Impacts of Urbanization as a Key Element of Socioeconomic Scenarios for Climate Change Research: Historical Experiences and Future Trends

Leiwen Jiang and Brian O'Neill
National Center for Atmospheric Research

Abstract:

A new set of alternative socioeconomic scenarios for climate change researches – the Shared Socioeconomic Pathways (SSPs) - include for the first time a more comprehensive set of socioeconomic conditions on population, GDP, urbanization, education, institutions, and other aspects of society. It can facilitate better analyses of mitigation and adaptation, but also raises new questions about the internal consistency of assumptions about different socioeconomic trends within each SSP for different regions. In this paper, we use urbanization as a starting point and assess the various patterns of interactions between urbanization and other elements assumed in the SSPs. We use historical statistics and data on future projections from the SSP database to study their relationship in the past, analyze the implied trends in each of the elements and their relationships assumed in the SSPs, and make recommendations on how to use urbanization projections in the socioeconomic scenarios of climate change research.

Extended Abstract:

Introduction

In projecting anthropogenic climate change and its impacts on human societies, socioeconomic scenarios play a key role, through helping researchers better understand how future emissions and consequences of climate changes might be affected by alternative social, economic, and demographic trends (O'Neill and Schweizer 2011). Over the past decade, the Special Report on Emissions Scenarios (SRES) developed by the Intergovernmental Panel on Climate Change (IPCC) has been widely used in climate change research communities, more specifically for the use of mitigation analysis (Nakicenovic N. et al. 2000). A new set of five alternative global socioeconomic scenarios – the shared socioeconomic pathways (SSPs) – is currently under development for the analyses of both mitigation and adaptation research communities, and expected to be adopted by the IPCC 5th Assessment Report (AR5) and beyond (Moss et al. 2010). The SSPs include for the first time not only alternative projections of population, GDP growth, technological changes, as in the past scenarios, but also projections of future urbanization and education outcomes, as well as qualitative storylines about the development of institutions, policy orientations and other aspects of society (O'Neill et al. 2011). This more comprehensive

set of socioeconomic scenarios will facilitate better analyses of climate change mitigation, and meet the needs of climate change impacts, vulnerability and adaptation (IAV) research community. However, it also raises new questions about the internal consistency of assumptions about different socioeconomic trends within each SSP for different regions of the world.

In this paper, we use urbanization as a starting point and assess the various patterns of interactions between urbanization and other elements assumed in the SSPs, such as population growth, education, economic, and institutional factors. We will study how changes in urbanization have related to other SSPs elements over the past decades, and analyze the implied future trends in each of the elements and their relationships assumed in each of the SSPs, in order to make recommendations on how to use the urbanization projection of the SSPs for climate change mitigation and adaptation researches.

Data and methods

We use historical statistics on urbanization, GDP growth, education attainment, and population growth for the past 5-to-6-decade to understand the historical relationships of these variables included as the SSPs basic elements. The data on urbanization and population for the period 1950-2010 are from UN Population Division (UN 2010, 2011); data on GDP growth of 1950-2010 is from Penn World Tale (PWT 7.0, Heston et al. 2011); data on education (mean year of schooling) for the period of 1960-2010 is from IIASA World Population Program (Lutz et al. 2007). For the analysis of future trends, we use the projections on urbanization from NCAR (Jiang and O'Neill 2011, submitted), GDP growth from OECD Economics Department (Duval and De la Maisonneuve, 2010; OECD, 2012), and population and education from IIASA World Population Program (KC et al. 2010). The projection data are all available at the SSPs Database.

As some of the analyses are conducted at regional levels, we derive the aggregate statistics from the original data at the national level. Because the different data sources have different number of countries being included in the databases, the national statistics is summed up to the regional ones, weighing the historical and projected national population of each region.

We carry out statistical analysis to explore the correlations between these variables in the history, and identify different patterns across regions by development levels and over time; we compare the implied future changes in the relationships between these variables under each socioeconomic pathway with the historical patterns, and test the internal consistencies of the relationships over time and across regions.

Primary results

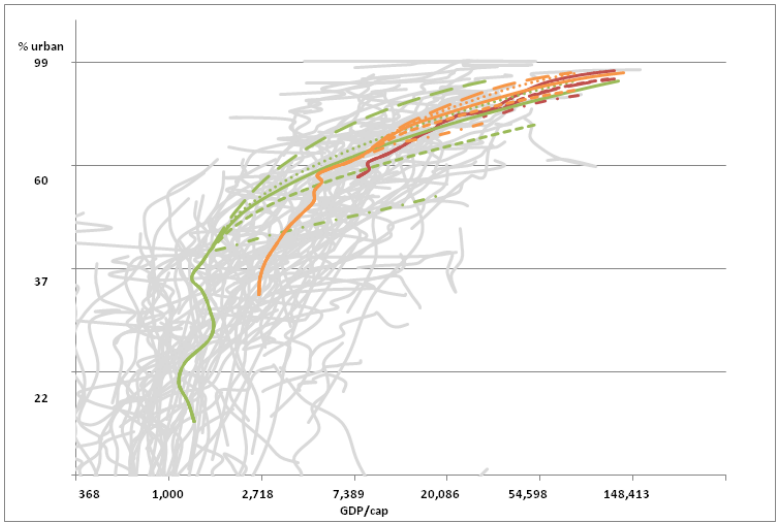
We first explore the historical relationships between urbanization growth rate and per capita GDP growth rate for the world, and for the high, medium and low income regions (see detailed region definitions at the SSP Database). It suggests a positive correlation between urbanization and GDP growth for the whole world (Table 1), and for both the high and medium income regions. However, it has a weak negative correlation among the low income countries, indicating the experiences of some African and Latin America countries in the past in which urbanization was not accompanied by economic growth and progress in industrialization (Fay and Opel 2000). As for the future implied in the SSPs, the correlations between urbanization and GDP growth are all positive, which could be regarded as a continuity of the historical experiences from the high and medium income region but not much from the low income region. However, we do see the variations across SSPs. While the correlation in the medium income region is strongly under all SSPs, it is not always very significant in the high income region. Particularly under SSP1, representing a world of sustainability (O'Neill et al. 2011), the correlation is only 0.237. In the world of SSP1, the environmentally friendly living arrangements and human settlement design trigger fast urbanization of small size of population living in resource-efficient compact cities, which is not accompanied by a fast economic expansion in the high income regions. Moreover, the correlation between urbanization and economic growth in the low income region under SSP3 is not very strong either (0.374). Because SSP3 represents a fragmented world in which the low income region lags far behind other regions in socioeconomic development which results in unfavorable economic and politic conditions for rural-urban migration and urban development.

The correlation between urbanization and population growth is less significant than the correlation between urbanization and per capita GDP growth (Table 1), and has also a larger regional variation. In particular, the correlation coefficient is negative among the medium income countries, resulting from the rapid urbanization and demographic transition experienced by the emerging economies in the more recent decades. This type of historical patterns and large regional variation to certain extent repeat in the future decades under different SSPs. For instance, under SSP5 which represents a conventional development pathway, the population growth rate is low in the low and medium income countries but high in the high income countries, because of their various stages of demographic transition. In the meantime, urban settlement is favorable in all regions, because of rapid technological development and capabilities of building cities though large scale engineering projects. However, the room for further urbanization growth in the high income countries is limited given that they have been already urbanized. As a result, the correlation between urbanization and population growth in these countries will be much weak than that in the low and medium income countries.

Table 1 Correlation coefficients between urbanization growth rate and population and GDP growth rate in the past decades (1950-2010) and for the future (2010-2100) under the Socioeconomic Pathways

	correlation with population growth rate				correlation with GDP/capita growth rate			
	World	High income	Med. Income	Low income	World	High income	Med. Income	Low income
historical	0.121	0.312	-0.164	0	0.394	0.576	0.558	-0.05
SSP1	0.646	0.150	0.655	0.717	0.806	0.237	0.883	0.627
SSP2	0.581	0.115	0.599	0.650	0.759	0.262	0.845	0.577
SSP3	0.322	0.621	0.048	0.251	0.596	0.619	0.635	0.374
SSP4	0.350	0.216	0.546	0.252	0.693	0.333	0.859	0.631
SSP5	0.526	0.025	0.650	0.705	0.796	0.431	0.871	0.609

Figure 1 Relationships between urbanization level and per capita GDP of all countries in the past (in grey) and for low income region (in green), medium income region (in orange) and high income region under each SSPs



Moreover, Figure 1 demonstrates that the relationships between urbanization level and per capita GDP under each SSP fall into the range of historical experiences of all countries in the past decades. To a large extent, it suggests the urbanization projections for the SSPs are plausible and provide robust storylines consistent with historical experiences for the climate change researches.

References:

1. Nakicenovic N. et al (2000) Special Report on Emissions Scenarios: A Special Report of Working Group III of the Intergovernmental Panel on Climate Change (Cambridge University Press, Cambridge).
2. Moss RH et al. (2010) The next generation of scenarios for climate change research and assessment. Nature 463: 747-56.
3. United Nations (2010) *World Urbanization Prospects. The 2009 Revision* (United Nations Publication, New York).
4. United Nations (2011) *World Population Prospects 2010 Revision*. (United Nations Pulcation, New York).
5. O'Neill, B.C. and Schweizer V. (2011) Projection and prediction: map to the road ahead. Nature Climate Change 1: 351-353.
6. O'Neill, B.C., Carter, T.R., Ebi, K.L., Edmonds, J., Hallegatte, S., Kemp-Benedict, E., Kriegler, E., Mearns, L., Moss, R., Riahi, K., van Ruijven, B., van Vuuren, D. 2012. Meeting Report of the Workshop on The Nature and Use of New Socioeconomic Pathways for Climate Change Research, Boulder, CO, November 2-4, 2011. Available at: http://www.isp.ucar.edu/socioeconomic-pathways.
7. Jiang, L., O'Neill, B.C. (2011) Urbanization in Developing Asia: Alternative scenarios and implications for rural-urban migration. International Union for the Scientific Study of Population (IUSSP) Working Paper.
8. Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 7.0, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, June 2011.
9. Lutz, W., Goujon A., KC S. (2007) Reconstruction of populations by age, sex and level of educational attainment for 120 countries for 1970-2000, Vienna Yearbook of Population Research, 5: 193-235.
10. Samir KC, Bilal Barakat, Anne Goujon, Vegard Skirbekk, Warren Sanderson, Wolfgang Lutz (2010). Projection of populations by level of educational attainment, age, and sex for 120 countries for 2005-2050. *Demographic Research* 22(15): 383-472
11. Duval, R. and C. de la Maisonneuve (2010), "Long-Run GDP Growth Framework and Scenarios for the
12. World Economy", Journal of Policy Modeling 62, p. 64-80; also published as OECD Economics Department Working Papers 663, OECD, Paris
13. OECD (2012) "Long-term growth scenarios", OECD Economics Department Working Papers, OECD, Paris, forthcoming.
14. Fay, M. & Opal, C., 2000. *Urbanization Without Growth: A Not So Uncommon Phenomenon*, World Bank Publications.