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Adapting global shared socio-economic pathways for national and local scenarios

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ABSTRACT

Socio-economic scenarios enable us to understand the extent to which global-, national- and local-scale societal developments can influence the nature and severity of climate change risks and response options. Shared socio-economic pathways (SSPs) enable a systematic exploration of the challenges to adaptation and mitigation that alternative futures entail. However, SSPs are primarily defined for the global scale. If countries are to test their adaptation and mitigation options for robustness across plausible future socio-economic conditions, then SSPs require country-relevant detail to understand climate change risks at the national and local scales. New Zealand is used to illustrate how nationally relevant socio-economic scenarios, nested within SSPs can be developed to inform national- and local-scale studies of climate change impacts and their implications. Shared policy assumptions were developed, involving a mix of climate-specific and non-climate-specific policies, to demonstrate how international links and global-scale developments are critical locally—local choices may accelerate, reduce or even negate the impact of global trends for extended periods. The typology was then 'tested' by applying it in a local context. The research challenges observed in developing credible, salient and legitimate national-scale socio-economic scenarios include issues in developing scenarios across a multidisciplinary team. Finally, recommendations for adapting shared climate policy assumptions to produce national and local scenarios, and for assessing the feasibility and effectiveness of climate change adaptation options are presented. These include the need for: guidelines to embed national scenarios in global frameworks; a limit the number of plausible futures; inter-operability of models; an ability to work towards effective multi-disciplinary teams and integrative research; and the opportunity to involve participatory processes where feasible.

1. Introduction

Risk related to climate change is the product of three interacting drivers: climatic hazards, exposure to those hazards, and vulnerability to those hazards (IPCC, 2014). All three change over time. Much research has focused on understanding and quantifying future global changes in climate-related hazards, and on understanding and modelling the sensitivity of natural and human systems to

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those changes. Much less effort has been invested in understanding how socio-economic trends could alter both exposure and vulnerability to hazards over time, which could have a critical influence on the actual risks from future climate change and the feasibility and effectiveness of adaptation options at a national or local scale.

A global climate scenario toolkit was developed (Ebi et al., 2013; Kriegler et al., 2013; O'Neill et al., 2013; van Vuuren et al., 2013) to provide a typology of alternative futures, and that has enabled systematic exploration of adaptation and mitigation challenges arising from alternative socio-economic futures for different climate scenarios (O'Neill et al., 2017; Riahi et al., 2017).

Several elements constitute the typology of alternative futures. The first element is the *representative concentration pathways* (RCPs), which describe the global atmospheric radiative forcing associated with varying levels of GHG emissions and concentrations (van Vuuren et al., 2013) up to 2100, and provide input to physical climate models to understand consequent changes in temperature and sea level. Global climate models provide boundary conditions for regional climate modelling, with finer spatial and temporal resolutions and characterization of additional climate variables (such as climate extremes) of relevance to policy, planning and resource management.

The second element is *the shared socio-economic pathways* (SSPs), which describe future global socio-economic conditions, including associated emissions of GHGs (O'Neill et al., 2013). They outline plausible alternative states of human and natural societies at a macro scale, and include narrative and quantitative elements of socio-ecological systems such as demographic, political, social, cultural, institutional, lifestyle, economic and technological variables and trends. They also include the human impacts on ecosystems and ecosystem services, such as air and water quality, and biodiversity. The global SSPs are designed to be extended to regional and sectoral scenarios.

The architecture and application of SSPs in impact, adaptation and vulnerability studies have mostly been at the global or broad regional scale (e.g., Arnell and Lloyd-Hughes, 2014; Hasegawa et al., 2015; O'Neill et al., 2013). Risks from climate change always reflect the interplay of forces across different scales, but local conditions can influence the severity of climate-related risks and adaptation options. There are only a few examples of studies that build on the SSP architecture and apply it at the regional level (Alfieri et al., 2015; Carey, 2014; Palazzo et al., 2017), the national scale (König et al., 2015; Steininger et al., 2016), or the sub-national scale (Absar and Preston, 2015; Nilsson et al., 2017).

SSPs do not themselves contain climate policies, and require the development of additional shared policy assumptions (SPAs) that describe how a world that follows a specific SSP might, in a specific climate change context, adapt to change and reduce emissions to achieve a certain climate outcome prescribed through an RCP. Kriegler et al. (2013) argue that global SPAs should only contain information about climate policies. We argue, however, that *national* SPAs, especially if they seek to inform understanding of climate change risks and adaptation options, need to contain a mix of climate-specific and non-climate-specific policies to ensure scenarios are credible with stakeholders and salient to the climate change risks individual countries face. This is because national and local choices for managing natural resources and hazards will strongly influence how climate-related risks materialize, and which response options are more or less consistent with existing institutions and governance mechanisms. Such an approach would enable consistency with a country's distinct environmental and land-use governance and institutional architecture. In other words, there are potentially multiple synergies and conflicts arising from the interaction of climate and non-climate policies in a given jurisdiction (e.g., Daigneault et al., 2017a), and these interactions need to be captured in a national-scale scenario to understand the risks and feasible responses.

In addition, the global typology assumes that nations are "mini-worlds" which is unlikely to hold true in many cases and as such the architecture will not reflect the local conditions which can influence the severity of climate-related risks and adaptation options. Recent research has presented methods to 'downscale' global assumptions and estimates, with a primary focus on quantifying metrics that are typically broad and based on a consistent set of inputs and assumptions across countries (Leimbach et al., 2017). Examples include using population, productivity, and capital stock growth to estimate regional per capita GDP (Dellink et al., 2017), or changes in age structure, educational attainment, and economic growth to project national per capita income (Cuaresma, 2017).

Accordingly, this paper develops a set of globally linked, national-scale socio-economic scenarios to 2100 and applies them for illustrative purposes in a New Zealand (NZ) setting to address the consistency between global scenarios of climatic and socio-economic projections and parallel scenarios for national and local level analysis through nationally specific shared socio-economic pathways (SSPs). Achieving such consistency is essential to provide a rigorous context at the national scale that fits into larger global assessments of hazards, exposure and vulnerability to climate risk. The scenarios are intended to be "plausible and often simplified descriptions of how the future may develop, based on a coherent and internally consistent set of assumptions about key driving forces and relationships" (Rounsevell and Metzger, 2010). The challenge is to reflect a country's unique conditions and plausible development choices within a set of global socio-economic development trajectories. Such scenarios will help assess climate-related risks, vulnerabilities and adaptive response options. In principle the scenarios could also help assess mitigation options, though less emphasis is given to greenhouse gas (GHG) emissions, except where they reflected environmental policy changes that also interact with a country's vulnerability to climate change.

Developing national scale scenarios, and within them specific local scenarios, is challenging because no country can be adequately understood as a *mini-world*. For scenarios to have traction in their local jurisdiction and reflect national governance and cultural traditions, they must have:

- credibility (scientific adequacy of the technical evidence and arguments)
- salience (relevance of the assessment to the needs of decision makers)
- legitimacy (production of information and technology that consider stakeholders' divergent values and beliefs) (Cash et al., 2002)