Assessing Climate impacts on the Quantity and quality of WAter

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ACQWA

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THE ACQWA PROJECT: AN OVERVIEW OF THE ISSUES, METHODS AND SOLUTIONS

1. Key issues

As the evidence for anthropogenic contributions to climate change becomes clearer, so too does the realization that its effects will have impacts on environmental and socio-economic systems (Beniston 2002, Orlove et al. 2008). Some regions are more vulnerable than others, both to expected physical changes and to the consequences they will have for ways of life. In particular, mountainous regions are recognized as particularly sensitive physical environments with populations whose histories and current social positions often strain local capacity to accommodate intense and rapid changes to their resource base.

In this context, the European Commission has recently funded a research project entitled ACQWA (Assessing Climate change and impacts on the Quantity and quality of WAter). The objectives of the ACQWA project are to assess the impacts of a changing climate on the hydrologic cyle in mountain regions, focusing on the quantity and quality of water. Special attention is paid to regions where snow- and ice melt represent a large contribution to streamflow (Barnett et al. 2005) Indeed, with increasing evidence of glacier retreat, permafrost reduction and snowfall decrease in many mountainous regions, thus suggesting that climatic change may seriously affect streamflow regimes (Etchevers et al. 2002, Burlando et al. 2002), in turn threatening the discharge of water resources, increasing the downstream risks related to mass movements and floods, impacting hydropower generation, agriculture, forestry, tourism and aquatic ecosystems (Beniston, 2004; Brown et al. 2007, Stoffel et al. 2008). As a consequence, socio-economic structures of populations living downstream will be also affected, requiring better water resource management, and the development of strategies to avoid exacerbating situations of potential conflicts of interest. Already in today's climate problems of water resource appropriation are already seen to lead to tensions between different economic actors, and these tensions are likely to increase as the basic resource becomes rarer.

2. Methodologies

The ACQWA project aims to use advanced modeling techniques to quantify the influence of climatic change on the major determinants of river discharge at various temporal and spatial scales, while analyzing their impact on society and economy. A novel component of the ACQWA project is that both climatological and socio-economic feedback mechanisms will be identified and evaluated. The initial focus will be on the selection of appropriate continuous transient scenarios from the 1960s up to 2050. In comparison to many existing studies, the limitation of the modeling horizon to the middle of the 21st century allows for more realistic assessments of the progressive impact on the social, economical and political systems. These systems are expected to evolve typically in an adaptive mode on shorter time scales than the centennial ones, eventually shifting to new equilibria when forced abruptly.

Using these continuous transient scenarios to provide initial and boundary conditions, regional climate models will provide the essential information on shifting precipitation and temperature patterns. In addition, snow, ice, and biosphere models will be coupled with hydrological models in order to assess the changes in basin hydrology and seasonality, including theamount, and incidence of extreme events in catchment areas. The type of extremes that will be analyzed here take into account particular weather patterns that can lead to exceptional flooding (e.g., storms of Mediterranean origin), and geomorphic hazards. These hazards include various forms of erosion and slope instabilities that often contribute to increased sediment loading and thus to problems for infrastructure close to the rivers or hydropower installations.

Environmental and socio-economic responses to changes in hydrological regimes will be analyzed in terms of hazards, aquatic ecosystems, hydropower, tourism, agriculture, and the health implications of changing water quality. Attention will also be devoted to the interactions between land use/land cover changes, and changing or conflicting water resource demands. Integration of the information from all these sectors and the impacts on economies will feed into a quantitative model of water use incorporating supply and demand. The supply side requires inputs from both the regional climate models and from socio-economic sectors based on property, costs, and regulatory factors. Demand reflects population evolution, costs, and economic activity.

The resulting integrated model will permit the construction of plausible scenarios and allow us to evaluate various policy options for adaptation and mitigation. A significant novelty provided by the model constructs that will be implemented by the project is the ability to not only focus on the changes of the mean values, but also to assess the variability at different time and space scales. It will thus be possible to identify changes of the hydrological response to climatic change, while assessing its impact on a number of socio-economic sectors resulting from modifications of the temporal and spatial structure of the key variables describing water resources. Using this approach, inter-annual variability, distribution properties and scale issues will naturally be encompassed. Variability estimates will represent an important input for the analysis of the costs and benefits of the changes as well as the associated new risks these represent for societies.

The research on policy for adaptation/mitigation will involve not only European but also non-European partners, and will provide one of the major social-science outputs of the ACQWA project.

3. Case-study areas

The Rhone and Po river basins in the European Alps will be a common “test ground” for model investigations, where the different methodological approaches will converge to the basin scale through appropriate up- or down-scaling techniques. Both basins constitute ideal case-study areas, as they comprise all the elements of the natural environment that will be modeled (snow, ice, vegetation, hydrology). At the same time, these are highly regulated watersheds, subject to hydropower, irrigated agriculture, and tourism activities in the context of a climate that is at the borderline between Mediterranean and continental, and are therefore particularly vulnerable to climatic change. The methodologies developed over the first three years for the Alpine region will be

subsequently applied to non-European study areas, in particular the Aconcagua Basin in Chile where receding glaciers pose a genuine threat to water availability, and in Central Asia (Kyrgyzstan) where the same process involving much larger glaciers could represent significant economic opportunity, for example the development of hydro-power as a source of foreign income.

4. Interdisciplinarity: a key aspect of the project

The focus on water is the key element of the ACQWA proposal, because it is an essential for human populations, as well as animal and plant communities. Water is relevant in every aspect of mountain systems, in the physical, biological and socio-economic systems. It directly influences the energy supply (hydropower), tourism (snow, water usage, glaciers), forestry and agriculture (productivity changes with changes in water supply, need for irrigation) and services from natural and semi-natural ecosystems. On the other hand changes in any of these compartments will produce a feedback on water availability. Afforestation and deforestation processes triggered by climate change will likely affect the water balance, the generation of flood runoff and the sediment production due to enhanced or damped erosion. The project aims at going beyond the current state of modeling by accounting for such feedback mechanisms, particularly focusing on the impact of changing forests on the water regimes. Increased competition for water among these sectors may arise, requiring regulatory or market mechanisms to attenuate tension and assure efficient and equitable use. Achieving sustainable water use poses particular challenges for policy making because of its nature as a public good and also because it often has both upstream/downstream *and* transboundary/transnational characteristics. Any changes in climate affecting precipitation and the behavior of snow and, where relevant, glaciers, will have a major influence on the seasonality, amount, and quality of surface runoff. The main changes are thus expected in the surface water systems. These systems will be comprehensively analyzed, in order to quantify the changes affecting the streamflow regime, having the potential to cause uneven temporal distribution of the resource throughout the year. Thus, the project will mainly concentrate on surface waters, both because mountain regions are in generally depend on them rather than on groundwater, and the configuration of topography and landscape that do not allow the presence of sizeable alluvial deposits necessary for groundwater systems to develop. However, an assessment of the impact on downstream river-fed groundwater systems will be carried out, though without detailed modeling of the aquifer systems, by considering the effects on the recharge of groundwater systems due to predicted altered streamflow regimes and to modified space-time precipitation patterns.

The diverse and complex issues discussed succinctly above require an interdisciplinary and holistic approach to water management as climatic and socio-economic pressures change in the future. The project will promote a set of methodological approaches aimed at addressing these key issues and will prepare a decision-making framework for mountain water management. Short-term solutions to current and future problems of water resource management include, at least from a technological point of view, the construction of reservoirs to buffer the effects of increasing drought. The caveat of this solution is that there is a reduction in the social acceptability related to the construction of new dams in many areas since artificial lakes can also result in negative environmental impacts. Longer-term solutions require addressing the issues of greenhouse-gas emissions, beyond the 2012 targets imposed by the Kyoto Protocol.

Changing land use in catchment areas may also be a means of adapting to the negative consequences of water availability and quality in many mountain regions in a changing climate. While the main focus is on the European case, its strengths and weaknesses are best assessed in a comparative framework. Response strategies are thus studied by contrasting the Europe Alps, with their relatively high level of economic development and robust institutional structure, with Central Asia and Chile, where standards of living and latent conflict compromise effective water management.

5. Funding and duration of the project

The ACQWA project is thus a truly interdisciplinary initiative that brings over 30 European, South American and Central Asian teams together from the physical, biological, social, economic and political sciences. The 5-year project was allocated 6.5 million Euros (roughly $8.75 million) and will be completed by the end of 2013.

For further information: www.acqwa.ch

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