ADAPTIVE WATER MANAGEMENT: HOW TO COPE WITH UNCERTAINTY

Water management practitioners are faced with a number of serious challenges that have emerged in recent years. Management styles must be innovated to meet a perceived need for integrated approaches and a stronger emphasis on the human dimension in times of increasing uncertainty and complexity due to climate change and globalisation. This policy brief highlights recent developments in adaptive water management, taking into account uncertainty and complexity. Key insights from European research into adaptive management and social learning suggest important benefits from a paradigm shift in water management towards collaborative governance and integrated, adaptive water management regimes. In order to realise these benefits through practice, a new generation of water management practitioners needs to be trained in participatory system design and implementation skills.

Background

In the past decade, a major change in the rhetoric surrounding water resources management became evident. The debate is now dominated by an increased awareness of integrated management approaches, taking into account environmental, economic and social considerations, and by the search for strategies that go beyond technical end-of-pipe solutions. In other words, the importance of improving water governance is now widely recognised.

The European Water Framework Directive (WFD) is a major piece of European legislation that provides a significant opportunity for change in Water Policy. The WFD has a holistic goal of achieving a good state of all European Waters by 2015, based on the development of River Basin Management Plans. It prescribes the involvement of all interested parties and the general public in developing, implementing and updating such plans. In a similar spirit, the European Water Initiative, launched during the Sustainability Summit in Johannesburg 2002, aims at supporting developing countries in implementing Integrated Water Resource Management Plans by 2020.

In recent months the debate on improvements to water management has been increasingly dominated by the need for adaptation to climate change. This debate has shifted the importance of addressing increasing uncertainties to the centre stage. Experience from the past is no reliable guide for the future, and water management is confronted from all fronts with unprecedented situations.

Overall, the perceived need to change water management concepts and practice, to involve a wide range of stakeholders and to foster social learning can be explained by several insights that are not entirely new but have only recently been seriously taken into account:

- Increasing interdependence between government bodies and other stakeholders (e.g. collective decisions, distinctive competences and complementary contributions) reduces the efficacy of a traditional command-and-control management style and requires a shift towards a more interactive and participatory style.
- The increasing complexity of natural resources management (e.g. a shift towards integrated approaches in management objectives, heightened awareness of the complex nature of socio-ecological systems) requires an enhanced capacity for learning and innovation that functionally engages a wider group of stakeholders.
- Increasing uncertainties (e.g. climate change, dynamic socio-economic conditions) require a more adaptive and flexible management approach to realise a faster coping cycle that allows the rapid assessment and implementation of the consequences of new insights. This requires new skills and capabilities, informal management structures and the inclusion of expert knowledge as well as local lay knowledge.

The rising demand to account better for the full complexity of those systems being managed is driven in part by better appreciation of increasing uncertainties due to climate change and globalisation. In developing and threshold countries, in particular, socio-economic change is occurring at an unparalleled fast pace. Established planning approaches in water management, developed in industrialised countries that rely strongly on the ability to predict the effect of management measures, and design systems that can be controlled are less appropriate in highly uncertain and complex situations.

However, barriers to innovation are often more conceptual than technical. Progress in developing, and in particular in implementing, innovative management approaches has not kept pace with the expressed need for change in management paradigms and practices. Integrated and adaptive management approaches are required that perform...
well under complex and unpredictable conditions and that can be tailored to the institutional, cultural, environmental and technological settings of river basins.

The past may not be a reliable guide for the future: Boat in the Guadiana basin reminding visitors that there used to be water and a fishery prior to overexploitation by agricultural irrigation (by courtesy of Andrew Ross)

Adaptive management to cope with uncertainties and complexity

Uncertainties and complexity

Uncertainties and complexity characterise water management. Water management traditionally emphasises the reduction of uncertainties, often by designing systems that can be predicted and controlled. This has resulted in a strong emphasis on technical solutions to rather narrowly defined problems. However, human-technology-environment systems are more appropriately described as complex adaptive systems where unpredictable co-evolution makes uncertainty irreducible. Managing under inevitable uncertainty requires improved learning and adaptation, in addition to control. Water management science must confront the main barriers to learning and adaptation: path dependence emerging from sunk costs in prior paradigms, infrastructure and existing practices. Developing new paradigms and practices has gained increasing importance with the attempt to implement integrated management approaches. The prospects of climate change strongly suggest that the goal of management should be to increase the adaptive capacity to cope with uncertain developments rather than to try to find optimum solutions. What kind of uncertainties now have to be taken into account when trying to manage complex adaptive systems in an uncertain environment?

- Ambiguity (= more than one legitimate and plausible interpretation) exists in defining operational targets for different management goals to be achieved; conflicts of interest require participatory goal setting (not by experts alone) and a clear recognition of the uncertainties in this process.

- The outcomes of management measures are uncertain, due to the complexity of the system to be managed and to uncertainties in environmental and socio-economic developments that influence the performance of implemented management strategies.

- New knowledge about system behaviour may suggest options for change in management strategies.

- Changes in environmental and/or socio-economic conditions may demand change in management strategies.

Water management has a strong and successful tradition in dealing with environmental uncertainties that can be captured by formal and quantitative methods. However, even for factors such as the variability of precipitation, where these methods worked in the past, climate change introduces major uncertainties. The importance of different perspectives and framings of the problem, for example, in scenario planning, are beyond the scope of current management practice. Changes in water management paradigms and innovative methods are required to do justice to the real complexity that water management has to face.

Adaptive management

Adaptive management can be defined as a systematic process for improving management policies and practices by learning from the outcomes of implemented management strategies.

The idea of adaptive management has been discussed in ecosystem management for quite some time. It is based on the perception that the ability to predict future key drivers that influence an ecosystem, system behaviour and responses, is inherently limited. The most effective form of adaptive management employs management programmes that are designed to experimentally compare selected policies or practices by evaluating alternative hypotheses about the system being managed. This implies that hypotheses can be generated and that the outcomes of experiments allow a differentiation between the comparative advantages of different hypotheses.

As defined above, adaptive management is rather encompassing and broader than the established use of the concept in environmental management. A systematic approach to learning under conditions of high uncertainty need not necessarily include the implementation of small-scale experiments on the ground (which are not always possible) but should be perceived as the guiding paradigm for the design of adaptive policy processes. Figure 1 shows the different steps in any iterative policy cycle embracing assessment, policy development, implementation and monitoring. Implementing a systematic approach to learning that takes uncertainties into account is reflected in the requirements for the different steps in this policy cycle:
The role of social learning

What is social learning?

Social learning in river basin management refers to developing and sustaining the capacity of different authorities, experts, interest groups and the public to experiment, learn, discuss and manage their river basins effectively. Collective action and the resolution of conflicts require that people recognise their interdependence and differences, and learn to deal with them constructively - this need not imply consensus. The various groups need to learn about and heighten their awareness of their biophysical environment and the complexity of social interactions.

Why is social learning needed to move towards and sustain integrated, adaptive water management?

Technical infrastructure (e.g. large technical infrastructure for flood protection), citizens' behaviour (expectations regarding safety in floodplains, risk perception) and habits, and engineering rules of good practice are often mutually dependent and stabilise each other. This has the effect that changes towards new and improved resource management schemes are blocked. If the costs deployed in building and maintaining those structures, both physical and relational, preclude opportunities to experiment with innovative options, society's capacity to learn and adapt to uncertainty is constrained. Social learning has proven crucial to break up such "lock-in" situations. It is required for implementing change towards and for sustaining adaptive management practices, as well as experimentally developing and implementing innovative technologies and practices to adapt to uncertainty.

The social learning concept takes into account that the processing of factual information on a problem cannot be seen independently of social involvement and processes of social exchange. Social involvement refers to essential elements of social processes, such as the framing of the problem, management of the boundaries between different stakeholder groups, the type of ground rules and negotiation strategies chosen or the role of leadership in a policy process. The following box illustrates the role of framing in more detail.

A broadened role for models and information and communication tools

A social learning perspective leads also to a broadened view on the role of models and information and communication tools in the whole policy process. Models and the whole modelling process play a leading role in adaptive water management. In addition to prediction, models can be used for exploratory analysis, communication and entrenched conflicts among actors. The framing of an issue includes, for example, what is at stake, who should be included and which roles they should play. Processes of framing and reframing are essential elements of social dynamics and conflict resolution in group processes. This applies to local communities as well as transboundary river basins commissions.

In particular during the initial stages of dealing with a problem, the Framing and Reframing of a Problem Domain determine the direction of the overall process. Actors perceive frames that determine how they give sense and meaning to information and their physical and social environment. Frames may derive from cultures, social roles, scientific disciplines, etc. Differences in the framing of issues are among the key reasons for problems in communication and entrenched conflicts among actors. The framing of an issue includes, for example, what is at stake, who should be included and which roles they should play. Processes of framing and reframing are essential elements of social dynamics and conflict resolution in group processes. This applies to local communities as well as transboundary river basins commissions.
when models are used for exploratory purposes, uncertainties can be considered a source of innovative thought. From this perspective, the purpose of a model, its properties, the role of uncertainties and validation cannot be understood in isolation but only in the context of a particular modelling exercise. For decision-makers, this means that models and the whole modelling process are tools to support social learning. Table 1 summarises the implications of different modelling purposes on the system characteristics, represented in a model, the role of uncertainties and how the quality of the model is evaluated (model validation).

<table>
<thead>
<tr>
<th>Purpose</th>
<th>System characteristics characteristics</th>
<th>Role of uncertainties uncertainties</th>
<th>Model validation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prediction</td>
<td>Central elements of overall structure known, abstract representation possible</td>
<td>Uncertainties must be constrained within manageable bounds</td>
<td>Agreement of model results with observed system behaviour</td>
</tr>
<tr>
<td>Exploratory analysis</td>
<td>Evolutionary trajectories may explore large development space</td>
<td>Uncertainties identify priority areas for research and innovation</td>
<td>Plausibility of results based on expert and stakeholder judgment. Completeness of mapped space.</td>
</tr>
<tr>
<td>Communication</td>
<td>Complex dynamics leading to counter-intuitive behaviour. Robust knowledge of system complexity available</td>
<td>Uncertainties must be clearly captured to build a realistic understanding of where learning and intervention are possible.</td>
<td>Adoption of new insights</td>
</tr>
<tr>
<td>Learning</td>
<td>Reflexive system Different perspectives on the system</td>
<td>Role of uncertainties in social interactions must be addressed</td>
<td>Facilitation of social learning in group, plausibility assessment by stakeholders</td>
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Table 1: Implications of different modelling purposes

How to manage change

The implementation of adaptive management is only possible if certain structural conditions are fulfilled. Hence the implementation of adaptive management needs an integrated system design. Which features of a management regime render it more adaptive to maintain environmental, economic and social sustainability in a fast-changing, uncertain world? Some structural requirements for a system to be adaptive have been summarized in table 2.

The characteristics of integrated adaptive regimes are best seen as working hypotheses since the change towards more adaptive regimes is still slow, and empirical data and practical experience are thus limited. One possible reason for this lack of innovation is the strong interdependence of the factors that stabilise current management regimes. One cannot, for instance, move easily from top-down to participatory management practices without changing the whole approach to information and risk management. Such change is hindered by the reluctance to act without the guarantee of certainty. Science and policy will always be faced with the challenge of designing processes of change without completely understanding the system and problems to be managed.
To constructively engage such uncertainty, learning processes should become an integral part of any management regime, deliberately applied so that policies and practices emerge from adaptive design rather than chance or political necessity. This is indicated in Figure 2 where the two kinds of learning cycles are integrated into the policy cycle introduced in Figure 1.

Learning cycles may be introduced at the measures level as part of operational adaptive management. For example, they could be applied to test new approaches where large uncertainties prevail, such as the introduction of water trading or decentralised technologies at household level. Learning cycles aiming at structural change may be introduced at an earlier stage of the policy cycle during goal setting and policy formulation. New approaches may often require major transitions. This may be put into effect in the attempt to implement innovative measures when realizing that barriers in structures prevent change (e.g. rigid legislation, prevailing habits of consumers, dominant technologies) or even in an anticipatory fashion at an early planning stage. Structural changes imply there are learning cycles at the early stage of goal setting and policy development. In most cases, such transitions will involve a wider range of stakeholders. They may require changes at a higher governance level than the planning process. It will be a major challenge to implement learning cycles that a) have the required degree of freedom and sufficient resources (time, money) to succeed in reframing problems and solutions and to develop innovative approaches and b) are linked to formalised policy and management processes to enable new approaches to also lead to significant, comprehensive change.

**Key insights and recommendations for policymakers**

- The complex socio-ecological nature of river basin environments and the inherent uncertainties associated with their management have to be taken into account in policy development and implementation.
- Management strategies should be robust and perform well under a range of possible but initially uncertain future developments. This implies an increased use of scenario planning.
- The design and sustained execution of transparent and open social learning processes is a key requirement to address uncertainties and develop the capacity to respond to new insights and surprise.
- An increase in, and maintenance of, the flexibility and adaptive capacity of water management regimes should be a primary management goal.
- Entrenched perceptions and beliefs block innovation and change. Space has to be provided for creative and out-of-the-box thinking by explicitly including learning cycles in policy development and implementation.
- There is a significant need to train a new generation of water management practitioners skilled in participatory integrated system design and implementation.
Some references of interest (NeWater only)


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