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Integrating top–down and bottom–up approaches to design global change adaptation at the river basin scale

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ABSTRACT

The high uncertainty associated with the effect of global change on water resource systems calls for a better combination of conventional top–down and bottom–up approaches, in order to design robust adaptation plans at the local scale. The methodological framework presented in this article introduces "bottom–up meets top–down" integrated approach to support the selection of adaptation measures at the river basin level by comprehensively integrating the goals of economic efficiency, social acceptability, environmental sustainability and adaptation robustness. The top–down approach relies on the use of a chain of models to assess the impact of global change on water resources and its adaptive management over a range of climate projections. Future demand scenarios and locally prioritised adaptation measures are identified following a bottom–up approach through a participatory process with the relevant stakeholders and experts. The optimal combinations of adaptation measures are then selected using a hydro-economic model at basin scale for each climate projection. The resulting adaptation portfolios are, finally, climate checked to define a robust least-regret programme of measures based on trade-offs between adaptation costs and the reliability of supply for agricultural demands.

This innovative approach has been applied to a Mediterranean basin, the Orb river basin (France). Mid-term climate projections, downscaled from 9 General Climate Models, are used to assess the uncertainty associated with climate projections. Demand evolution scenarios are developed to project agricultural and urban water demands on the 2030 time horizon. The results derived from the integration of the bottom–up and top–down approaches illustrate the sensitivity of the adaptation strategies to the climate projections, and provide an assessment of the trade-offs between the performance of the water resource system and the cost of the adaptation plan to inform local decision-making. The article contributes new methodological elements for the development of an integrated framework for decision-making under climate change uncertainty, advocating an interdisciplinary approach that bridges the gap between bottom–up and top–down approaches.

1. Introduction

The Mediterranean basin is identified as a climate change "Hot Spot" at the global scale (Giorgi and Lionello, 2008; Mariotti et al., 2008), and significant impacts are expected on its water resources (Iglesias et al., 2007; Bates et al., 2008) and related ecosystem services (Bangash et al., 2013). Adaptation strategies are needed, but raise policy and scientific challenges (Smith, 1997; Hallegatte, 2009; Biesbroek et al., 2010; Haasnoot et al., 2013) that generate an increasing number of research initiatives and policy recommendations in the water sector in particular (Ludwig et al., 2011; EC, 2013; Quevauviller, 2014 Quevauviller, 2014). Adaptation is expected to be flexible, adaptive, and based on an integrated water resources management framework. The capacity to adapt is dynamic and influenced by economic and natural resources, social networks, entitlements, institutions and governance, human resources, and technology (IPCC, 2007a,b). Therefore, effective adaptation pathways would require a mix of structural and non-structural measures, including regulatory and economic instruments as well. To design

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the appropriate mix, adaptation measures should be “cost-effective”, but also “environmentally sustainable, culturally compatible and socially acceptable”, and their selection should be based on the results of “vulnerability assessments, costs and benefits assessments, development objectives, stakeholder considerations and the resources available” (UNECE, 2009).

Two main approaches are commonly applied to design climate change adaptation plans at the river basin scale: “top–down” and “bottom–up” approaches. Top–down (or ‘scenario-centred’) methods involve downscaling climate projections from General Circulation Models (GCM) under a range of emissions scenarios, providing inputs for hydrologic and management models to estimate potential impacts and, finally, to analyse adaptation measures (e.g. Caballero et al., 2007; Sperna-Weiland et al., 2012; Milano et al., 2012; Pulido-Velazquez et al., 2014). Nevertheless, the vast majority of existing top–down studies stop at the impact assessment phase (Wilby and Dessai, 2010). The term “top–down” is used because information is cascaded from one step to the next, with uncertainty expanding at each step of the process. However, as uncertainties increase along the top–down modelling chain, at best it provides an “uncertain outlook”, which complicates the definition of adaptation strategies; at worst, it provides results too uncertain for decision-makers to even consider them. Despite this unavoidable propagation of uncertainty (Dessai et al., 2005; Ekström et al., 2013), this should not be used as an excuse for delays or inaction in adaptation, as water resource systems can be greatly affected (UNECE, 2009). Improving the top–down approach would require, on the one side, addressing the challenges of a more complex probabilistic multi-model ensemble forecast (Knutti et al., 2010) or, on the other side, addressing the uncertainty propagation through all steps involved in the regional climate downscaling and hydrological modelling (Ekström et al., 2013). The case for or against probabilistic approaches is made by biophysical and social vulnerability scholars respectively, the latter challenging the relevance of climate change probabilities in defining adaptation strategy (Dessai and Hulme, 2004).

The bottom–up approaches analyse social vulnerability and adaptive capacity to climate variations to make adaptation decisions (decision-centred approaches). These methods start with a range of possible local responses as a portfolio for coping with global change-related threats at the level of the different stakeholders (individuals, households and communities). Adaptation strategies are not presumed by the researcher but rather identified empirically from the community, using semi-structured interviews and focus group discussions, information from experts and local stakeholders, and available literature (Smith and Wandel, 2006; Adger et al., 2009; Bhave et al., 2013). The robustness of various possible adaptation strategies can then be assessed by evaluating their performances against a wide range of plausible scenarios (Groves et al., 2008), and, in some cases, without relying on emission scenarios but focusing on sensitivity analysis or stress tests (scenario-neutral approaches, Prudhomme et al., 2010). Many vulnerable systems are already coping with current climate change variability, which also provides a range of options on which to base adaptation and increases adaptation capacity (Dovers, 2009).

These two attitudes toward the “drama of uncertainty” (Mearns, 2010) can be summarised as: on the one side the “necessity-of-reducing-uncertainty camp” that would further investigate via a top–down approach in order to narrow down uncertainties and support adaptation from a “predict-then-act” perspective; and, on the other side, the “vulnerability-and-response camp” that develops tools and methods to analyse the risks associated with adaptation strategies. The distinction between the two camps is not straightforward, and scientists do not always belong to one camp only (Meyer, 2012). Several authors have already discussed the benefits of integrating both approaches in the adaption process (e.g. Barthel et al., 2008; Wilby and Dessai, 2010; Ekström et al., 2013), although only a few studies have combined them in practice (Mastrandrea et al., 2010; Bhave et al., 2013). Our interest lies in the interface between the two aforementioned approaches, leading to our investigation of a

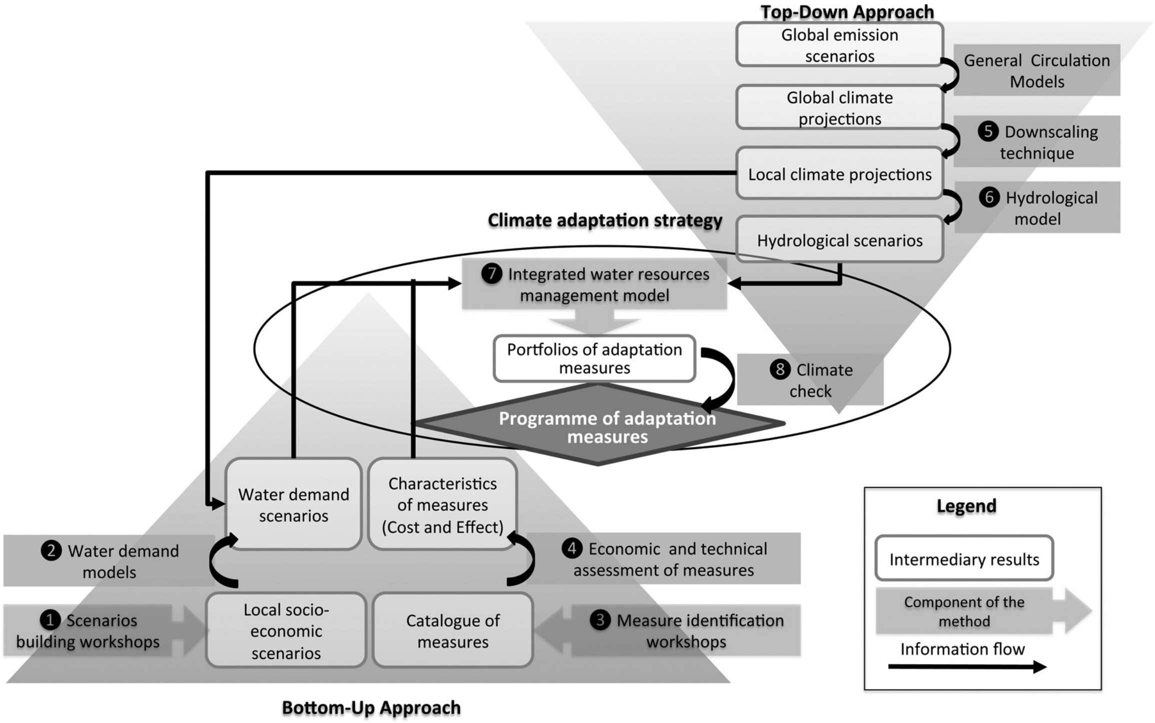

Fig. 1. Combining top–down and bottom–up approaches to support the design of climate change adaptation programme of measures. The components of the method are numbered in order to be described in Section 2.