompatibility of urbanization records lead to serious concerns about the historical trends represented by the dataset.

This paper uses a newly developed Degree of Urbanization (DOU) data to generate an alternative set of SSPs urbanization projections for the climate change research communities. The DOU methodology and dataset was a response to the UN Statistical Commission's request to define cities, towns, and rural areas, enabling more accurate international statistical comparisons. It relies on population grids to reduce bias caused by the varying shapes and sizes of spatial units used in traditional census methods. It uses the same thresholds globally to ensure consistency and comparability between different countries and regions. Using the

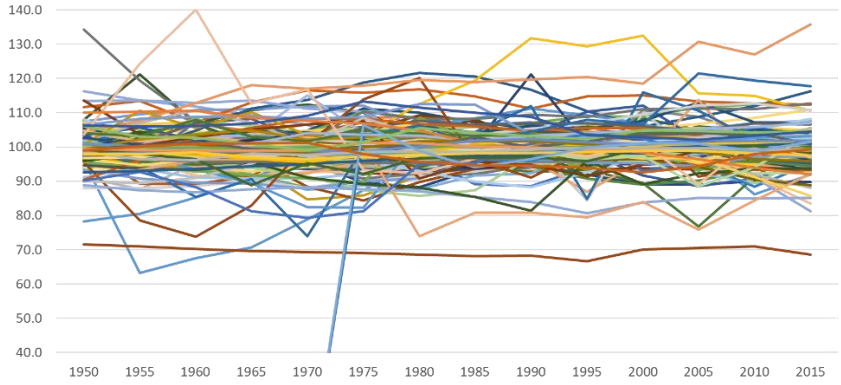
DOU dataset and adopting the improved urbanization projection model of the Community Demographic Model (CDM), we project urbanization trends for all countries and regions till the end of the century. The projection results are more robust and reflect a larger range of uncertainties in urbanization trends across countries at various stages of socioeconomic development and urbanization, embodied in the DOU data compared to the UN WUP dataset. A validation analysis shows that the model captures historical trends in national and subnational projections. The updated projections enable users to develop urbanization scenarios according to local socioeconomic contexts and environmental conditions by selecting pathways from nine available urbanization trajectories.

2. Data and Methods

The DOU dataset used for urbanization projections was developed by several international organizations, led by the European Commission. It introduces a harmonized methodology to classify territories along the urban-rural continuum, aimed at improving international comparisons of statistical indicators for cities, towns, and rural areas. It is based on population grids at 100- or 1000-meter resolution and other geographical information from the Global Human Settlement Layers (GHSL). Territories are classified into areas of different levels of urbanization according to thresholds in population density, human settlement size, and distance from the urban center. It includes three main categories (city, town and rural) at Level 1 classification or seven categories (mostly uninhabited area, dispersed rural area, village, suburban or peri-urban area, semi-dense town, dense town, and city) at Level 2 classification. Population census data combined with other GHSL geographic information layers provide direct rural-urban records from 1975. For several countries with no census data, a regression model was constructed using the complete dataset to predict urban share based on its relationship to GDP per capita. Linear interpolation was used to generate urbanization data every five years between 1975 and 2020. Moreover, the regression model is also utilized to backcast the DOU growth rate and estimate the DOU dataset retrospectively at 5-year intervals back to 1950. To group the population along the rural-urban continuum into a rural and urban dichotomy, we include cities and dense towns in urban and the rest into rural. Therefore, the two sets of DOU data are available for the SSPs urbanization projections, starting from 1950 and 1975 respectively. As it is preferable to use "real" data, our projections are based on 1975-2020 records. The estimated DOU data for 1950-1970 is also included in the output for users who want long historical information.

Compared to the UN WUP 2018 revision which is based on administrative records, the DOU data shows varying degrees of differences across countries and over time (Figure 1). The differences are relatively small in Europe, Latin America, and Oceania but significantly larger in Asian and African countries.

Figure 1 Differences (%) in urban population between DOU and WUP datasets



CDM's Urbanization Projection Model is adopted for projections. It is an expanded and improved UN urbanization projection model, by accounting for variations in urban growth among countries through selecting reference countries that are similar to the country under study. To reflect possible urban growth changes in the long run, the CDM model adopts two-stage reference country selection, and can make long-term urbanization projections. It arranges the reference countries in each of the two stages into fast, central and slow groups based on their urbanization growth rates and therefore produces nine urbanization trajectories to cover the plausible range of uncertainties. The model has been updated and improved through the use of data-driven machine learning approach. Therefore, it has become more capable of selecting reference countries or regions from large datasets and producing robust results.

3. Projected outputs

Comparing to the existing SSPs urbanization projections, the new results generally show similar patterns that all countries will continue to be urbanized in most cases, and urbanization trajectories span a large plausible range under different SSPs (Figure 2). Under the fast urbanization trajectories (SSP5 and SSP1), the urbanization levels of all countries will be converged to a high level (above 90%), while they can stay as diverse as today if all countries follow the slow urbanization pathway (SSP3). It is noteworthy that the projections indicate a declining trend in future urbanization under the slow-slow trajectory which occurred in some countries during certain periods in the past.

Figure 2 Projected urbanization trends for selected countries

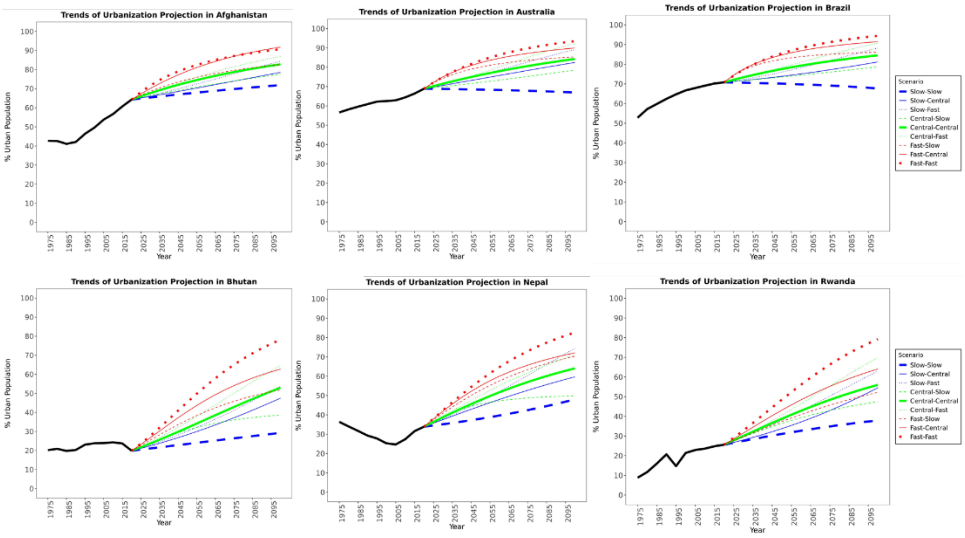
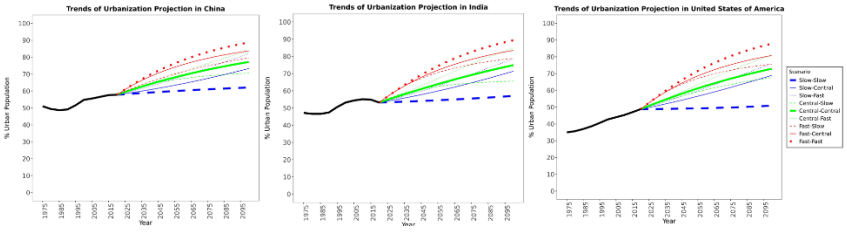
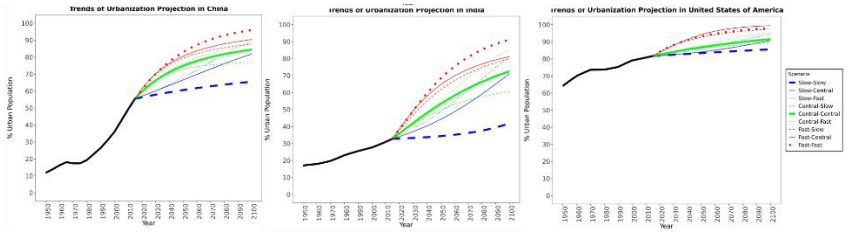


Figure 3 Urbanization projections for China, India, and the USA based on the DOU (a) and WUP datasets

(a) Projections based on DOU data



(b) Projections based on WUP data



A comparison of projection results for China, India, and the USA based on the DOU and WUP datasets reveals large differences. The DOU data displays similar urbanization levels for 2020 for the three countries, while the WUP suggests much higher urbanization levels for the USA than for China and India. The projected results based on the DOU data point to similar trends and variations among the three countries, while projections based on the WUP data show very different trajectories and ranges of uncertainties.

4. Discussions

The DOU dataset aims to enhance international comparability and ensure that national definitions of urban and rural areas align with global data. This will enable countries to track urbanization trends based on universal and consistent urban categorization thresholds. Using the DOU dataset for urbanization projections can help avoid inconsistencies in projection references due to varying urban definitions across countries and changing thresholds at different time periods. Therefore, the projection outputs are spatially uniform and temporarily consistent, ensuring compatibility among countries and over time. Moreover, DOU data based

on geocoded spatial information can provide detailed population data at various geographical scales. It can be used to generate spatially coherent data for urbanization projections for territories at the global, continental, national, and subnational levels.

The DOU methodology and dataset are intended to complement rather than replace national definitions used by countries and the UN WUP. The projections based on the DOU data can provide an alternative set of SSPs results for academic scholars, policy analysts, and decision makers for addressing the relationships between urbanization and socioeconomic and environmental factors, and offering insights into future global urbanization patterns and their potential impacts on sustainable development.