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Assessing climate change impacts on the quantity of water in Alpine regions: Foreword to the adaptation and policy implications of the EU/FP7 "ACQWA" project

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ABSTRACT

This paper provides a short introduction to the special issue of "Environmental Science and Policy" dedicated to policy issues emerging from the large integrating European "ACQWA" project. This 5-year research project focused on upstream–downstream links related to water resources in mountains where snow and ice are a major component of the hydrological cycle – and thus extremely vulnerable to climatic change. Contributions to this special issue explore issues of governance in different socio-political contexts (Europe, Chile, Kyrgyzstan), and for environmental and economic sectors that compete for water, such as freshwater ecosystems, agriculture or energy (hydropower).

1. Introduction

This special issue is based on the policy and governance analysis of the ACQWA project (Assessing Climate Impacts on the Quantity and quality of Water; www.acqwa.ch), a 7th Framework Project funded by the European Union (EU). The special issue comprises 9 contributions that draw upon the work of this major, 5-year project that has investigated the potential impacts of a changing climate on the quantity, seasonality, and quality of water originating in various mountain regions where snow and ice is a significant part of the environment.

In this geographical context, climate change takes on particular significance since snow and ice melt represent a large stream-flow component and a vital local resource for freshwater supply, hydropower generation, irrigation, tourism activities, and other industrial uses. Glaciers and snow pack act as vital natural storage systems, storing water as snow and ice through the wetter winter periods and releasing these provisions in the form of surface runoff during the drier summer months. Changes in precipitation and temperature will therefore impact both the quantity and timing of water available across these different sectors. Changes in the frequency or intensity of hazards (e.g., floods, glacier lake outburst floods, rockfalls and landslides) are also likely to have

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a range of socio-economic implications as shifts in temperature and precipitation would inevitably affect the altitude of the zero-degree isotherm, thus influencing glacier and snow melt, and enhance the risks of slope instability events as the mountain cryosphere rapidly changes.

2. Implications for policy

Mountains are recognized as very sensitive physical environments with local populations that are highly exposed to rapid changes in the resource base on which their economic livelihoods are dependent. Moreover, policy priorities for many mountain regions are often set by downstream actors, leading to trade-offs across different policy contexts that have the potential to be further exacerbated by changes in the hydro-climatic environment. While governance is well recognized as a core issue in current water resource related challenges, to date there is still a paucity of information on how adaptable water governance regimes in mountain areas could be to hydro-climatic changes and the socio-economic impacts that these changes imply.

The consequences of these impacts therefore need to be taken into account in the rules, rights and policies that structure the manner in which water resources are managed across its multiples uses, as well as the methods for protecting society from hydro-climatic related hazards. However, traditional governance and management approaches have often unsuccessfully coped with current internal or stochastic climate variability. Practitioners and scholars therefore not only need to address current rules and practices for managing historical challenges within the current envelope of uncertainty, but also to assess the adaptability of current frameworks for managing water resources and hazards to future climate change impacts.

In addition to the challenges of communicating and adapting to different scales of climate related challenge (i.e., internal or stochastic variability versus increased uncertainty and variability from climate change impacts), water resources governance and management adaptation must also deal with a number of other scale based challenges. These include: trade-offs across risk response when short term adaptation actions potentially undermining long term social-ecological resilience (Adger et al., 2009; Hill and Engle, 2013); balancing out proactive and reactive responses, as well as responses to multiple forms of stress at different magnitudes of physical change and scales of governance (Hill, 2013a); trade-offs between narrowly defined adaptation policies and other policy frameworks and economic sectors. Cross-scale and sector trade-offs need to be better understood in the process of developing adaptation and broader environmental policy, plans and projects that address the impacts of climate change (Adger et al., 2009; Hill and Engle, 2013). Furthermore, downscaling climate and socio-economic impacts to finer temporal and spatial scales can give decision makers a clearer view of how these tensions might play out in a future climate, and therefore allow them to better prepare for and respond to them.

At the European level, while European climate change and adaptation policy is still in its infancy, reflection of how to account for climate change impacts is happening in relation to the Floods Directive and the next round of River Basin Management Planning for 2015 according to the Water Framework Directive (European Commission, 2009). In Switzerland, a comprehensive climate change adaptation policy is in early development at the federal level. However, water resources use and management transcends multiple policy frameworks, and underlying trade-offs across different policy frameworks and sectors must still be better accounted for and remediated as we move into an era of potentially less manageable pressures from the hydro climatic environment.

3. Translating science to policy

Not only are the driving forces of climate highly uncertain, but fundamental scientific knowledge gaps limit the reliability of model projections (Hallegatte, 2009) with uncertainties in how climatic and non-climatic pressures will interact on different aspects of hydrology and ecology (Wilby et al., 2010). Traditional decision making tools, water management and infrastructure have however tended not to be developed to take account of the broader levels of uncertainty produced by climate change projections (Hallegatte, 2009). Despite scientific efforts focussed on the reduction of uncertainty, through enhanced data collection and modelling (Schneider and Kuntz-Duriseti, 2002), the uncertainty surrounding the specificity of climate change impacts remains a major challenge to planning and managing for future hydro-climatic conditions. However, policy makers, decision makers and water managers are increasingly recognizing the need to develop better tools to manage and cope with both existing and increasing levels of uncertainty from climate variability and climate change impacts (Hallegatte, 2009).

While in many areas better managing for current and future levels of uncertainty is key, effective monitoring and data provision remains a critical component to remediating challenges relating to the current lack of knowledge and data on hydro-climatic, other environmental criteria and usage particularly in nations that are most at risk with the least data infrastructure. This is and should remain a core component of the on-going work on climate services, WMO standards and data sharing at international as well as national levels. While this is vital in developing countries, wealthier nations should not cease to continue to maintain and where possible improve their own monitoring and data infrastructure.

The growing body of work on climate change and climate change impact projections, adaptation and adaptive capacity have developed a broad set of principles, determinants and indicators for adaptive governance and management of water resources. However, there remains a need for clearer guidance on practicable mechanisms and actions at different levels of policy making, institutions and water management. This could help better guide the concrete changes that need to be made in governance and management frameworks to improve their sustainability and adaptability. Often there has been too much focus on the technological aspects of water resources management and adaptation and not enough on the governance and social infrastructural aspects of water systems (Adger et al., 2009; Hill, 2013b).

4. The special issue

This special issue results from research that has taken place over the 5 year course of the ACQWA project (October 2008–September 2013). The studies presented have all drawn on the core scientific findings on climate change impacts from the physical science outputs of the ACQWA project as a starting point to explore the adaptation related challenges and solutions within and across the ACQWA case areas. A second special issue focusing on the physical aspects of changing water resources as investigated during the ACQWA project can help complement the issues discussed here (Beniston and Stoffel, 2014).

ACQWA utilized advanced modelling techniques to quantify the influence of climatic change on the major determinants of river discharge at various time and space scales, and analyze their impact on society and economy. The main focus was to develop continuous transient scenarios from the 1960s up to 2050. By focussing on developing scenarios of change up to 2050 for a set of river basins, the project aims to develop climate information downscaled to temporal and spatial scales that are more useful to the challenges decision makers face (Beniston et al., 2011). This shortened modelling horizon allows for a more realistic assessment of the potential impact on the governance and socio-economic system components.

Concurrently, challenges arising from existing pressures in the policy context need to be better accounted for and remediated as we move into an era of less manageable pressures from the hydro climatic environment. Therefore, this special issue aims to develop a better understanding of how climate change impacts may impact existing policy issues, as well as make suggestions for developing policy to avoid the exacerbation of multiple pressure points.

Articles in this special issue therefore assess some of the key socio-economic impacts (hydropower, agriculture, and tourism) of changing hydro-climatic conditions in the ACQWA case areas: Upper Rhone Basin, Switzerland; Po Basin, Italy; Aconcagua Basin, Chile; Syr Darya Basin, Kyrgyzstan; Cuyo Basin, Argentina. Furthermore, the articles seek to identify the particular challenges that arise from these climate change impacts for governance and institutional frameworks. By doing so, the special issue identifies lessons learnt for policy makers and water managers as well as applicable policy options for climate change adaptation.

The first paper (Hill Clarvis et al., 2014-a) compares the current policy and legislative frameworks for different aspects of water resources management to the projected impacts of climate change on the hydrology of the upper Rhone basin, in order to examine the appropriateness of the current approach for responding to a changing climatic context. Significant uncertainties pose numerous challenges in the governance context. The study draws on adaptive governance principles, to propose policy actions across different scales of governance to better manage baseline variability as well as more 'unpredictable' uncertainty from climate change impacts.

Three follow-on papers focus upon water resource availability in totally different geographical and political contexts to Europe, namely the problems encountered for rivers originating in the Argentinian Andes close to Mendoza (Schwank et al., 2014) the Aconcagua Basin in Chile (Hill Clarvis et al., 2014-b), and in the Central Asian republic of Kyrgyzstan (Sorg et al., 2014). Chile represents a highly contrasting situation to the European basins, from both a physical and a governance perspective. In Chile, water rights are a marketable commodity with minimal environmental regulation and no sectorial prioritisation. Government institutions are highly centralized, with limited agency and capacity of water managers at the regional level. Both Chilean and Argentinean case studies have experienced increasing drought periods (from a combination of reduced summer runoff and altering precipitation patterns), compounding existent water governance and management challenges. Competing claims for increasingly pressurized water resources across hydropower, agriculture and viticulture sectors must be balanced with the protection of water supply and sanitation services for local populations. Multiple governance challenges constrict the capacity to adapt, including the lack of available, accurate, systematized and accessible information on water rights, the sustainability of water resources, climate impacts data, as well as the constricted agency and capacity of regional water managers to plan and manage multiple competing uses in an integrated and flexible manner to take account of shifting hydro-climatological conditions at the basin level.

Similar problems in Central Asian states such as the Kyrgyz Republic are furthermore compounded by the difficulty for these states to apply the principles of equitable use of water and to agree on a balanced reservoir management, which would allow the generation of energy in winter – benefiting upstream countries such as Kyrgyzstan – and irrigation for large-scale agriculture in summer – benefiting downstream countries such as Uzbekistan. Current challenges in the water operating regime are likely to be exacerbated by climate change impacts as water shortages during summer become more frequent with expected decreases in summer precipitation and reduced glacial meltwater releases due to smaller glacier volume.

The policy implications of hydro-climatic impacts on agriculture, hydropower and aquatic ecosystems are also addressed in this special issue. Bozzola and Swanson (2014) show that, if managed efficiently, water storage can be used as a tool to smooth variability in climatic variables and the impacts of this variability on agriculture. The specific case study of the Po river basin has been analyzed in this context. It is characterized by heterogeneous topographical features and intensive water use in agriculture. Recent drought periods, along with increasing pressure by growing population and economic activities, have served to highlight the role played by stocks of water resources in dealing with fluctuations of surface water supply. It is shown that ground water, farm ponds, water in dams and lakes, or other forms of water stocks can be used to smooth the increasing volatility in surface water supply, triggered by higher rainfall variability.

Gaudard et al. (in this issue) have analyzed the particular case of the Mattmark Dam, in the Swiss Canton of Valais and show that the electricity demand is affected only modestly by climate change. Econometric tools are used to assess the impact of climate-induced variations of water on the wholesale power market and to see how changes in the behaviour of the electricity markets and adaptive hydropower reservoir management can buffer the effects of changing water amounts and seasonality. While climate change will affect hydropower because of the possible reduction in surface water flows and seasonal shifts in water availability, technological, economic and behavioural changes in the electricity system are, however, expected to exert a stronger impact on hydropower. In the Po Basin of Northern Italy, on the other hand, Maran et al. (2014) show that an increase in the variability of water availability may result in a number of impacts for energy generation and supply. In particular, the exploitation of existent hydropower plants would decrease as a result of the increase of inactivity time (for run-of-river power plants) and the stability of the electric system (the transmission grid) could be endangered because of the growth in the randomness of the source of hydropower.

Khamis et al. (2014) show in their paper whether current conservation and adaptation principles and governance frameworks for freshwater ecosystems would be appropriate in the face of projected climate change. The focus on glaciated watersheds in the Pyrénées and the Swiss Alps has shown that current legislative and policy mechanisms, which are at the base of ecosystem conservation approaches, need to be reconsidered, with a proposed shift in focus from a ''species-centric'' view to a more holistic ecosystem functioning approach.

The final paper (Hill Clarvis et al., 2014-c) considers the challenges that a future climate will inevitably impose to water governance paradigms. The authors show that in response to climate change impacts as well as the continuing challenges concerning uncertainty, resilience design principles (iterativity, flexibility, connectivity and subsidiarity) are already being operationalized in certain legislative frameworks. These examples are used to provide further guidance and potentially serve as templates for the shaping and drafting of climate and adaptive water legislation that can balance these issues of flexibility, iterativity with procedural certainty, as well as ensure integration across governance scales through connectivity and subsidiarity.

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