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## Editorial

# The role of global change research for aquatic sciences

The current special issue of *Aquatic Sciences* is based on contributions to the session on “Vulnerability of Water Resources to Environmental Change – A Systems’ Approach”, 12<sup>th</sup> July 2001, Amsterdam, as part of the Open Science Conference “Challenges of a Changing Earth” of the Global Change Research Community.

Currently, the global change research community devotes increasing efforts to developing joint programmes bridging the natural and the social sciences. During the conference all sessions were jointly organized by the WCRP – World Climate Research Programme, the IGBP – International Geosphere and Biosphere Programme and the IHDP – International Human Dimensions Programme. The Amsterdam declaration was adopted by the majority of the several thousands conference participants. The declaration states that research needs to take into account the complex dynamics of the global earth system, develop an integrated perspective, couple scales, establish stronger links to policy makers and develop an ethical stewardship for the planet earth. The declaration will be put into practice in a number of joint projects where the big programmes collaborate on focal themes (energy, food, water). Global change research had its initial focus on climate change and energy. Over the past years it has increasingly extended its activities to other areas such as food or water.

The special issue focuses on integrated research on water resources under Global Change, taking into account ecosystem and socio-economic context. Issues of water availability, quality and distribution as well as strategies towards integrated water resource management are addressed. Links are made between region specific issues and the global scale, e.g. state of the world water system, agricultural water use, and decoupling of economic development from water use intensity.

Water resources management has a strong tradition at local and regional scales with a focus on technical solutions to environmental problem. Nowadays it is widely acknowledged that the water crisis is a crisis of

governance. Institutional change and allocation issues are more important than technical solutions to deal with the complex and intricate problems we face today. Hence, multi-stakeholder dialogues have been initiated and more research is devoted towards elucidating governance issues. However, the urgent need for social science expertise lacks behind the capacities available. And there is still little awareness for the importance of the global dimension. The special issue makes a contribution to foster integration by assembling a number of papers that attempt to bridge scales from the regional to the global in water resources management. All contributions aim also at bridging the gap between disciplines, in particular the natural and the social sciences.

Sorooshian, Whitaker and Hogue present an overview of current measuring and research activities on climate change programmes and what they can tell about regional effects and their implications for water resource managers. Vörösmarty presents a review of critical aspects in water management points and issues in water resources management. Alcamo and Henrichs present a top-down approach for identifying regions whose water resources have higher sensitivity to global change than other regions. Their method allows identifying hot spots for water stress and point out the emergence of possible conflicts. Wallace and Gregory deal with the problem of water stress related to the increased requirements of water for food production. They stress the need to develop new models and integrated approaches to deal with the increased number of people at risk and how these might change as the population grows. Further improvements to these models require local/basin scale water resource data and, ultimately, the integration of relevant social, economic, institutional and legal information. Meybeck introduces a typology how to characterize anthropogenic impacts on rivers and corresponding management strategies. He emphasizes the importance of viewing anthropogenic impacts on rivers in a historical and global perspective. This is exemplified for the Seine River basin.

The contribution of Pahl-Wostl addresses the importance of the human dimension for transformation processes towards sustainability. The emphasis is on processes of social learning both in interdisciplinary cooperation and among different societal stakeholder groups. Today's problems are complex and require adaptive management strategies and institutional change. This can only be accomplished by incorporating stakeholders' beliefs and attitudes into integrated assessment processes and models.

After the sessions a panel discussion focused on critical issues regarding the role of science in achieving the goal of an integrated water resources management.

### **Panel discussion: Achieving integrated water resource management – How can science help?**

Panel members: P. Balabanis (EU DG Research), R. Bos (WHO), P. Kabat (IGBP), O. Pascal (Vivendi Water Group), S. Sorooshian (WCRP), N. Summerton (chairman of the panel, IHDP), A. Szöllösi-Nagy (UNESCO), K. Takeuchi (IAHS)

The following text summarizes items discussed during the panel session, some of which also refer to contributions during the preceding session.

A wealth of data and scientific knowledge has become available, that can support integrated water resources management. Better ways have to be identified to apply the improved understanding of the hydrological cycle, its interactions with other parts of the Earth system and effects of human activity at all scales for a sustainable development of water resources.

In the foreseeable future direct human activities, including economic development and population growth, seem to have stronger effects on the hydrological cycle and water resources than climate change. Expected longer term effects of climate change include decreasing water availability in several regions of the world, despite a general intensification of the hydrological cycle.

Climate change effects include increasing variability and more and stronger hydrological extreme events, such as droughts and floods. Better prediction of these extremes remains an urgent goal for global change science.

The presentations of session C1 showed that global and regional assessments of water resources are to be improved with respect to water quality aspects – also an important health issue- and ecosystem water requirements. Gaps in current understanding of water resources also include interactions of groundwater and surface water, and the role of technological and social change in water use. Integrated assessments of global change effects on water resources and feedbacks of changes

in water use in the Earth system remain a scientific challenge.

Future water-science has to give more emphasis to the communication of research results and the implications of that knowledge for decision-making at all spatial scales. Besides communicating the effects of human activities on the global water cycle, global change research also needs to downscale global or continental-scale information for regional applications in integrated water resources management. Since water-scarcity has strong technological, institutional, social, and cultural dimensions, many solutions have to be region-specific. The identification of future regional hot-spots of critical water situations through global / Earth system analysis may be a science link between global and regional scale.

Decision support systems can provide a tool for communicating information and inherent uncertainty. While new scientific knowledge can help to reduce uncertainty, more emphasis has to be placed on developing flexible adaptation strategies to change, in order to decrease vulnerabilities.

It was repeatedly stated during the panel-discussion that developing countries are most vulnerable to global change induced effects on water resources. While the biggest gaps in knowledge (e.g. ungauged basins) and often the most drastic changes (e.g. in land-use) are found in these countries, they also have the lowest capacity for adaptation to change and seem to be most vulnerable in particular to increasing variability and hydrological extremes.

This finding was generally confirmed by the global assessments presented in session C1.

When discussing solutions to the increasingly critical state of water resources in many regions of the world, it has to be recognized that a major obstacle on the way to sustainable water systems are existing institutions and structures, many of which are not sufficiently flexible to adapt to changes. Increased scarcity is often attributable to human and institutional problems, rather than to physical or economic problems per se.

A dialogue with stakeholders, such as initiated in this panel discussion, has to be part of future scientific activities in the water sector. Perspectives and beliefs of the decision makers and stakeholders in general have to be added to integrated modeling, assessments and scenarios.

When discussing water prices, it was recognized that for certain uses beyond the minimum requirement that everybody should be entitled to, better pricing can influence demand and increase efficiency in water use, e.g. in agriculture where most of all water is used. The political sensitivity of water pricing and of economic instruments generally, as a tool for environmental improvement, needs to be recognized however.

The three global change programmes with their new Joint Water Project, will engage in more activities to link their science more closely to water policy making. For that, the science priorities have to be stated very clearly. IPCC-like assessment reports may be one means for communicating scientific understanding of water resources.

We hope that the current Special Issue will in particular raise the awareness for an integrated and global, perspective by readers who are not regularly exposed to that theme.

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