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Regional, national, and spatially explicit scenarios of demographic and economic change based on SRES

A. Grübler [a,b,*], B. O'Neill [a,c], K. Riahi [a], V. Chirkov [a], A. Goujon [a], P. Kolp [a], I. Prommer [a], S. Scherbov [a], E. Slentoe [d]

[a] *International Institute for Applied Systems Analysis, Laxenburg, Austria*
[b] *School of Forestry and Environmental Studies, Yale University, New Haven, CT, USA*
[c] *Watson Institute for International Studies, Brown University, Providence, RI, USA*
[d] *Institute of Geography, University of Copenhagen, Copenhagen, Denmark*

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Abstract

We report here spatially explicit scenario interpretations for population and economic activity (GDP) for the time period 1990 to 2100 based on three scenarios (A2, B1, and B2) from the IPCC Special Report on Emissions Scenarios (SRES). At the highest degree of spatial detail, the scenario indicators are calculated at a 0.5 by 0.5 degree resolution. All three scenarios follow the qualitative scenario characteristics, as outlined in the original SRES scenarios. Two scenarios (B1 and B2) also follow (with minor adjustments due to scenario improvements) the original SRES quantifications at the level of 4 and 11 world regions respectively. The quantification of the original SRES A2 scenario has been revised to reflect recent changing perceptions on the demographic outlook of world population growth. In this revised "high population growth" scenario, A2r world population reaches some 12 billion by 2100 (as opposed to some 15 billion in the original SRES A2 scenario) and is characterized by a "delayed fertility transition" that is also mirrored in a delayed (economic) development catch-up, resulting in an initially stagnating and subsequently only very slow reduction in income disparities. The spatially explicit scenario interpretation proceeds via two steps. Through a combination of decomposition and optimization methods, world regional scenario results are first disaggregated to the level of 185 countries. In a subsequent second step, national results are further disaggregated to a grid cell level, taking urbanization and regional (rural–urban) income disparities explicitly into account. A distinguishing feature of the spatially explicit

* Corresponding author. Transitions to New Technologies Program, International Institute for Applied Systems Analysis, A-2361 Laxenburg, Austria.
E-mail address: gruebler@iiasa.ac (A. Grübler).

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scenario results reported here is that both methodologies, as well as numerical assumptions underlying the "downscaling" exercise, are *scenario-dependent*, leading to distinctly different spatial patterns of population and economic activities across the three scenarios examined.

Keywords: Downscaling; GDP density maps; Population density maps; Spatially explicit scenarios; National projections

1. Introduction

Long-term scenarios are an indispensable tool for the assessment of major uncertainties as well as of the consequences of alternative policy actions for global challenges, ranging from the implications of resource depletion to environmental issues such as climate change. In their quantitative incarnation, such long-term scenarios are usually developed with the help of formal models that attempt to describe the major interdependencies between scenario drivers, such as population growth on the one side and their consequences (e.g., environmental impacts) on the other. Such models vary widely in terms of their degree of detail, methodology, and system boundaries (e.g., in terms of sectors of human activities and types of environmental impacts covered), with the most comprehensive type frequently being referred to as "integrated assessment" (IA) models.

In terms of spatial resolution however, the state of the art IA models all share a common characteristic: they operate at comparably high levels of spatial resolution. These range from the global scale down to the scale of (typically a dozen or so[1]) world regions that can include a limited number of geopolitical global "players" in terms of individual countries, such as the USA and China, or groups of countries, such as the European Union. This commonality among IA models is explained by computational limits, as well as the daunting task of model calibration for literally hundreds of parameters for close to 200 individual countries and even thousands of smaller subnational regional entities for which, in most cases, reliable statistics are absent. Obviously, the question also arises as to whether such a higher degree of spatial resolution would be appropriate for the typical research questions addressed by IA models. However, as only IA models provide the type of globally consistent answers to research questions, such as the magnitude of possible climate change and its impacts or the feasibility and costs of counteracting global warming, there is strong interest on the part of a variety of user communities utilizing the results of global/world regional IA models to obtain information for use in national policy assessments or regional climate impact studies.

The high degree of spatial aggregation of customary Integrated Assessment models is also at odds with the prevailing dominant decision-making paradigm characterized by (1) agents defined at lower degrees of spatial resolution, as represented by the nation state, municipalities, individual firms, or (2) actors that transcend conventional "place-based" definitions altogether, such as multinational corporations. It is also at odds with the research needs from the "back end" of IA, namely, those disciplines dealing with environmental consequences that usually rely on a rich tradition of place-based impact research and spatially explicit modeling of (mostly) biophysical processes, ranging from land use changes such as

[1] See, for example, the models used for developing the IPCC Special Report on Emissions Scenarios (SRES, [1]). As an exception, we note here the ambitious project of an IA model disaggregated to 77 regions currently under development in Japan [2].