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Conference Report

IV International Experts' Meeting on Water Management and Climate Change: Dealing with Uncertainties, Zaragoza, Spain, 28 February–2 March 2011

Climate change and its possible impacts on water tend to focus mostly on the vulnerability of freshwater resources and associated negative impacts in socio-economic and environmental terms. The probabilities of increasing or decreasing precipitation in some areas as well as increased frequency of extreme events such as floods and droughts, are emphasized. This is in spite of the fact that present knowledge still does not allow us to understand and accurately predict how global changes may affect climatic patterns and how these, in turn, may affect precipitation and streamflows over specific geographical units, which is the level at which water resources planning takes place.

To address the changes, challenges and chances related to water management and climate change, the Aragon Water Institute and the International Centre for Water and Environment of the Ministry of Environment of Aragon, the Third World Centre for Water Management in Mexico and the International Water Resources Association jointly organized the "IV International Experts' Meeting on Water Management and Climate Change: Dealing with Uncertainties", in Zaragoza, Spain, 28 February–2 March 2011. Well-known international experts in the field of water management and climate change were invited to discuss future-oriented issues such as water management practices and how these should be modified to cope with climatic and other related uncertainties over the next two to three decades; what strategies and good practices may be available and may have to be developed to cope with the current and expected uncertainties in relation to climate change; what type of knowledge, information and technological developments are needed to incorporate possible future climate change impacts within the framework of water resources management, and similar issues. The topics of decision making in the water sector under changing climate and other uncertainties, and societal water security under altering and fluctuating climate, were discussed in depth, as well as case studies from basins, cities, regions and countries such as the Ebro Basin and the Himalayas; the Aragon and Catalonia regions in Spain and Gujarat state in India; the city of Zaragoza; and countries such as Australia, Greece, Mexico, Singapore, Spain and the Netherlands. Implications of climate change for agriculture in India and in the OECD countries were also discussed as well as experiences of several networks within Europe.

It was noted that precipitation is very likely to increase in high latitudes and likely to decrease in most subtropical regions. Average annual run-off and water availability are therefore expected to increase in high latitudes and some wet tropical areas, and to decrease in some dry regions of mid-latitudes and dry tropics. More variability can be expected as well as a much higher occurrence of extreme events such as floods and droughts, events that are critical for hydrological planning. Developing countries may face

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more challenging climatic conditions than developed countries because they are located in the tropical and sub-tropical climates where, historically, inter-annual and intra-annual climatic fluctuations are much higher, while developed countries are normally in temperate zones with comparatively stable climatic conditions. An additional argument for the expected higher impacts in developing countries is that, in general, their current water management practices, legal and institutional frameworks, human resources capacities, technology and information systems are mostly not robust enough to cope with the overall changes, uncertainties and challenges that may come with climate change and which may affect the whole spectrum of water uses in terms of quantity and quality as well as availability and demands for all uses.

Water resources management impacts are expected to extend to multiple policy areas such as food security, energy production, transportation and the environment, to give only some examples. In terms of agriculture, impacts may include changes in water quantity that may affect food production, storage and net availability for consumption; operation of irrigation systems and water management practices that may also not be robust enough to cope with the changing climatic patterns; impacts on crop yields and quality; incidence of pests and diseases and impacts on livestock. Strategies to counteract these likely impacts would include multiple actions, from adopting and developing more efficient irrigation technologies to improved management of natural resources (including, but not limited to water), recharge of aquifers, conjunctive use of surface and groundwater, and reduction of evaporation from soil surface and reservoirs. Adaptation and mitigation strategies could be the best way to face the potential challenges due to climate change. In terms of policies, adaptation measures are very complex and would require policy coherence between several sectors, use of policy instruments (mix of regulations), economic instruments and market-based approaches, political commitments to water policy, institutional reforms, improving human resources capacity, development of knowledge, information and monitoring for decision makers. These are all issues on which developing countries often lag behind and which will be more difficult to address under continuous changing conditions.

Even though the science of climate change has advanced significantly in recent years, there are still numerous gaps in terms of earth–ocean–atmosphere interactions, and how these may affect water resources at the river basin scales. Even after significant advances in remote sensing and understanding of teleconnections and modelling, many uncertainties prevail, ranging from reliable prediction of extreme river flow events to downscaling of rainfall to reasonable size planning areas. For example, regarding the glaciers in the Himalayan region, reaching any definitive conclusion has been very difficult, mainly because the network of observation continues to remain poor. Consequently, it is essential that the results of plausible development scenarios, suites of appropriate global and regional climate change models as well as reliable hydrological models, are generated producing probability functions for various impact elements which could be factored into the decision-making processes.

Discussions and arguments focused on the need to reduce the risk and the possible negative impacts that may occur due to climate change, always planning within a holistic framework which considers social, economic, political and environmental factors. Further discussions that focus on water conservation measures will be as important as those on adaptation, and recognition is needed that climate change is just one element of global change, but one which increases the urgency to plan, manage, develop and govern more efficiently the water resources available.

Feedback loops will become an integral part of the future water–climate relationship. Within any complex inter-relationship, when an important component changes, this invariably contributes to subsequent changes because the equilibrium is disturbed. Consequently, all types of feedbacks occur within the system, which are hard to predict. In terms of water resources, both planning and management need a new paradigm where change, and not stability, are the starting point of discussion. Therefore, to be effective, the water profession must broaden the debate on climate change and water and make it more realistic, considering facts and objective analyses of uncertainties based on the best up-to-date scientific knowledge. Addressing the multiplicity of causes behind the changes and not climate change alone should be the overall thesis guiding the planning and management on this topic.

Non-climatic factors are significant components of water management, and factors behind human-induced climate change are likely to affect the world of water significantly. Issues such as land use changes, structure and nature of population growth in the future, economic growth rates and development policies, food and energy requirements, consumption patterns, production levels and practices (both industrial and agricultural), large-scale water diversions, development of numerous feedback loops due to economic, social and political reasons which will significantly alter current forecasts, technological advances, their social acceptance and adoption rates, etc., may influence both water and local and regional climate in various complex ways even more than a local–regional manifestation of climate change, at least over the short to medium terms.

In terms of planning and investment, the Netherlands has developed strategies which include both short-term (every 5 years to assess the quality of the dikes) and long-term evaluation cycles (25–50 years on the capacity to prevent flooding, including whether policy changes are needed). An additional 200-year plan considers the shared economic responsibility of the government and the citizens against floods, when they live in flood-prone areas. Adaptation costs would not be inexpensive for the country, since they are expected to be about 0.5% of GNP. Nonetheless, since urban development of new infrastructure between 2011 and 2020 is calculated to be approximately E90 billion, and since 400,000 houses are planned to be constructed in flood-prone areas between 2011 and 2030, freshwater supply and flood risk management have to be considered on a long-term perspective.

One could argue that the real challenge the world faces at present is how to cope with increasing global uncertainties and driving forces, only one of which is climate change. It is certainly not the most pressing one over the short term, but one that needs to be understood and planned for in the long term. Within this framework, any hope of dealing with the situation the water sector is likely to face due to climate change has to rely on issues such as improved water governance, better and more robust infrastructural development, more emphasis on efficient water demand management, increased water efficiency and less water consumptive activities. In fact, the challenges recognized by a country such as Australia could well be considered by every other country so that they are prepared. This would require, *inter alia*, development of a water culture which should be an integral component of sustainable use, with competing interests being balanced and reforms which focus on addressing objectives; realization of the importance of transparency, especially as information has become a critical tool for planning and decision-making; and stakeholder management.

At present, a main constraint has been that experts working in climate groups are still hesitant to involve other important areas of knowledge and expertise such as water, energy and agriculture. The non-realization of the essential requirement of involving these sectors is seriously hampering the move towards developing sustainable solutions in critical areas such water.

Finally, to paraphrase Donald Rumsfeld, in the field of climate change there are known knowns, known unknowns and unknown unknowns, including implications of numerous feedback loops which are yet to develop and very difficult to predict with any degree of accuracy. It is the task of policy makers, managers, scientists and the public to work towards realistic adaptation and mitigation strategies that could be implemented over the long-term.

The invited papers that were specially prepared for the workshop will be peer-reviewed and published as a special issue of this journal.

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