The SSPs' Potential to Frame and Enhance the Usefulness of Population-Environment Research

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Population scholars have much to offer climate change research and policy. Yet the discipline's scholarly contributions are scattered in diffuse outlets, cover a multiplicity of topics, and are not well connected to climate science.

We argue that given the enormity of the climate challenge, and the increasing sophistication of population-climate research, it is essential that demographic research be relevant and accessible to climate scientists and policymakers. As organizations such as the IPCC grapple with better understanding climate change determinants, consequences, and response options, demographers' perspectives, methodologies, and findings hold important insight.

This paper argues that the new scenario framework being developed by the climate research community holds potential as an organizing tool for demographic scholarship relevant to climate change, as well as a means of usefully identifying population-climate research gaps. Engaging the SSPs also acts as a bridge to the research community focused on climate "Impacts, Adaptation, and Vulnerability" (IAV) as well as to the community focused on "Integrated Assessment Modeling" (IAM). Demographers have much to offer the IAV and IAM communities, as well as much to learn from IAV- or IAM-focused research. Finally, the SSP framework is motivated by a desire to produce tangible outcomes of relevance to the ongoing assessment efforts of the IPCC. In this way, the effort would enhance the policy impact of population-environment scholarship.

A New Lens on Socio-Economic Pathways Toward Different Climate Futures

As explained earlier in the seminar, the new approach takes, as its start, scientific understanding of plausible futures of atmospheric composition – known as "representative concentration pathways" (RCPs; van Vuuren et al., 2012). Then, at the same time that the climate modeling community is producing simulations of climate change resulting from the RCPs (Taylor et al., 2011), a first set of Shared Socio-economic Pathways (SSPs) has been developed covering a wide range of plausible socio-economic futures. This approach allows parallel development of climate science and the research aimed at understanding socio-economic determinants and implications.

The range of socio-economic factors important to include in these pathways is vast – demographic, economic, political, technological, and socio-cultural dimensions are all critical. In addition, conditions of ecosystems and ecosystem services that have been affected by human activity must also be considered, including air and water quality, biodiversity, and ecosystem form and function. Pathway development must therefore rely on current scientific understanding of the interaction of a range of socio-economic and biophysical factors. Indeed, given this complexity, a key challenge is the generation of a parsimonious set of socio-economic and ecological considerations within the SSPs.

Several routes have been undertaken to identify central SSP elements and narratives including expert elicitation (Schweizer and O'Neill, in press), creation of large numbers of candidate pathways (Schweizer and O'Neill, in press), and group consensus processes (O'Neill et al, in press). Thanks to

input from demographic researchers throughout this development process, the SSPs include informed population, education, and urbanization projections at the national level with global coverage. Global, spatially-explicit population projections are also currently being developed.

The frameworks described by the SSPs can be applied in research studies and integrated scenario development, allowing for harmonization of key inputs. Given a sufficient number of studies using common assumptions about future climate and societal conditions, broad conclusions about options for responding to climate change will be able to be drawn in a way that is supported by a diverse research base. In this way, SSPs will provide a common foundation from which different research communities can engage (Kriegler et al. 2012: O'Neill et al., in press).

Demographic Research and Socio-Economic Pathway Development

As noted, population-climate researchers, and demographers more generally, have already contributed projections, scholarship and expert comment toward SSP development. Indeed, a vast array of demographic research examines the included socio-economic processes, and their interactions, even if not explicitly engaging climate. And demographic processes are obviously key when considering challenges to mitigation and adaptation under future climate conditions.

Within the process of SSP development, a first consideration was to determine the demographic variables centrally important to include given their relevance to mitigation and adaptation challenges. An excellent example of demographic research incorporated within the SSPs is provided by K.C. and Lutz (submitted; see Lutz, 2013, for a summary). The authors translate the SSP narratives into five alternative demographic scenarios providing projections by age, sex and level of education for 171 countries up to 2100. In addition, Jiang and O'Neill (in preparation) translate the SSP narratives into alternative projections of national-level urbanization. The new demographic scenarios, which are available online at https://secure.iiasa.ac.at/web-apps/ene/SspDb along with other quantitative elements of the SSPs and a discussion of assumptions and methodology, present a major step forward as compared to the earlier SRES scenarios that only considered total population size (Nakicenovic et al. 2000).

Still, a key challenge for the demographic research community is to determine *if there are demographic futures not well represented in the current set of SSPs? Are there additional demographic scenarios that should be considered – perhaps a wider range of outcomes? Different combinations of trends? Surprises?*

Demographic Insight Can Aid SSP Internal Consistency

Also, the demographic dynamics assumed in SSPs obviously do not act in isolation. As a result, scholarship linking urbanization, for example, with fertility or economic growth will ensure that the SSP storylines are internally consistent. In other words, *are the current demographic assumptions consistent with other scenario elements?*

Demographic research has indeed documented connections between urbanization and fertility (e.g. Shapiro and Tambashe 2002; White et al. 2008), with fertility research clearly being another central

arena of potential contribution to socio-economic pathways. Understanding shifts in fertility decline is also important as recent work has demonstrated a reversal of declining fertility has occurred in some nations at high levels of economic development (Myrskyla, Kohler and Billari 2009). Further, scenarios may benefit from knowledge of shifting family size preferences in the context of transitioning fertility (Yeatman, Sennott and Culpepper 2013). Interesting recent scholarship has also linked fertility to institutions such as those governing land tenure. In Kenya, for example, tenure systems and land scarcity have played a critical role in recent fertility declines (Shreffler and DoDoo 2009).

Of course, these spatial and temporal variations in fertility decline suggest the demographic transition is differentially unfolding across global regions. Large-scale regional scenarios may benefit from tapping into the demographic perspective on these distinctions (e.g., Bongaarts 2009; McNicholl 2011) and also to accurately consider regional potentials for a "demographic dividend" as related to intensified economic growth (e.g., Eastwood and Lipton 2011).

As another example, a substantial amount of research links urbanization to economic development and GDP, yet few of these interactions have been incorporated in integrated assessment models (Krey et al., 2012). Even so, new efforts have been made to explain the 'no growth' urbanization experienced in sub-Saharan Africa throughout the 1980s and 1990s. Fox (2012) argues, for example, that technology and institutional innovations represent key determinants of urbanization through resulting health gains and enhanced food security especially in urban regions. Such de-coupling of urbanization from GDP and economic development, particularly in some global regions, has important implications for global emission models that consider such interactions. These nuanced discussions of urbanization determinants also deserve a place in the narratives describing shared socio-economic pathways.

Demographic research also reveals that both urbanization and aging are linked to energy use patterns, a key determinant of future emissions (O'Neill, Ren, et al. 2012). In industrialized settings, aging may reduce long-term emissions by up to 20 percent through decreased economic productivity and reduced consumption. Urbanization in less developed settings, however, may counteract these reductions by yielding a 25 percent increase in emissions due to the heightened consumption and economic productivity associated with urban living (O'Neill et al. 2010). The demographic perspective and toolkit has also shed light on household and living arrangements and their potential future changes (Zeng et al. 2013). Since households are primary units of consumption and consumption drives emissions, understanding these demographic shifts is also important for SSP development.

Population researchers are also making important advances in the measurement and spatial projection of urbanization and urban populations. As examples, the Global Rural Urban Mapping Project (GRUMP) represents the first spatial rendering of global urban areas with population estimates, making use of satellite data. In addition, researchers are generating new methods for estimating and forecasting urban and city population that combine demographic and econometric techniques and use survey, census and spatial data (Montgomery and Balk 2011). Understanding climate vulnerability along China's coast provides an example of these endeavors' importance. While China's population growth between 1990-2000 was 1.04%, urban growth was double at 2.33%, with particularly high concentrations in urban coastal regions (Smith 2011). Such spatial precision in urban estimates and projections can usefully be engaged in development of shared socio-economic pathways.

The SSPs as a Framework for Identifying Population-Environment Research Needs

The population-environment research community can also engage the SSPs as a framework for identifying research areas that could usefully contribute to this important effort. As an example, we could ask: *Which demographic factors and relationships can be reliably projected quantitatively and can we do better than we are doing now?* The ongoing efforts to spatially represent future urban populations represent such a contribution.

In addition, to vastly enhance the policy relevance of local studies, the *SSPs can offer a basic level of harmonization that will facilitate generalization across a range of case studies.* Specifically, the SSPs can be used for local analyses by providing guidance on global patterns to be linked to context-specific case studies. The intent is not that the SSPs offer deterministic parameters but rather assumptions that can frame the variation examined within local settings – and, in this way, provide essential insight into the implications of different pathways.

More specifically, demographers working in particular local settings can contribute to understanding the implication of climate futures by framing their research, at least in part, with SSP storylines. Indeed, the many facets of the SSP storylines offer unlimited research questions for demographers – and answers to the questions would aid in refinement of the pathways and understanding of related mitigation and adaptation challenges.

One of the authors (LH) can reach to her own collaborative research in rural South Africa as an example. This work has been examining migration as a livelihood strategy among natural-resource dependent rural households at the Agincourt Health and Demographic Surveillance Site (Hunter et al. 2013; Leyk et al. 2012). A useful extension would be to consider how the patterns that have been identified might shift under different future socioeconomic pathways. As others studying migration-environment connections do similarly, this research can more usefully be linked to generalize with regard to future climate challenges under different scenarios. And more broadly, by doing so, *we can better understand how the patterns described in broad SSPs might vary across specific local areas characterized by different development level, economic contexts, or other socio-cultural distinctions.*

Other useful and interesting demographic scholarship would examine *which demographic factors contribute most to the challenges to mitigation and adaptation? How does this vary regionally or by development level? What can existing case study literature tell us about this already?*

In all, demographic factors certainly play a fundamental role in determining the planet's climate future. While demographic scholarship has already played a role in the generation of the shared socio-economic pathways, population researchers must continue to engage future iterations. In addition, we are well-positioned to make use of the SSPs in our own scholarship and thereby offer important contributions to understanding the implications of various climate futures.

Importantly, research studies need not examine the entire socio-climate system to contribute to this process. Instead, given relatively harmonized objectives and boundary parameters, research focused on portions of the socio-ecological systems that shape climate futures can become integrated into holistic modeling efforts that feed more directly into policy.

Key is the opportunity provided here to generate scholarship more easily integrated into broader climate science and policy – a window of opportunity for our research to truly make a difference.

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