TRANSITION TO ADAPTIVE WATER MANAGEMENT: THE NEWATER PROEJCT

NeWater Working Paper 1

NeWater –
New Approaches to Adaptive Water Management under Uncertainty

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Authors	C. Pahl-Wostl, T. Downing, P. Kabat, P. Magnuszewski, J. Meigh, M. Schüter, J. Sendzimir, and S. Werners
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Pahl-Wostl, Claudia, NeWater working paper series editor
Institute of Environmental Systems Research, University of Osnabrück, Germany

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Abstract

Water Management is facing major challenges due to increasing uncertainties caused by climate and global change and by fast changing socio-economic boundary conditions. Adaptive management is advocated as a timely extension of IWRM to cope with these challenges. Adaptive management aims at increasing the adaptive capacity of river basins based on a profound understanding of key factors that determine a basin's vulnerability. More attention has to be devoted to understanding and managing the transition from current management regimes to more adaptive regimes that take into account environmental, technological, economic, institutional and cultural characteristics of river basins. The paper identifies major challenges for research and practice how to achieve this transition. The European project NeWater project is presented as one approach where new scientific methods and practical tools are developed for the participatory assessment and implementation of adaptive water management. The project puts strong emphasis on establishing science-policy dialogues at local, basin and global scales.

Key words: adaptive water management, uncertainties, stakeholder participation, IWRM, European research, global change, vulnerability.

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1 Introduction

Sustainable water resources management is an issue of increasing concern and is perceived as the major resource challenge of the 21st century. Sustainable development in ecological, economic and social terms can only be achieved if sufficient water is available (Cosgrove and Rijsberman, 2002)

Water scarcity or abundance, whether absolute or induced, is not, however, the only fundamental challenge. Water quality and pollution are major, and increasingly well-known, issues contributing to the emerging water crisis. Less publicized are challenges inherent in the variability and changing nature of water supplies, along with the limited nature of scientific information and technical knowledge. In many situations, basic hydrological and other data are unavailable, and projections of future drivers, such as climate change, are rather uncertain. This means that reliance on conventional methods of water management, based on the statistical analysis of historical data series, is not sufficient. Under such conditions, analysis must proceed iteratively with an emphasis on uncertainties rather than on the known (Pahl-Wostl, 2002a; Kabat and van Schaik, 2003). Furthermore, such challenges are not confined to water *per se*, but are also inherent in many other aspects of the rapidly evolving practices of environmental management Water problems and water management options are as much a product of the social, economic and institutional context as they are of the bio-physical and technical factors governing local hydrological conditions (Gleick, 2003). Many water related challenges have to do with socio-economic distribution and access, especially in developing regions. For people who can afford to pay or who belong to elite social groups, water is often not scarce, even in situations where the supply is extremely limited. Since water is the cornerstone of most economic activity, equitable distribution of supplies under changing conditions is often more of a challenge than absolute limitations on the available resource.

This paper aims at developing the rationale for a transition in science and practice of water management based on a critical analysis of current approaches and underlying concepts and the challenges water management is already facing today and is expected to face in the future.

1.1 The Intellectual Challenge

Historically, most water management problems were solved by additional infrastructure development, that is, by focusing on the supply side. Now, development opportunities are increasingly limited and perspectives are shifting toward improving the management and allocation of the resource base. However, this shift has been only partial. Many water planners and managers – in political positions, the private sector, non-governmental and governmental organisations, and funding agencies – remain focused on opportunities for technical solutions and supply development. As a result, substantial tensions exist between those advocating management solutions designed to increase the efficiency, equity and sustainability of water use, and those who still see additional (infrastructure) development as the best solution to water problems (Moench et al, 2003). This tension is compounded by questions of control. Water development is generally a large-scale construction activity requiring major resources and organisation which are both often the prerogatives of large, state-run types of governance structures.

These characteristics have contributed to the development of much large, centralised water infrastructure around the world. Such infrastructure is becoming inherently unsuited to support many water management functions. Efficient water use and equitable allocation depend on the behaviour of the individual users (over a wide range of scales, from the individual farmer or domestic consumer to users of very large quantities, such as major hydropower facilities). Management for efficiency and equity, but also for increasing uncertainty, will have to be), in many ways, an inherently local activity where courses of action and the incentives to undertake them are contingent on specific local hydrological, economic, technical and social conditions. Here we experience a scaling problem – how to integrate management approaches at local, regional and basin wide scales?

Beyond the shift from supply development, the increasing complexity and interlinked nature of social and water use systems at global, regional and local levels is a major factor reshaping water management needs and practices. Globalisation and the concentration of economic and other systems can have tremendous implications for water supply and use. For example, the factors influencing crop choice are heavily influenced by global market conditions or by agricultural subsidies (as in the EU and North America). In contrast to previous centuries, water diversions now often present a major fraction of river flows or groundwater recharge, and river basins are increasingly becoming physically and economically interconnected.

Given the complexity of the problem and the increase in uncertainties in the light of global change (e.g. changes in the likelihood of extreme events such as droughts or flooding), along with globalisation which is increasingly influencing river-basin level water management, new approaches are required to guarantee sufficient water of satisfactory quality for competing demands and protection from water-related risks (Kabat et al. 2003; Pahl-Wostl, 2002a). For example, the need to make large investments to cope better cope with the impacts of climatic extremes, such as (floods and droughts) cannot be as yet be substantiated in a fully deterministic way as this would require the provision of exact information on the frequency and magnitude of climatic extremes in the future. Instead, these and other future developments, including institutional and governance structures, are surrounded by broad margins of uncertainty, which makes both short- and long -term IWRM strategies complex and difficult.

Integration and new approaches to manage risks in the light of increasing uncertainties require transformation processes in institutional resource regimes and management style. Technical solutions are no longer sufficient to tackle the intricate problems we face today. Equally important are issues of good governance, with the human dimension in a prominent place. Scaling issues need to be explored to understand the complex dynamics of institutional resource regimes and to improve the match between biophysical and actor based scales. The strong tradition of local and regional water resources management has to be combined with integrative river basin approaches and has to be embedded into a perspective of global change. This necessitates linking research areas that have up to now developed rather independently with little exchange among them.

1.2 State-of-the-Art IWRM concept

To deal with the challenges elaborated in the previous sections, Integrated Water Resources Management (IWRM) must be able to respond to changes in the natural and social environment and to anticipate the uncertainties associated with these changes. The current IWRM[1] concept (GWP-TAC, 2000) does not elaborate on water management under uncertainty, nor does it include approaches and methods towards *adaptive* water management strategies. We advocate *adaptive water management* as an essential and timely extension of the IWRM approach.

The idea of adaptive management has been introduced in resources management for quite some time (Holling, 1978; Walters, 1986; Pahl-Wostl, 1995: Lee, 1999). It is based on the insight that the ability to predict future key drivers, as well as system behaviour and responses, is inherently limited. Adaptive management can more generally be defined as a systematic process for continually improving management policies and practices by learning from the outcomes of implemented management strategies. The most effective form of adaptive management employs management programs that are designed to experimentally compare selected policies or practices, by evaluating alternative hypotheses about the system being managed (e.g. Gunderson, 1999; Kiker et al, 2003: Richter et al, 2003). In the approach promoted in this paper, adaptive management has yet another target: to *increase the adaptive capacity of the (water) system*. It aims at integrated system design. The problem to be tackled is to increase the ability of the whole system to respond to change rather than reacting to undesirable impacts of change. Hence it is a pro-active management style. In Box 1 key concepts that we consider to be essential ingredients for understanding adaptive water management are defined.

BOX 1: Definitions of the key concepts and their relationship

Adaptive management has referred to implementing policies as experiments. Adaptive management can more generally be defined as a systematic process for continually improving management policies and practices by learning from the outcomes of implemented management strategies. As Bormann et (1994) defined it "Adaptive management is learning to manage by managing to learn". (In its most effective form it employs management programs that are designed to experimentally compare selected policies or practices, by evaluating alternative hypotheses about the system being managed. The goal of adaptive water management is to increase the adaptive capacity of the water system in a river basin based on a sound understanding of what determines a basin's resilience and vulnerability.

Vulnerability can be defined as: "the degree to which an *exposure unit* is susceptible to harm due to exposure to a perturbation or stress, and the ability (or lack thereof) of the exposure unit to cope, recover, or fundamentally adapt" (Kasperson et al. 2000). Vulnerability is the underlying exposure to damaging shocks, perturbations or stresses, rather than the probability or projected

[1] IWRM is most often quoted as '*a process which promotes the coordinated development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems*' (GWP-TAC, 2000). IWRM thus aims to simultaneously address two complicated and complex problems : sustainable development and cross sectoral planning.

incidence of those shocks themselves. This working definition of vulnerability encompasses **adaptive capacity**: the potential or capability of a system to adjust, via changes in its characteristics or behaviour, so as to cope better with existing and future stresses. More specifically, adaptive capacity refers to "the ability of a socio-ecological system to cope with novelty without losing options for the future" (Folke et al. 2002) and "that reflects learning, flexibility to experiment and adopt novel solutions, and development of generalized responses to broad classes of challenges" (Walker et al. 2002). Clearly, the focus of adaptive capacity is on the management of coupled socio-ecological systems, while vulnerability primarily refers to exposure to adverse impacts.

One feature of vulnerability and adaptive capacity is **resilience:** the amount of change a system can undergo and still retain the same controls on function and structure, the degree to which a system is capable of self-organization and the ability to build and increase the capacity for learning and adaptation (Holling 1973).

To choose between different management regimes requires the construction and analysis of **scenarios**: plausible descriptions of how the future may develop based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Scenarios may be derived from projections, but are often based on additional information from other sources, sometimes combined with a narrative storyline (McCarthy et al. 2001).

A key element of adaptive management and the transition to more adaptive management regimes is the participation of **stakeholders**: It is important to point out that stakeholders should not be confused with the public at large. A stakeholder is only defined in reference to a particular issue. "A stakeholder is an individual or group influenced by – and with an ability to significantly impact (either directly or indirectly) – the topical area of interest." The more tangible a problem and the more long-lasting an issue is on the public agenda, the better defined and organized are stakeholder groups. "Public" is defined here as all the members of the communities or citizens, interested in the local water issues and groups of water consumers. "Stakeholders" are defined here as representatives of organisations such as water providers, firms, NGOs and official representatives of water users, who have an interest in the water issues in their case study. The split between Public Participation and Stakeholder Participation is deliberately made, since methods for encouraging their participation and the level at which these different groups can participate and their role in the process are different (Pahl-Wostl, 2002b).

The role of participatory processes is an important characteristic of the **governance** system. Water governance refers to the range of political, social, economic and administrative systems that are in place to regulate the development and management of water resources and provisions of water services at different levels of society. One important aspect of governance is the role of **institutions,** defined as the formal and informal rules governing the behaviour of human beings. Formal institutions include laws and regulations (such as the European Water Framework Directive), formal organizational structures and formal procedures. Informal institutions refer to the rules and norms that are followed and developed in practice.

2 The transition to adaptive water management

We need to improve our understanding of the transition of current water management regimes to adaptive water management. The leading edge of innovation points toward transition, but requires rigorous science/policy processes to bridge the many barriers that have fragmented our thinking and practices in river management. The transition to more adaptive management is part of the "soft path" advocated by Gleick (2003) to build greater flexibility in water management regimes to address the rising uncertainty from global change:

"A transition is under way to a 'soft path' that complements centralized physical infrastructure with lower cost community-scale systems, decentralized and open decision-making, water markets and equitable pricing, application of efficient technology, and environmental protection."

The soft path implies a change towards understanding management as learning rather than control, towards including the human dimension as integral part of the management process.

The central tenet of our argumentation concerns the transition from currently prevailing regimes of river basin water management into more adaptive regimes in the future. This transition, in general, calls for a highly integrated water resources management concept. The need for greater integration is now widely recognised and accepted but there is, in actuality, little theoretical foundation as well as practical experience regarding how this integration could be achieved or of the consequences of attempts to achieve it.

Figure 1 represents essential elements of this transition. It compares the prevailing management regime with an adaptive regime and key areas of policy oriented research required to understand the transition process. The integration of these key areas will be essential for success.

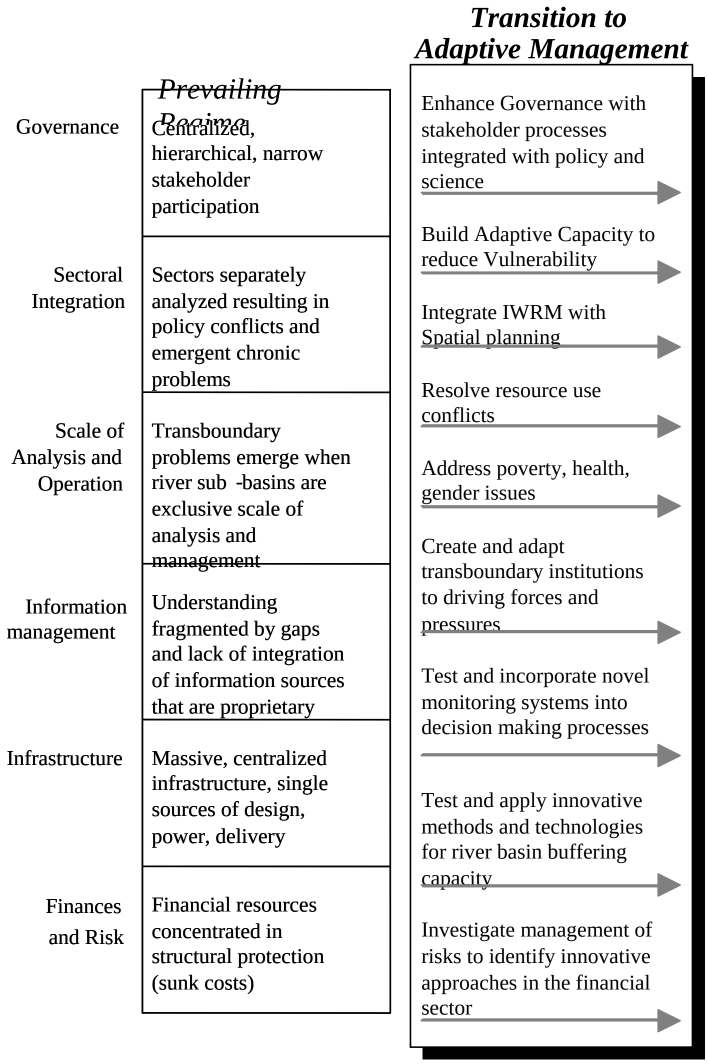

Figure 1: Major factors that determine the transition from the prevailing to an adaptive management regime.

A regime is not simply a management philosophy alone. It is characterized by a particular management style and the constellation of factors it entrains. Key factors reflecting this style include governance, the degree of sectoral integration, scale of analysis and operation, role and management of information, technical infrastructure, the structure of the financial sector, and risk management. Management styles are operational expressions of underlying paradigms. The fragmented world that must be "tamed" by the "command-and-control" view in prevailing regimes contrasts sharply with the fluid and dynamic sense of integration suggested by the adaptive regime's paradigm: "living with change" (Pahl-Wostl, 2002). By contrasting essential elements of the two regimes in their extremes the figure illustrates the challenge of the transition.

Understanding the barriers to integrated and adaptive management requires critical reflection on current modes of **governance**. The governance style in the current system is centralized and hierarchical with narrow stakeholder participation. Modern experiments in governance search for effective working alliances of governments, market parties (including among others the water services sector and the financial services sector) and communities. Similarly, insights into how institutions, people, organisations and sectors can work together are being applied to build more effective and practical science/policy decision processes. Theory and practice in science and governance stand to gain from these experiments. Currently such experiences and potential and limitations of processes of social learning in river basin management are investigated in the European project HarmoniCOP (Harmonizing COllborative Planning – www.harmonicop.info). Improved concepts of collaborative governance create the context for better science, policy and local practice that is necessary for the transition to more adaptive management regimes. In the adaptive regime governance is polycentric and stakeholder participation plays a major role. Hierarchical governance that is enhanced with better feedback from stakeholder processes can lead to a society-wide increase in adaptive capacity that can innovatively respond to uncertainty and change in river basins.

Maintaining control while improving adaptive capacity will provide security as well as novel responses that decrease vulnerability in river basins. The **sectoral fragmentation** characterizing current regimes is a key factor in their low adaptive capacity. The integration of IWRM with Spatial Planning is here of prime importance, and the transition requires the development of concepts and tools that can achieve this integration and resolve resource use conflicts. Geographical fragmentation that aggravates transboundary issues can be addressed by **multi-scalar analysis and practice**, supported by adaptive management. Poverty, health and gender issues must likewise be integrated. The sharing of data and **information** is a key issue which requires a careful analysis of how and why current transboundary regimes fail in this respect (Timmerman and Langaas, 2003). In many cases the information that would be required for adaptive water management is not available, requiring the development of a new generation of monitoring systems and the involvement of stakeholders in data collection and monitoring. For example the South-West Florida Water Management District has developed a monitoring system that increasingly relies on volunteer measurements by private citizens of groundwater levels to increase the spatial and temporal resolution of data to levels useful for policy. As another example, currently, an adaptive management process joins local governments, NGOs, citizens and scientists in determining and monitoring indicators of adaptive capacity in the Oder river valley in southwest Poland (Sendzimir et al. 2003)

Similarly, differences in the design of **infrastructure** would be required under an adaptive management regime. In the current management regime, technical infrastructure is designed to be rigid and centrally controlled. This applies for example to the design of dikes for flood management or of water supply systems to meet peak demand at any time. One consequence of implementing big infrastructure is that huge sunk costs make these systems extremely inflexible (Tillman et al, 2004). In an adaptive regime technical infrastructure combines centralized and de-centralized systems in a multi-scale, modular approach. This gives the systems the characteristics of a complex adaptive system, with internal degrees of freedom and distributed control, that have a higher capacity to buffer variability in both the socio-economic and natural environment.

"Living with change" implies a different approach to dealing with risk. The transition to adaptive management requires new approaches to risk management in the water sector and risk sharing which includes innovative approaches in the **financial sector**, in particular.

All these different factors are not independent but have co-evolved and are now highly interdependent as a constellation of interlocking approaches and structures that characterize a management regime. Transition requires concurrent and synergistic change in multiple factors. The development of concepts and tools that guide an integrated analysis and support a stepwise process of change and a continuous critical evaluation of progress are therefore a key element of the research activities in any transformation process.

Based on the above schemes we identify the following key areas where scientific breakthroughs and transfer into practical applications are required:

- governance in water management (methods to arrive at polycentric, horizontal and broad stakeholder participation in IWRM)
- sectoral integration (integration of IWRM and spatial planning; integration with climate change adaptation strategies; cross-sectoral optimisation and cost-benefit analysis)
- scales of analysis in IWRM (methods to resolve resource use conflicts; transboundary issues)
- information management (e.g. multi-stakeholder dialogue; multi-agent systems modelling; role of games in decision making; novel monitoring systems; community decision support systems (?)in water management)
- infrastructure (innovative methods for using river basin buffering capacity; role of storage in adaptation to climate variability and climate extremes)
- finances and risk mitigation strategies in water management (new instruments, role of public-private arrangements in risk-sharing)
- stakeholder participation; promoting new ways of bridging between science, policy and implementation

3 Building a sound scientific base for need and direction of change

The analysis of the need and direction of a transition towards more adaptive management regimes should be guided by a sound understanding of what determines the current and future vulnerability of the water resources in a river basin. Adaptive management as outlined in the previous sections introduces new objectives for integrated water management – to reduce vulnerability and increase adaptive capacity to enhance the ability of water management systems to cope with increasing uncertainties. Hence more emphasis is needed on research into areas such as assessment of vulnerability and resilience, the role of impacts of global change, and adaptive capacity. This is a new and up to now largely neglected field of activity for both research and practice. Figure 2 gives an example of a hypothetical vulnerability matrix that could be the result of a vulnerability assessment, created in interactive exercises with stakeholders and experts.

Exposure units		Stresses: Drought	Riverine flooding	Increased runoff	Rapid economic growth	Higher standards for water quality
	Riverine ecosystems	Change in habitat characteristics, loss of biodiversity, desertification 2	Pollution impacts 2	Change in habitat characteristics, loss of spawning habitat 2	Indirect effects on habitat quality/exploitation 4	Improved status 5
	Water-borne recreation	Low flow limits on boating 4	Periods of restricted use 2	Pollution impacts on recreation 1	Indirect effects on demand 2	Improved opportunities 5
	Water for cooling power stations	Impact on plant output 3	Impact of flooding on infrastructure 1	Requirements for filtering 1	Increased demand 4	Restricted discharges 3
	Private housing and property	Restrictions on water use 4	Impacts on buildings in flood plain 5	Requirement for local drainage 2	Use of new technologies 2	Investment in additional sewerage 3
	Domestic consumers	Loss of ability to conserve water during drought 3	Sewerage flooding and site contamination 2	Indirect effect on water quality 1	Trends in water use technologies 3	Increased charges for treatment 3

Figure 2 A hypothetical vulnerability matrix with examples of types of stresses and exposures. The columns include some of the climatic, environmental and economic stresses that may be present, and the rows represent the exposure units of natural resources (e.g., riverine ecosystems, the supply/demand balance, water recreation), economic infrastructure (e.g., power stations, private property), and actors (e.g., domestic consumers). The cells suggest the kinds of indicators that would be part of the framework, and the values in the cells are qualitative ratings of the relative exposure of specific elements or actors in the basin to specific stresses or threats (hypothetical ratings from 1 to 5).

Such a vulnerability matrix can be used to establish the **baseline** vulnerability or adaptive capacity as a description of current conditions, including existing or needed information on socioeconomic conditions, stresses, vulnerabilities and adaptations. A vulnerability baseline includes a description of current vulnerabilities to stresses (such as climate variability, drought, economic restructuring, policy changes). An adaptation baseline includes a description of the current range of adaptations to stresses. In order to be useful for establishing a baseline and for monitoring change, assessments must be rapid and must be based on data that are readily accessible.

Understanding key factors that determine vulnerability and adaptive capacity and being able to monitor change are required in a cyclic response and learning process as outlined in Figure 3.

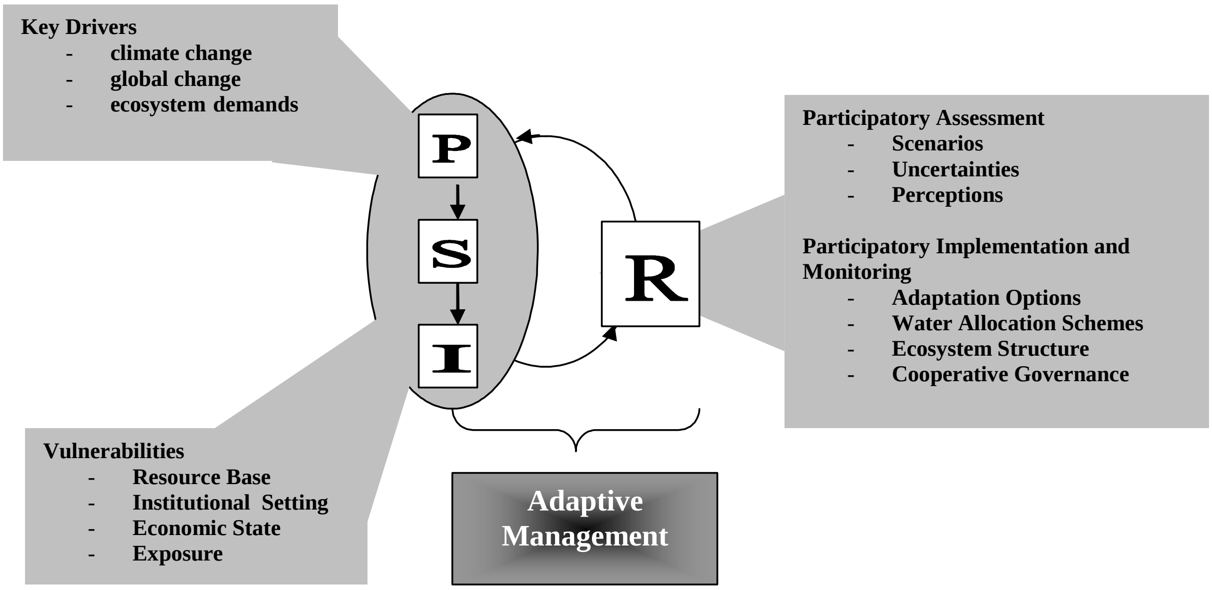

Figure 3 Adaptive management represented in an extended PSIR (Pressure-State-Impact-Response) framework – system design to increase the ability of the system to cope with change – R as part of the autonomous response strategies. The whole process has to be perceived as being iterative and proceed in cycles in contrast to the quite linear and sequential approach that is often adopted when using the PSIR scheme. The boxes indicate the type of variables and processes that are of importance.

Figure 3 summarizes how the system design uses the so-called PSIR (Pressure – State – Impact – Response) framework. Increasing the adaptive capacity implies an integrative view on the nature of response to stress. Management does not focus on individual responses at the end of a linear sequence of understanding individual pressures, their effects on system states and their impacts. Rather, it aims to increase the ability of a system to adapt fast to changes. Such management practices must build on a profound understanding of the dynamics of human-technology-environment systems. For an ecosystem, adaptive capacity might increase with the diversity of functional groups operating at different scales and responding to different environmental conditions in the system (Pahl-Wostl, 1995; Peterson et al. 1998). Far less knowledge exists on how the characteristics of water management systems – the combination of technologies, institutions and decision making mechanisms and ecosystem properties – influence their ability to cope with variability and change. For example, we are only beginning to appreciate the sophistication of some traditional cultures in establishing complex institutional structures to govern resource use at local and landscape scales (Ostrom, 1999). Or recently research has devoted more attention to understanding how formal institutional settings and different approaches to allocate water property rights influence the adaptive capacity of the institutional framework (Pagan and Crase, 2004). In this area there are major challenges for research and practice and there is an urgent need to collect and analyse more systematically experiences from different regions and countries.

4 Implementation of a new research agenda – the NeWater project

The challenges outlined in the previous sections are tackled in a European project: NeWater[2] (New methods for adaptive water management under uncertainty). New methods for the transition to adaptive water management will be tested in a number of case studies in Europe, Africa and Central Asia. Emphasis will be given to the assessment of key drivers of global change and the vulnerability of river basins. Concerned practitioners in the basins will play a crucial role in guaranteeing that the methods developed meet the demands from the practitioners and take into account local concerns and expertise. They will benefit from being able to direct research efforts to the issues of most relevance to them. Based on a joint assessment, suitable methods and tools for improved basin management will be developed and tested.

[2] The NeWater project is an Integrated Project in the 6th Framework Programme of the European Union. The total funding from the European Union is 12 Million Euro over a duration of 4 years (begin January 2005). The project will closely cooperate with another European IP AquaStress (Mitigation of Water Stress through new Approaches Integrating Management, Technical, Economic and Institutional Instruments) following a similar paradigm of adaptive and participatory water management.

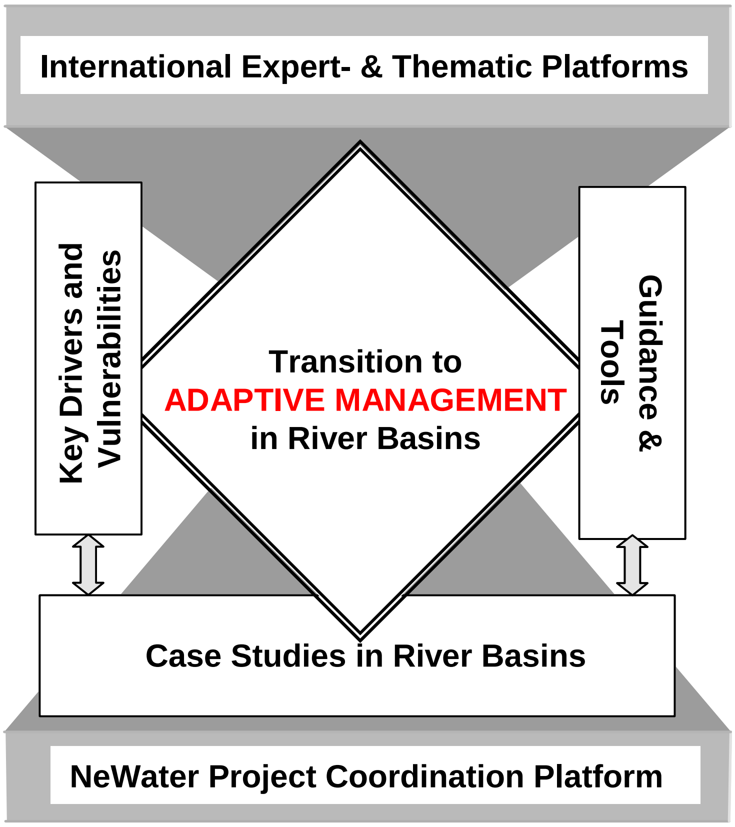

Figure 4 Major building blocks (work areas) of the NeWater project.

Figure 4 represents the major building blocks of NeWater: **Work Area Transition to Adaptive Management** will develop new concepts and methods for understanding and implementing the transition from current practices to more adaptive management to increase the adaptive capacity of river basins. WA Transition will integrate results and tools from **Work Area Drivers and Vulnerabilities** that will investigate vulnerabilities and adaptive capacity of river basins and develop practical toolkits to set the baseline for understanding the priorities to be addressed by adaptive management strategies. **Work Area Case Studies** will carry out stakeholder processes and coordinate empirical research in the selected river basins to generate input to the development of new concepts and methodologies and to provide a test bed for their plausibility and applicability under different environmental and societal conditions. **Work Area Guidance and Tools** will further develop tools and guidance for practitioners based on new conceptual insights, experience collected in the basins and the needs from ongoing policy processes, in particular the European Water Framework Directive and the European Water Initiative. Research activities and the development of guidance for practitioners will pay much attention to integrating results from previous and ongoing EU projects and to engaging in an intensive dialogue with the wider community of IWRM experts. **Work Area International Platforms** will establish the link to relevant European activities and ongoing policy processes. The platforms will provide immediate feedback from and to policy processes, in particular to the implementation of the European Framework Directive[3] and the European Water Initiative[4]. **Work Area Internal Platforms** will implement a flexible and interactive management structure that serves the purpose of such an innovative and modular project.

The case studies were chosen to provide a rich base of empirical knowledge covering different environmental, institutional, cultural and economic settings. Fig. 5 shows the location of the case study basins:

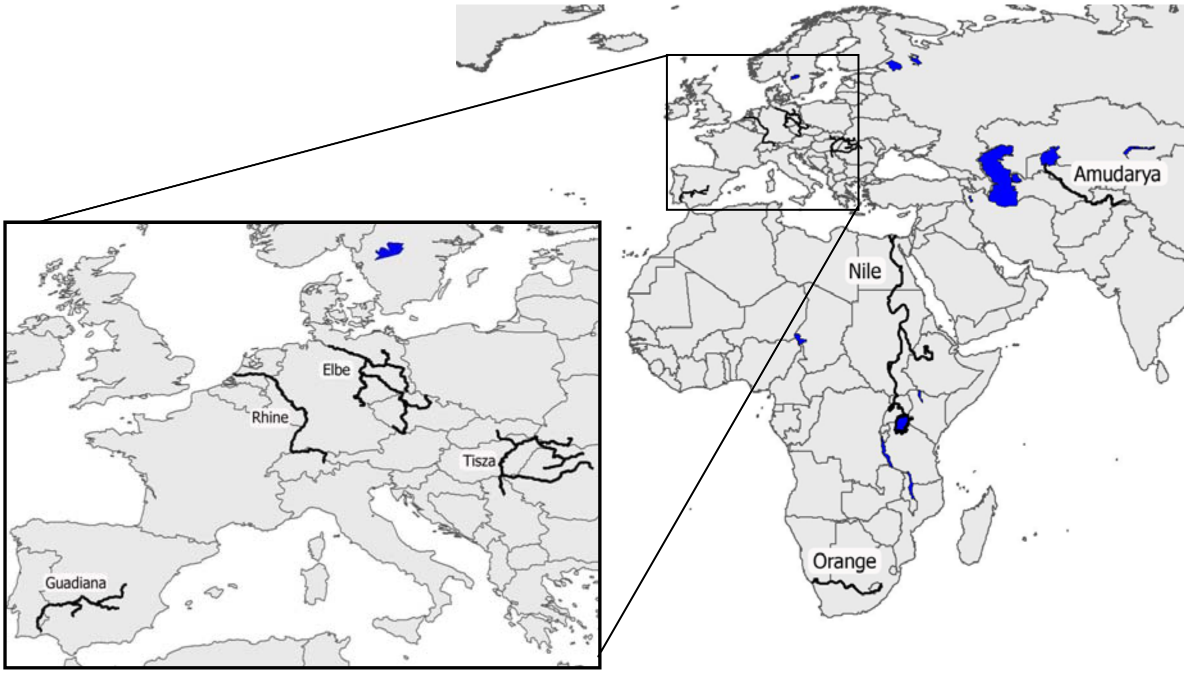

Figure 5 Location of case studies in the NeWater project.

The selection of case study basins was based on the following criteria:

- ***Vulnerability to key drivers and pressures*** - The basins are representative of many of the major issues in water management and/or are expected to suffer major impacts of global environmental change.
- ***Contrasting wet and dry basins in different institutional contexts*** - They provide wide geographical, cultural and institutional coverage, with two basins in

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[3] The European Water Framework Directive adopted October 2000 prescribes to all member states of the European Union to achieve a good ecological status of aquatic ecosystems by 2015. It requires to develop and implement river basin management plans and to include stakeholders and the public into this process (europa.eu.int/comm/environment/ **water/water-framework**/index_en.html).

[4] The European Water Initiative supports the Johannesburg development goals to half the number of people without access to safe water and basic sanitation by 2015 and to generalise the adoption and practice of integrated river basin approaches based on knowledge and innovation (europa.eu.int/comm/research/ **water-initiative**/index_en.html).

the existing European Union (as it was before May 2004), one in a wetter and one in a drier location (Rhine and Guadiana); two basins in EU accession countries, again wetter and drier (Elbe and Tisza); and three in developing countries.

- ***Water Framework Directive pilot studies*** The European basins all include sub-basins which are pilot basins for the implementation of the European Water Framework Directive.
- ***EU Water Initiative – intercontinental links*** The basins in developing countries provide a linkage to the priorities of the EU Water Initiative, focussing on Africa and Central Asia.
- ***Cross border legal and governance issues*** **-** All basins are transboundary.
- ***Information accessibility*** **-** All have adequate or good data availability.
- ***Working links with local stakeholders and actors*** **-** Research and stakeholder processes are ongoing, and NeWater partners have existing stakeholder contacts.
- ***Appropriate scale*** **-** All are relatively large basins, providing the opportunity to analyse water management issues at a range of spatial scales.

NeWater will also devote much attention to achieve a true integration between social, natural and engineering sciences and to bridge the science policy gap. Despite much efforts in recent years, there is still a huge gap between the social and the natural/engineering sciences. Whereas more formal approaches such as decision theory have started to be integrated, more qualitative approaches in the social sciences are still neglected. NeWater will address the strong need to bridge the "hard" and "soft" approaches in systems analysis

Soft systems approaches take into account that reality is partly socially constructed and that an understanding of subjective perceptions and the collective framing of a problem situation are essential to deal with complex environmental problems and management tasks (Checkland, 1999; Walker et al, 2002; Pahl-Wostl, 2002a, 2004). Hard systems approaches emphasize the need for factual analysis and "objective" and "hard" decision criteria. It may be highly misleading and even detrimental to achieving sustainable resources management if one relies on hard systems approaches in situations where uncertainties in the factual knowledge base are high and conflicts about values and management objectives are substantial.

The promise of applying systems science as a bridge between hard and soft systems approaches is realized as all stakeholders join to review technologies, policies, underlying assumptions and worldviews and re-assess the main goals and questions on which policies and practice are based. This allows participants recurring chances to correct the hypotheses, policies, action plans, and measuring tools (such as indicators) in a transparent and cyclic process. Systems methods help people see what they normally do not consciously think about or discuss in an open forum: feedback loops with complex interactions and delays that create long and mid-term impacts, expectations they hold about other people's behaviour and framing of the context into which they embed the problem under investigation. Such a dialogue is greatly facilitated by qualitative and quantitative modeling. The transition to adaptive management requires that stakeholders grasp how the system behaviour emerges from structure and the underlying worldviews. These methods help in that transition by exposing links between natural, economic and social processes that may sometimes be counterintuitive.

5 Discussion

Transition to adaptive water management is advocated in this paper as the major challenge for water management in the future. We strongly promote the argument that water management can only be integrated if it is adaptive and participatory. However, current practice is still dominated by the heritage of a technology-driven command and control approach. Therefore the challenge is the transition process towards more adaptive management itself. Part of the slow progress in implementing adaptive water management may be due to the fact that too little attention has been devoted to impediments to change. However, it is important to emphasize that we do not advocate adaptive water management as a type of “ideology”. NeWater aims at providing the scientific basis for better understanding the requirements for adaptive water management regimes and for developing a sound methodology based on factual analyses and stakeholder participation in order to assess, evaluate and implement new management strategies appropriate for the environmental, economic, institutional, social and cultural setting in a river basin.

The 6th framework programme of the European Union offers unique opportunities for a type of innovative research that is crucial for understanding and managing a transition to more adaptive water management regimes. The major advantages can be summarized as:

- Possibilities for interdisciplinary projects where disciplines can be chosen to meet the demands of the complex problems under investigation instead of being constrained by the disciplinary structure characterizing many funding agencies.
- Strong stakeholder participation and participatory action research.
- Direct combination between basic and applied research and tool development for practitioners
- New opportunities for public-private partnerships.
- Possibility to include case studies from Europe, Africa, and Central Asia.

NeWater provides a unique opportunity to promote a strong dialogue between industrialized and developing countries in both research and implementation, helping to avoid the problem that the concepts developed for IWRM tend to be biased by experience drawn from industrialized countries.

Reaching our goals requires an intensive dialogue between the science and policy communities. NeWater will implement strong stakeholder interactions in the case studies under investigation where new concepts and methods are assessed, developed, evaluated and implemented in participatory processes. The global research to application platform comprises as members most international stakeholders in the water field. Such a strong embedding into the research and policy communities will guarantee critical feedback and fast dissemination. We hope that this paper will stimulate further dialogue, and we invite comments from interested readers.

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