New methods for adaptive water management under uncertainty – The NeWater project

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Abstract: The European 'Integrated Project' (IP) NeWater is presented, an inter-disciplinary project developing new methods for integrated water resources management taking into account the complexity of the river basins to be managed and the difficulty to predict the factors influencing them (e.g. climate, socio-economic developments). The central focus of NeWater is a transition from currently prevailing regimes of river basin water management to more integrated, adaptive approaches that cope with growing uncertainty like climate change. Water management must become more flexible and responsive to change to be able to cope with increasing uncertainty. New management approaches must be tailored to the evolving institutional, societal, economic, environmental and technological setting of a basin. Therefore NeWater identifies key elements of current water management regimes and investigates their interdependence focusing on transformation processes of these elements in the transition to adaptive integrated water resources management. Investigated key elements include for instance governance in water management, sectoral integration, scales of analysis, information management, vulnerability, infrastructure, finances and risk mitigation strategies, and stakeholder participation.

The paper summarizes expected achievements and portrays how these results may contribute to the European policy on water resources management and its relations to the European Water Framework Directive and the European Water Initiative. Addressed outcomes are (a) an understanding of aspects that determine adaptive capacity and vulnerability of river basins, (b) a comprehensive methodology to develop, implement and decide between alternative management regimes, (c) support for a paradigm shift in water management in science, policy and practitioners communities at European and Global Scales, and (d) an innovative toolkit and guidance for practitioners in applying adaptive management.

Key words: IWRM – WFD - adaptive management – uncertainty – adaptive capacity

1. INTRODUCTION

Former approaches to water resources management were characterized by a range of clearly defined problems that society needed to solve. This includes sewage disposal, water supply, water pollution and quality or flood control. In general these problems were confined to sectoral management approaches while potential undesirable long-term consequences were not taken into consideration. The human dimension was taken into account as an "external" boundary condition. The system paradigm on which traditional water management is based can be characterized by a "command and control" approach.

The growing awareness that water requires a holistic management approach has lead to the creation of the Global Water Partnership (GWP – see http://www.gwpforum.org/servlet/PSP). The GWP along with many other institutions and individuals developed integrated approaches to address the short-comings of sectoral water resources management. Though organizations like the Tennessee Valley Authority practiced integrated management approaches for a long time (Newson, 1992, Snellen & Schreven, 2004) the definition of *Integrated Water Resources Management* (IWRM) by the Technical Advisory Committee of Global Water Partnership became the most cited approach. They defined IWRM as '*a process which promotes the co-ordinated 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-TEC, 2000).

However, there is a growing number of critical statements claiming that the adaption of IWRM theory into successful local planning is not always consequent or feasible (Biswas, 2004; Jeffrey, in press). One major cause for this lack of success is that the IWRM concept does not consider different types of uncertainty in the management process and the system itself.

The paper briefly addresses some challenges and shortcomings of the IWRM concept (section 2) and gives examples of uncertainty (section 3) that should be considered in IWRM. Section 4 describes the transition of prevailing management to more adaptive approaches and the core theme of the NeWater project introduced in section 5. Section 5 gives an overview of the research approach chosen in the NeWater project and of expected contributions of NeWater to European water policy.

2. IWRM: FROM A CONCEPT TO IMPLEMENTATION

Sustainable water management became an issue of major concern over the past decade. It has become increasingly clear that the pressing problems in this field have to be tackled from an integrated perspective, taking into account environmental, human and technological factors and in particular their interdependence. Due to the growing awareness that water plays a central role in industrial, agricultural, economic, social and cultural development, various management approaches have been developed to integrate them on the basis of the IWRM concept. Since the UNCED 'Conference on Water and the Environment' in Dublin (1992) with its concluding '*Dublin Principles*' the term IWRM became ***the*** keyword for all attempts of innovation in water management.

Kommentar: Reference to Rio summit, Gleick?

In many cases water management became a purposeful activity with multiple and partly conflicting goals to maintain and improve the state of water resources. Water as a resource must be allocated among competing uses. However, in many areas the available water is polluted and hence cannot be used for many purposes or requires expensive treatment. An uncontrolled urbanization and fast industrialization in developing and threshold countries contribute to exacerbate the pressure on the water resource. Although technologies and knowledge are in most cases available, the implementation into practical action is lacking.

Efforts to apply an integrated perspective broadened the appreciation of water resource availability from the absolute (gross volume) to the specific characteristics (the spatio-temporal distribution of water flows) that support the functioning of ecosystems and society integrity of riverine ecosystems and preserve their ability to provide services valuable to humans.

Given the strong technology-based tradition of water management, it is useful to point out that technologies are embedded in a network of social routines and institutions that link technologies to their function to achieve the overall management objectives. This area of research has not yet received sufficient attention, since often technical systems have been studied in isolation from their social context. Furthermore, technical solutions have been developed and implemented without taking into consideration institutional settings and governance issues which often has been the cause for failure.

Extremes and disasters

Dealing with extremes has always been one of the major challenges for water management. Natural water supply varies over time, and some variability can be compensated by the natural buffering capacity of the water system. Technical facilities have been used with the intent to extend the capacity of the water system to cope with extremes. Large-scale technical infrastructure has been implemented to shield human activities from the variability of the resource. Reservoirs, water diversions and artificial storage are used to enhance the resource base in case of droughts. Dikes and levees were built to protect settlements from floods in case of excess precipitation. However, the limitations of the ability to control extremes by technical means have become very clear during weather extremes over the past years. The century or even millennium flood of the Elbe in 2002 was followed by a century drought and heat wave in 2003 in Europe where dikes broke due to excess dryness of the building material.

Implementation limitations

Such events have triggered an increasing awareness in water managers of the possible challenges posed by global and climate change. It becomes more and more difficult to predict probabilities for weather extremes, a capability fundamental to current and future strategies to deal with risks. It has become even more difficult to quantify potential damages caused by weather extremes. Looking into the past does not tell us much about an uncertain future.

It is obvious, and also stated by most critiques on IWRM implementation in literature, that development of management strategies depends on knowledge about the managed system, a foundation riven with innumerable uncertainties of various sources (see chapter 3). Strategy development involves underlying risk-analysis, scope of action, and decision-making in addition to many other managing steps. Inflexible management approaches, which do not seek to monitor changing contexts and trajectories of an evolving system, can only amplify the negative consequences of ignorance of these changes.

Recently various authors argued that the IWRM approach is not really applicable as it is defined by GWP, generally due to operational questions and related problems of establishing measurable criteria (eg. Jeffrey and Gearey, in press, Kluge 2005, Lankford and Cour 2005).

Biswas (2004) and a couple of respondents to his article pointed out several barriers to implementation. Integration of sectors and issues would require more centralized policy development and implementation and thus larger, slower, and more bureaucratic authorities to handle all policy aspects. Furthermore, objectives like stakeholder participation and decentralization would be unlikely to promote integration. Biswas (2004) even stated that the GWP approach is unimplementable, internally inconsistent, based only on trendy words, and does not provide any guidance for water professionals as to how the concept could be used to make planning and decision-making more efficient. While Biswas is correct in criticising the vagueness of the IRWM concept, it should be noted that he regards only the operational (what will be) side of the concept.

Further implementation obstacles might be:

- Abstractness: there is no clear ontology of IWRM concepts, eg. on 'related resources'. Are related resources just neighbouring resources or does it includes all interrelated multi-sectoral areas?
- Uncertainty in management process, system understanding, modelling, knowledge, etc. (see chapter 3)
- Lack in scientific basis: as pointed out by Jeffrey & Gearey (in press) there is no reported empirical evidence for the benefits of IWRM. It can be characterized as a normative pragmatic approach without a deep scientific basis building on verifications and observations;
- No guidance how to deal with contradictory or competing demands on water usage; little implementation guidance generally;
- Missing operable indicators or criteria for indicating implementation success;
- No concrete convincing implementation has been reported so far;

These statements and obstacles provide evidence for the need to reconsider the underlying paradigms of policy-making and water management. It can be claimed, that in reality the ideal IWRM approach is rarely implemented whole, often in part. Only selected sub-sets of IWRM issues that fit to specific, local circumstances are implemented in river basins.

Consequences for management strategies

All these factors, limit the success in implementing the IWRM approach. We are strong supporters of an integrated approach to water resources management but claim that IWRM cannot be realized without rethinking fundamental assumptions and paradigms underlying current management approaches (Pahl-Wostl, 2002):

- Expand technical management to truly integrate the human dimension.
- Make management more adaptive and flexible to make it operational under fast changing socio-economic boundary conditions and climate change

This poses considerable challenges to the tradition of water management characterized by a prediction-and-control approach and an emphasis on technical solutions. To face those challenges **adaptive water management under uncertainty** is advocated as a timely extension of water management and a requirement to really move towards IWRM (Pahl-Wostl et al, in press).

The **NeWater projec**t (www.newater.info) is based on the hypothesis that IWRM cannot be realized unless current water management regimes undergo a transition towards more adaptive water management. This hypothesis needs to be critically tested and current arguments supported by more in-depth scientific analyses. This requires developing a sound conceptual base to characterize what makes a water management regime adaptive, why and under which conditions adaptive regimes should perform better, and how a transition towards more adaptive water management regimes can be achieved and the goals of IWRM be realized. To improve the applicability for a broader range of river basins the reasons for the lack of implementation must be further analysed and turned into concrete adaptive management strategies.

3. INCREASING UNCERTAINTIES AND COMPLEXITIES IN WATER MANAGEMENT

With the advent of climate change and the potential increase in the likelihood of extreme events, water managers' awareness for uncertainties and critical reflections on the adequacy of current management approaches has started to increase. However, climate change is only one and not even the most important source of uncertainty.

Uncertainties interfere with the management cycle at all stages from defining goals to implementing measures and monitoring their performance. Ambiguity exists in defining operational targets for the different management goals to be achieved and conflicts of interests require participatory goal setting (not by experts only) and a clear recognition of uncertainties in this process.

Outcomes of management measures are uncertain due to the complexity of the system to be managed and uncertainties in environmental and socio-economic developments influencing the performance of implemented management strategies. New knowledge about system behaviour may suggest options for change in management strategies. Changes in environmental and/or in socio-economic conditions may demand change in management strategies.

One may distinguish different types of uncertainty (Pahl-Wostl, et al, 1998, Funtowicz and Ravetz, 1990; Walker et al, 2003; Oberkampf, et al, 2001):

The best known type is lack of knowledge due to limited availability and variability in data. Quite a few technical approaches exist to include such uncertainties into simulation models. Uncertainties may be captured by including uncertainty bounds in results from model simulations or other types of quantitative assessments.

An equally important but less often acknowledged type of uncertainty is uncertainty in system understanding, not only historic trends but the system elements and their interactions (feedback loops and delays) that generate those trends. This applies in particular to socio-economic systems and human behaviour where more than one possible interpretation exists for the same phenomenon. But also the understanding of ecosystems is not as far developed as that of hydrological systems, the home turf of many scientists and practitioners working in water management. IWRM requires understanding human-environment-technology-systems in their full complexity!

Another source of uncertainty inherent in system behaviour rather than in the knowledge about it is the inherent unpredictability of certain factors. One prominent example is climate change, corresponding changes in nature and likelihood of extreme events. To cite one example among many, animal evolution in response to climate change is already documented, but the full consequences for ecosystems or society is hardly known. Uncertainty may also arise from the diversity of institutions and underlying mental models that constrain stakeholder perceptions and actions. Stakeholders may hold different perceptions and use the same type of information to construct quite different meanings of what is at stake: the goals to be achieved, likelihood of the success of measure etc. The simultaneous presence of multiple frames of reference to understand a certain phenomenon is also called ambiguity (Dewulf et al, in press).

Finally one should not neglect uncertainty in the implementation of regulatory frameworks (Newig et al, in press) which may prescribe an operational implementation of policy goals such as “the good ecological status” required by the WFD.

In the face of these challenges, ignorance and/or negligence represent more of a non-approach to deal with uncertainty in water management. Management needs first to broaden public debate and understanding of such uncertainties and the consequences of failure to address them. Numerous technical and quantitative approaches already exist to include uncertainties in the analysis and policy formulation. Qualitative uncertainty can be tackled in a variety of participatory approaches targeted at achieving learning processes and negotiations with agreements despite different perspectives.

To take into account all uncertainties in a more comprehensive fashion, a change in the overall management approach is needed. Adaptive management embeds uncertainty as fundamental principle in the management approach (Gunderson, Holling and Light 1995).

The adaptive management process is represented by fig.1 as a structured learning cycle that iteratively links four phases:

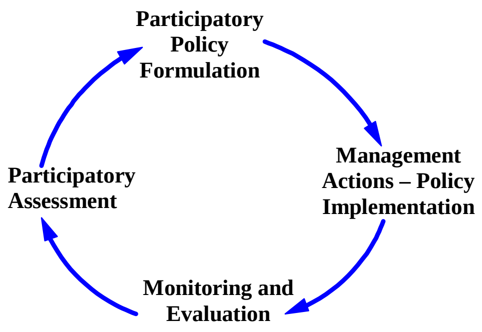

Figure 1. Four phase of the adaptive management process

Adaptive management strategies:

- are robust under different possible future developments
- allow changing course based on new insights
- help establish and sustain institutional settings and technological systems that are flexible and error-tolerant.
- offer a framework for transparent and fair learning and decision making processes.

What are now the requirements for dealing with uncertain developments in an adaptive management approach in river basins?

(1) New information must be available and/or consciously collected (e.g. indicators of performance of management regimes, indicators for change that may lead to desirable or undesirable effects)

(2) The actors in the management system must be able to process this information and draw meaningful conclusions from it. This can be best achieved if monitoring and information collection is based on formulating hypotheses about the system to be managed.

(3) Management must have the ability to implement change based on processing new information and implement a decision process that is transparent as to who decides based on which evidence and why.

4. TRANSITION TO ADAPTIVE WATER MANAGEMENT REGIMES

New management approaches must be tailored to the institutional, societal, economic, environmental and technological setting of a basin. This can only be achieved by further developing and applying innovative methods for the participatory assessment and implementation of a transition from current management regimes to regimes more adapted to meeting future challenges for water management.

A management regime is here referred to as the whole complex of technologies, institutions[1], environmental factors and paradigms that are highly interconnected and together form the base for the functioning of the management system targeted to fulfil a societal function. Due to the high interconnectedness and internal logic, it is assumed that individual elements of the regime cannot be exchanged arbitrarily.

Some structural requirements for a system to be adaptive have been tentatively summarized in the following table. Two different regimes are arbitrarily contrasted as the extreme, opposing ends in table 1 derived from Pahl-Wostl et al in review. Any regime typology rejects the idea of an infinite variety of approaches and is based on the assumption that management regimes can be clearly classified into different groups based on some internal logic of cohering characteristics.

Table 1 – Distinguishing characteristics of management regimes

	Prevailing Regime	**Integrated, Adaptive Regime**
Governance	Centralized, hierarchical, narrow stakeholder participation	Polycentric, horizontal, broad stakeholder participation
Sectoral Integration	Sectors separately analysed resulting in policy conflicts and emergent chronic problems	Cross-sectoral analysis identifies emergent problems and integrates policy implementation
Scale of Analysis and Operation	Transboundary problems emerge when river sub-basins are the exclusive scale of analysis and management	Transboundary issues addressed by multiple scales of analysis and management
Information Management	Understanding fragmented by gaps and lack of integration of information sources that are proprietary	Comprehensive understanding achieved by open, shared information sources that fill gaps and facilitate integration
Infrastructure	Massive, centralized infrastructure, single sources of design, power	Appropriate scale, decentralized, diverse sources of design, power

[1] Institution refers to the formal (e.g. laws) and informal (e.g. norms) rules that determine the behaviour of actors but not to the physical structures that are referred to as organizations.

	delivery	delivery
Finances and Risk	Financial resources concentrated in structural protection (sunk costs)	Financial resources diversified using a broad set of private and public financial instruments

Understanding the barriers to integrated and adaptive management requires critical reflection on current modes of governance. The governance style in many current systems 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 the 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. Careful analysis of transboundary barriers to sharing of data and information is required to clarify why current regimes fail in managing international river basins (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, adaptive management regimes would stimulate innovations in the design of infrastructure. 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.

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.

The concept of transition used in the NeWater project makes use of recent work on socio-technical transitions, an active area of research building strongly on complex systems and evolutionary approaches. In order to understand change and transitions it is useful to distinguish the following three levels (macro-meso-micro) of a system (Pahl-Wostl, 1995; Geels, 2001; Rotmans et al, 2002):

- The Landscape or macro-level with stabilizing factors that constitute the context for a water management regime. The landscape encompasses e.g. environmental variability, legal frameworks, deeply rooted societal norms and cultural values. The landscape provides the context and also the selection environment within which a management regime unfolds. The landscape level must not be entirely independent from the micro and meso level since feedback processes can operate bottom-up (e.g. diffusion of innovation) and top-down (e.g. selection of regime).
- The management regime or meso-level with stabilizing interdependencies between the elements as described in the previous section.

- The niches or micro-level where innovative approaches can develop in a locally protected environment (e.g. large scale research projects, subsidized pilot studies) and/or in new areas of application such as the restoration of riverine landscapes that has started to become an integral part of water resources management

NeWater gives in particular attention to the role of different stakeholder groups in the transition processes.

5. THE NEWATER PROJECT

The European NeWater[2] project (New methods for adaptive water management under uncertainty) is guided by the hypothesis that water management has to become more adaptive to realize and sustain integrated and sustainable water resource management. The major task is to understand and manage the transition process towards more adaptive water management regimes given the high inter-connectedness and complexity of riverine water systems. By this NeWater addresses some of the present and future challenges of water management advocating integrated water resource management (IWRM) concepts.

NeWater Objective

The challenges of understanding the transition towards adaptive water management is tackled in NeWater. The project aims at the development of a conceptual framework for understanding and a comprehensive methodology and range of tools for analysing and implementing transitions to adaptive water management. This comprises the development of a scientific foundation for managing uncertainties, interactions across scales, integration across sectors and exposure to future stresses for climate resources, conflicts between water quantity, water quality and ecosystem services as well as tools for the assessment of vulnerability and adaptive capacity that supports transitions to effective adaptive management of river basins.

Investigations are performed in close liaison to stakeholders 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.

NeWater working areas

To develop concepts and tools that guide an integrated analysis and support a stepwise process of change in water management, the NeWater project is structured into work blocks that are mutually dependent (see fig.

[2] The NeWater project (www.newater.info) is an Integrated Project in FP 6 of the EU with 12 Mio Euro EU funding over 4 years (start January 2005).

2). It also adopts a management structure that allows effective exchange between innovative research on integrated water management concepts and practical applications and testing in selected river basins through a participatory process.

Work block 1**'Transition to Adaptive Management'** develops 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. The hypothesis will be tested that one can identify a finite number of typical water management regimes and typical transition pathways based on understanding the interdependence and the roles of such key factors as: management paradigms, governance, information management, scale of operation and integration, technical infrastructure and environmental factors. Work block 1 integrates results and tools from Work Block 2 '**Drivers and Vulnerabilities**'. The latter develops tools and methods to investigate concepts of how society and ecosystems in river basins respond to shock and stress (Resilience (R), vulnerability (V) and adaptive capacity A)). The factors and their interactions that influence R, V and A in river basins will be examined in the field in collaboration with researchers and practitioners in case study river basins. These studies will help set the baseline for understanding the priorities to be addressed by adaptive management strategies.

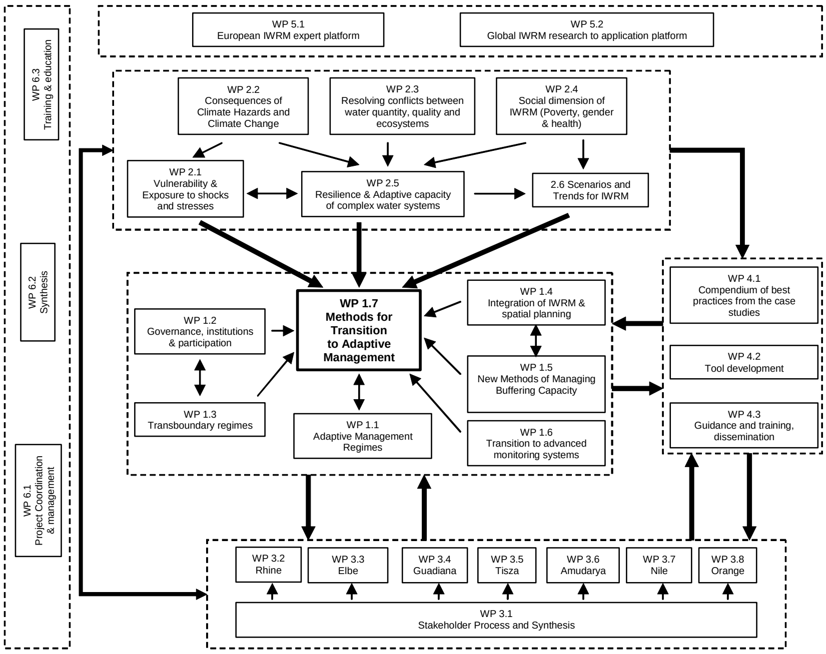

Figure 2. Structure of NeWater project in work blocks

A key question is how to make new ideas and methods accessible to practitioners and professionals actively engaged in river basin management. Work block 4 **'Guidance and Tools'** will further develop tools and guidance for practitioners based on new conceptual insights, experience collected in case studies and the needs from ongoing policy processes, in particular the European Water Framework Directive and the European Water Initiative. A tool may be a guideline, procedure, protocol, method, technique, an artefact, a device, an apparatus, a software model, or a mathematical algorithm that support the implementation of adaptive management approach or the research needed to develop that approach. Research activities and the development of guidance for practitioners will integrate results from previous and ongoing EU projects and engage in an intensive dialogue with the wider community of IWRM experts.

The research and development activities are strongly connected to a number of case studies in Europe (Elbe, Guadiana, Rhine and Tisza), in Central Asia (Amudarya) and in Africa (Nile and Orange). These case studies (Work Block 3) coordinate empirical field research to generate input to the development of new concepts and methodologies (Work Blocks 1 and 2) and provide a test bed for their plausibility and applicability under different environmental and societal conditions. Participation of stakeholders will play a crucial role in guaranteeing that the methods developed meet their demands and take into account concerns and expertise in the basins.

The case studies were chosen to provide a rich base of empirical knowledge covering different environmental, institutional, cultural and economic settings with exemplary character for other basins. Therefore following criteria were important for the selection of NeWater case studies:

- 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 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.

Work block 5 **'International Platforms'** establishes the link to relevant European activities and ongoing policy processes. The platforms provides immediate feedback from and to policy processes, in particular to the implementation of the European Framework Directive and the European Water Initiative. Work block **'Internal Platforms'** implements a flexible and interactive management structure that serves the purpose of such an innovative and modular project.

Results and expected impacts from NeWater

The NeWater project is designed to deliver results for the development of new knowledge skills, and to better integration and use of existing skills in the European Research Area (ERA). It will therefore reinforce international competitiveness of the ERA in the field of environmental research. It is a multi-disciplinary project, which combines scientific expertise from natural and environmental sciences, and social sciences (including economics), with participatory approaches through involving stakeholders and practitioners from water management sectors in defining the research agenda. This integrated and highly participatory approach is the main guiding paradigm that is expected to result in novel approaches to:

- **governance in water management**: methods to arrive at polycentric, horizontal broad stakeholder participation in IWRM will be developed and tested in case studies. Based on results from the European HarmoniCOP project, protocols for the guidance on how to perform and evaluate stakeholder processes for integrative water resource management will be documented. Furthermore NeWater will provide an improved understanding of governance issues. Little research has been done o far on analysing flexibility and adaptive capacity due to different governance styles and a transition between them.

- **sectoral integration:** NeWater framework will include concepts and tools that help to overcome the sectoral fragmentation and come to an integrative management. Sectoral fragmentation is a key limiting factor for adaptive capacity. integrated IWRM and spatial planning; with climate change adaptation strategies, cross-sectoral optimisation and cost-benefit analysis.

- **information management**: since information and data are crucial for adaptive management, NeWater will analyse why current transboundary regimes fail in that issue. Novel monitoring systems for decision systems will be developed where necessary.

- **infrastructure:** innovative methods for river basin buffering capacity; role of storage in adaptation to climate variability and climate extremes

- **finances and risk mitigation strategies:** considering uncertainty and (climate) change in the transition process to adaptive management requires also the development of new instruments for risk management, risk mitigation public-private arrangements in risk-sharing in the water domain.
- **stakeholder participation**: promoting new ways of bridging science, policy and implementation

Contribution to European water legislation and policy developments

The Water Framework Directive (WFD) is the strictest and most significant act in European Water legislation. The WFD goes beyond and aims at integrating the fragmented legislation of the past by prescribing as a goal to achieve the good ecological state of all European freshwater bodies by 2015. Neglecting that its success has yet to be proven by the year 2015, the WFD has already activated considerable research and management activities all over Europe. Concerning all management levels, from European level to local level, the framework has increased the awareness for the need for integrated water management. This experience provides a motivation to export that 'model', eg. via the IWRM component of the EU Water Initiative.

NeWater results can contribute to the success, implementation and also transfer of the WFD. However, in some areas NeWater goes even far beyond the goals of the WFD. We agree with Rahaman et. al (2004) who pointed out that the WFD and its daughter directives do not match with all principles of IWRM. From our perspective the WFD neglects following issues which were also pointed out by Rahman et al:

- an insufficient multi-sectoral view on catchments,
- halfhearted public participation by missing guidelines,
- a missing focus on poverty,
- the promotion of technology-oriented management approach for drinking water instead of considering human components,
- an omitting gender awareness.

It is for example impossible to realize a good ecological state of European rivers by restoring floodplains without taking into considerations requirements for flood protection (Pahl-Wostl, in press). Even in Europe poverty is an issue and even more so in the target countries of the European water initiative.

NeWater will not produce generic recipes to be applied in each basin. This would be in contradiction to the need and clearly stated objective to develop management strategies that are tailored to the institutional, economic, environmental and technological characteristics and the history of a basin.

NeWater will develop:

- an innovative cookbook with connected toolkit and guidance for practitioners in applying methods for the adaptive management of river basins.
- an understanding of aspects that determine adaptive capacity and vulnerability of river basins
- a comprehensive methodology to develop, implement and decide between alternative management regimes

To achieve its objectives NeWater research is designed as a highly interactive and dynamic process. NeWater does not prescribe an integrative framework such as a DSS or intergrated model which would constrain the type of knowledge that can be integrated. NeWater aims at the joint design of an interactive, integrated and open knowledge base. This is also a novel experiment in how to conduct interdisciplinary research which is carefully monitored and analysed to draw lessons for similar projects in the future.

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