Pahl-Wostl, C. 2006. The importance of social learning in restoring the multifunctionality of rivers and floodplains. *Ecology and Society* **11**(1): 10. [online] URL: http://www.ecologyandsociety.org/vol11/iss1/art10/

Research, part of a Special Feature on Restoring Riverine Landscapes

The Importance of Social Learning in Restoring the Multifunctionality of Rivers and Floodplains

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ABSTRACT. Those involved in floodplain restoration have to cope with historical conflicts between human and ecosystem needs. The topic is of high importance in Europe due to the European Water Framework Directive that requires restoration and/or maintenance of a "good ecological status of aquatic ecosystems." However, the seeming trade-off between flood protection and floodplain restoration may change due to a shift in the water management paradigm toward more integrated approaches, in contrast to the command and control approach of the past. This shift in paradigm is summarized in the guiding principle for water management in the Netherlands "Living with floods and give room to water" rather than "Fighting against water." The paper discusses the role of social learning in the transition toward the adaptive management of floodplains and rivers that is required to restore and maintain multifunctional riverine landscapes. In addition to the uncertainties resulting from our limited knowledge about the complex spatiotemporal dynamics of floodplains, we have to take into account the ambiguities that arise as a result of the different perceptions of stakeholders.

Key Words: *conflict resolution; social learning; adaptive management; participatory modeling; floodplain restoration*

INTRODUCTION

The ability to constrain rivers in their tendency to meander and to temporally flood large parts of the landscape has been perceived as a great achievement in environmental control by humans. However, as so often in environmental management, what has proved to be an initial success story has developed over time into a major conflict between the protection of riverine ecosystems and the management of rivers for human purposes. Furthermore, it has become increasingly evident that flood control efforts such as levee and dam construction, have led to more severe flooding by preventing the natural dissipation of excess water in floodplains. The cost of flood damage has increased, because people who believed that they were safe places have developed floodplains. In response to these insights, a real change in attitude toward water management, in general, has taken place over the past decade. The emphasis has started to shift toward integrated planning and management approaches, making use of ecosystem services that are only provided by multifunctional riverine landscapes. For example, the water management paradigm in the Netherlands has changed, e.g., "coping with floods and give room to water," in contrast with the previously dominant paradigm "fight against water and control floods" (DWC 2002). Given the history of the Netherlands, this is a remarkable change that has been brought about mainly by the insight of the need for new management approaches in times of increasing uncertainty because of climate change and fast-changing socioeconomic boundary conditions. Such developments, which can also be observed in other countries, should facilitate efforts to restore riverine landscapes.

Trade-offs between flood protection and the restoration of floodplains are reduced in the new management paradigm. However, a change in attitude is not yet sufficient to guarantee a real change in management practices. Water is still allocated primarily to activities that promise clear and quantifiable economic benefits such as hydropower generation or irrigation for agriculture. Different elements of the management regime such

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Table 1. Example of three different types of stakeholder processes. The nature of the processes influence social learning.

Type of process	Who is involved	Lead of process	Possible outcomes of process
Regional forums	Representative from stakeholder groups in which choice is hardly ever based on sound analysis	Water management authority	Binding recommendations on management plans, voluntary action to be included in management plans
Stakeholder platforms in action research	Representative from stakeholder groups with choice based on institutional analysis	Scientific project–external facilitation	Recommendations to be fed into formal process, formal institutional setting to realize agreed agenda for action
Stakeholder process	Individuals and representatives from stakeholder groups	Bottom up without formal lead, often individual leaders emerging	Implemented action at local scale, increased awareness and start of formal policy process

as technologies, management practices, legal frameworks, or social norms have coevolved and have stabilized each other. Furthermore, individual and collective cognitive processes have a strong tendency to maintain internal coherence, despite of a potential increasing mismatch with the changing context in which they are embedded, and thus, they resist change (Röling 2002, Pahl-Wostl, *in press*).

To understand barriers to change, it is useful to analyze in more depth the types of changes that need to occur in the social system and the nature of conflicts in the transition to a sustainable management of riverine landscapes, as well as possible strategies for their resolution in social learning and decision-making processes. In doing so, one has to take into account that in restoring the multifunctionality of riverine landscapes, one has to deal with "messy problems" when there are large differences regarding the perceptions of the nature of the problem, the need for action, and the type of action that should be taken. Such differences arise, on one hand, from uncertainties in the factual knowledge base, and on the other hand, from ambiguities in problem framing, and in the diverse ways in which the nature of the problems are perceived. Despite the considerable body of knowledge that has been collected about riverine ecosystems and floodplains, huge knowledge gaps still exist with respect to quantitative assessments of spatiotemporal water requirements and the impact of change on ecosystem properties. In addition, it is not clear what a "desirable" future state of a floodplain should be or how it can be achieved (Hughes 2003).

Uncertainty and data gaps may block scientific deliberations. In this respect, it is useful to make a distinction between (1) uncertainty in the knowledge base, (2) ambiguity in the framing of different stakeholder groups, and (3) subjective perceptions. Here, uncertainty is defined as a lack of knowledge or information about a phenomenon that originates in the factual knowledge base, whereas, ambiguity refers to the simultaneous presence of multiple frames of reference to understand a certain phenomenon (Pahl-Wostl et al. 1998, Dewulf et al. 2005).

One of the strategies for dealing with uncertainty can be to gather new knowledge to reduce uncertainties. This may include the implementation of well-designed experiments using an adaptive management approach (Holling 1978, Richter et al. 2003) based on the insight that the response of an ecosystem to management interventions can be predicted only to a limited extent. Hence, management must be able to adapt to new insights, gained during the process of implementing measures of intervention. Numerous formal approaches exist to represent uncertainties in models. However, whereas quite a few efforts have been devoted to tackle uncertainty, ambiguities and social constructions of reality have received far less attention. Moreover, it has been shown that different perspectives on a problem domain receive increasing importance when uncertainties in both the factual knowledge base and decision stakes are high (Funtowicz and Ravetz 1993, Pahl-Wostl et al. 1998). Strategies for dealing with such phenomena must build on the interpretative traditions of the social sciences that deal with the ways in which people use knowledge from their own experiences or other sources to make sense of the world. Strategies must also build on the ways in which people perceive an issue, because this can influence the communication in a group of actors.

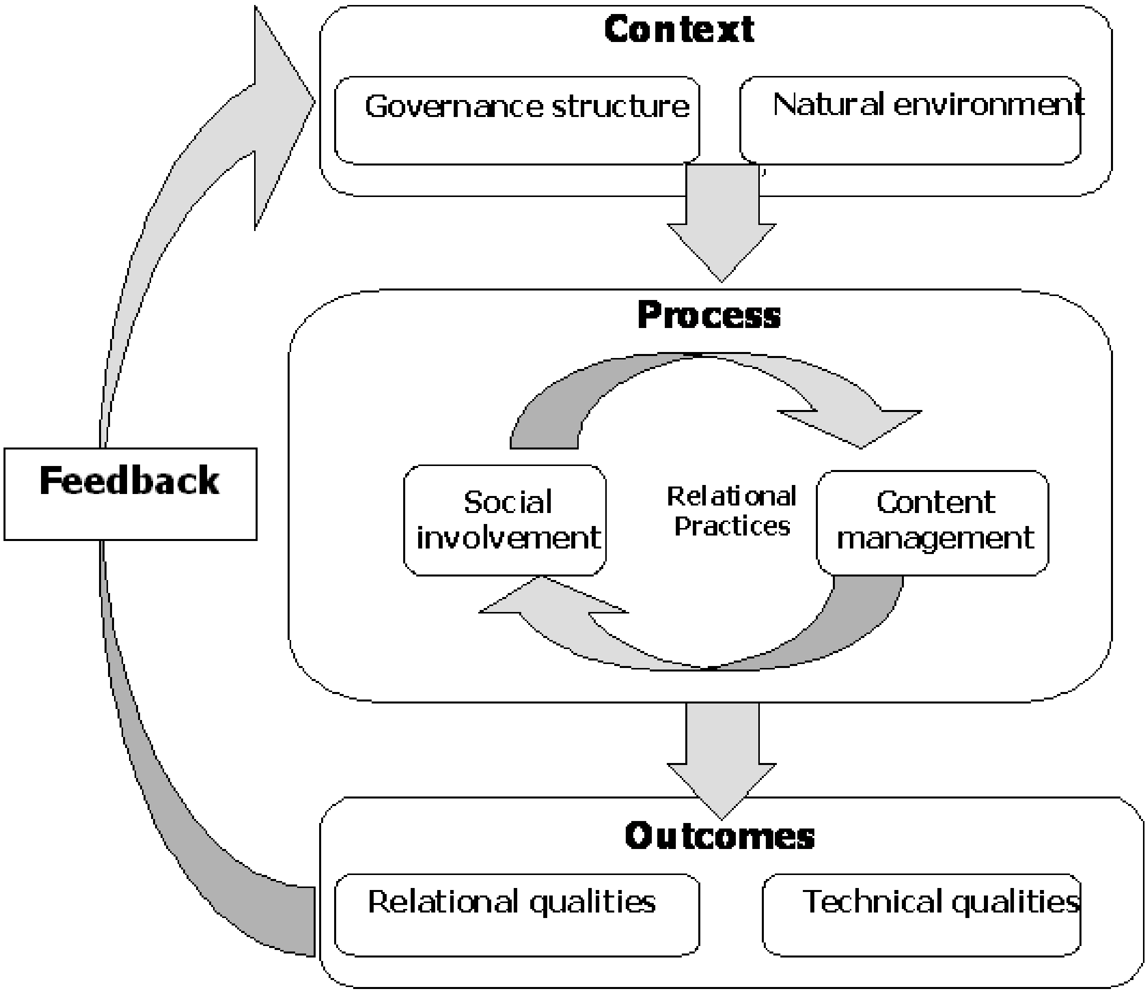
Gray (2004) provided evidence to show that the ways in which stakeholders frame the issues can explain collaborative success or failure. The convergence or divergence of the stakeholders' frames can explain the success or failure of resolving a conflict. Frames may refer to risk attitudes, conflict management styles, role of power, power relationships, and views of nature such as vulnerability (Hanke et al. 2002, Gray 2003, 2004). Frames mainly arise through social interactions, and may be influenced by social norms and/or cultures. Collective frames may also support the formation of a group identity. Gray reported one example in which a conflict about the formation of a nature park led to the reinforcement of a collective identity among the stakeholders in the region who felt seriously threatened by both environmentalist groups and the government. Hence, a strange coalition arose between environmentalists and governmental representatives who pursued quite different interests. The conflict was never resolved, which was attributed to a lack of reframing and, thus, the failure to develop a joint base for communication. Resolving conflicts must include processes of social learning and instances of reframing.

A CONCEPT FOR SOCIAL LEARNING IN ENVIRONMENTAL MANAGEMENT

The notion of social learning has become quite popular, but its meaning is very broad. It has been used to refer to the processes of learning and changes in individuals and social systems. In the influential work of Bandura (1977), social learning refers to the learning that individuals obtain by observing others and their social interactions within a group, e.g., through imitation of role models. This concept assumes an iterative feedback between learners and their environment, i.e., the learner is changing the environment, and these changes are affecting the learner.

This approach is too narrow to embrace all of the learning processes of relevance in resources management. One area of major concern is institutional change, i.e., the role of informal institutional settings and participatory approaches. Institutions such as formal rules, laws, customs, and norms may constrain change and learning. Informal institutional settings, in particular, actor platforms are enabling institutions that may trigger institutional change. Of major interest in this respect is the concept of "communities of practice" developed by Wenger (1998) that emphasizes learning through participation. Individuals engage in actions and interactions that have to be embedded in culture and history. Such interactions are influenced by and may change social structure and, at the same time, the individual gains experience situated in a context. Such learning processes confirm and shape the identity of the individual in its social surroundings. They confirm and change social practice and the associated interpretation of the environment. Social learning processes are codified in shared practices, tools, concepts, symbols, or material artifacts embedded in a context of meaning. Obviously, the membership of groups in participatory settings cannot be directly compared to the workplace in which people spend a significant part of their daily lives. However, we also expect that learning will not only remain in the cognitive realm, but that it will lead to joint practices and collective action.

Fig. 1. Conceptual framework for social learning in resources management. Information and communication technology tools may play a decisive role in supporting and shaping relational practices that link social involvement and content management. This also implies a new role for simulation models in such processes.



Such a broad understanding of social learning, rooted in the interpretative strands of the social sciences, also characterizes the approach adopted by the HarmoniCOP project (HarmoniCOP 2003). The major objective of this project is to increase the understanding of participatory river basin management in Europe. It aims to generate useful information about the scientific base of social learning and the role of information and technology (ICT) tools in river basin management, as well as to support the implementation of the European Water Framework Directive. Figure 1 illustrates the conceptual framework for social learning developed in the HarmoniCOP project to account for learning processes in water resources management (Pahl-Wostl 2002, *in press*, Craps 2003, Bouwen and Taillieau 2004). The framework is structured into context, process, outcomes, and a feedback loop to account for learning. The context refers to the governance structure and the natural environment in a river basin. The ultimate goal is to improve the state of the environment, which in practice, most often implies a change in the governance structure. Social learning is assumed to occur at two levels, on short to medium timescales at the level of processes between actors, and on medium to long timescales at the level of structural change in the governance structure. A change in governance may imply the implementation of new formal and informal institutional settings such as laws, the formation of water-user associations or voluntary cooperative agreements. It may also lead to changes in norms and cultural values when change is linked to a larger societal perspective (Tabara and Pahl-Wostl, *personal observation.*)

The process concept referring to multiparty interactions in actor networks has two pillars (Fig. 1). These relate to the processing of information about a problem, i.e., content management, and engaging in processes of social exchange, i.e., social involvement. Social involvement refers to the essential elements of social processes such as the framing of a problem, the management of the boundaries between different stakeholder groups, the types of ground rules and negotiation strategy chosen, or the role of leadership in the process. The central hypothesis of this concept is that the management of content and social involvement is interdependent and cannot be separated, and that ICT tools play an important role. The overall process leads to both technical qualities such as the improvement of the state of the environment, and to relational qualities such as an increase in the capacity of a stakeholder group to manage a problem and/or institutional change. Both technical and relational qualities provide feedback to a change in the context.

Preliminary results from a number of European case studies present evidence for the importance of problem framing, boundary management, and the establishment of ground rules for the success of participatory processes in river basin management (Tippett et al. 2005). Table 1 provides examples of three different types of processes as they have typically occurred. Often, the roles of participants in such processes are not well defined. Nevertheless, information exchange operates in the expert-technocratic tradition in which scientific advice is provided to the competent authorities that implement technological solutions with little explicit or transparent interaction among stakeholder groups and the public at large. Hence, the ambition of the new European water policy and new insights from collaborative governance are still quite different from those that are implemented in water management practices. However, signs of change are visible.

Regional forums have been implemented as part of the formal participation process of the European Water Framework Directive (e.g., Borowski 2004) and by water management authorities that have started stakeholder participation on their own initiative (e.g., Orr et al., *in press*), since they realized that complex management problems cannot be solved by top-down implementation. An example of an innovative water board is the Emscher Genossenschaft, i.e., it has restored the Emscher, one of the most polluted rivers in Europe. They have realized from the beginning that river restoration and innovative approaches to flood protection have to be combined, and that this cannot happen without the involvement of stakeholder groups and the public (Emscher Genossenschaft 2005). In these cases, the competent authority is the convener and owner of the process. In general, such forums are directly linked to real decision-making processes.

Increasingly, participatory research projects implement stakeholder platforms (e.g., Pahl-Wostl and Hare 2004). In this case the convener of the process is the research project with the goal to develop a joint ownership of the process by all participants. Such processes are, in general, not directly linked to formal decision-making processes, which may be an advantage to promote more innovation and openness. It may also be a disadvantage due to the possible lack of commitment. Hence, the quality of the process gains a much higher importance for developing joint action. In some cases, participatory processes develop from the bottom up. In a case in Belgium, for example, such a process led to the restoration of a riverine floodplain in a densely populated area after trust had been established that flood protection would still be guaranteed (Craps and Prins 2004). In most cases, such processes are centered on local issues, and are driven by a local hero(s) without any formal moderation.

THE IMPORTANCE OF SOCIAL LEARNING IN RIVER RESTORATION

The transition from regulated rivers to a multifunctional dynamic landscape will involve major changes in the roles of stakeholders, institutions, and management paradigms. Table 2

Table 2. Comparison of some characteristics of the current state of regulated and controlled rivers with features of a potential future state with a multifunctional dynamic landscape to illustrate the need for social learning and institutional change.

	Current state with regulated and controlled rivers	Potential future state with a multifunctional dynamic landscape
Stakeholder groups and their role	• Authorities as regulators in a highly regulated environment • engineers who construct and operate dams, reservoirs, and levees • environmental protection groups fighting for floodplain restoration • insurance companies selling insurances against flood damage • house owners living on floodplains • agriculture using land in the vicinity of rivers • shipping industry interested in well-functioning waterways	• Authorities as facilitators of an adaptive management process with shared responsibilities • landscape architects • engineers who have skills in systems design and cooperate with ecologists • environmental protection groups • insurance companies • homeowners with property on a floodplain with higher risk of being flooded • tourism industry and tourists using the floodplains for recreation
Stakeholder participation	• Little stakeholder participation–sometimes consultation in which different stakeholder groups and the public at large are asked to give their opinions on a management plan or scenario that was prepared by experts.	• Stakeholders and the public are actively involved in river basin management. In this case, one may talk of a coproduction of knowledge, of codecision making. Active involvement can range from just having discussions with the authorities and experts, to actively contributing to policy development, i.e., codesigning, influencing decisions, i.e., codecision making, or even full responsibility for parts of river basin management.
Paradigm of water management	• Management as control. Technology driven. Risk can be quantified and optimal strategies can be chosen. Zero-sum-games in closed decision space • Implementation of controllable and predictable technical infrastructure, e.g., reservoirs, dams based on fixed regulations for acceptable risk thresholds.	• Adaptive and integrated water management. “Living with water”. Acceptable decisions are negotiated. • Implementation of a multifunctional landscape and increased adaptive capacity of the system. Designed risk dialogue and cascade of adaptation measures to live with extremes. Increased importance of real-time forecasting systems.

(con'd)

Institutional setting and governance	• Institutional fragmentation • Flood protection, nature conservation, regional planning, and water management are often located in different authorities. Even the European Water Framework Directive does not address flood management. However, it asks to preserve and/or restore the good ecological state of freshwater ecosystems. This will include the restoration of floodplains and will, thus, directly interfere with flood protection.	• Polycentric governance and better institutional interplay • Better horizontal and vertical integration of formal institutional settings to overcome fragmentation that might imply new institutions such as river basin management panels with defined responsibilities and decision-making capabilities. • Stronger role of informal institutions and participatory approaches
Adaptive capacity	• ”Hard” approach to systems design that has as a goal to implement long-lasting optimal solutions. Adaptive capacity is in general quite low due to the high costs of infrastructure and often quite inflexible legal regulations, e.g., water use rights allocated for decades, technological norms that prescribe good practice and prevent innovation, and change to new management practices.	• ”Soft” approach to systems design that allows to take new insights into account and respond to changing environmental and socioeconomic boundary conditions. This is more in line with the new paradigm of adaptive water management.

illustrates well that a transition to a new management regime, perceived as a condition for the restoration of multifunctional dynamic landscapes, will require substantial changes in the role and power of different stakeholder groups. Engineers have to extend their skills and share the responsibilities for the work with ecologists and landscape architects. However, water engineering is a profession with well-established rules of good practice that engineers have to follow to be recognized in the community. Such rules are not easy to change, even when convincing alternatives are available. Some homeowners will face a loss in the value of their property if certain areas, now protected from flooding, are assigned to temporally flooded zones. Some parts of industry will face losses, whereas, others will benefit. The influence of governmental authorities will partly decline if the management scheme becomes more participatory.

Institutional changes must overcome fragmentation, which may result in friction, but they could also be perceived as an opportunity. Problems with institutional settings may arise from problems of interplay, the horizontal fragmentation of institutions in different sectors, e.g. spatial planning, water, agriculture, or the vertical fragmentation of institutions in the same sector at different scales, e. g., local-community, regional-province, national-country, transboundary. Some formal legal regulations may have to be improved. For example, in Germany, the Emscher Genossenschaft, a water management association attempted to introduce integrated flood management using highly sophisticated models for real-time forecasting. The authorities that judged the technical quality of dikes and levees for flood protection could not accept the new management approach. They felt that it was not safe, because of the lack of technical norms and standards (German Water Board, *personal communication*). In this case, water management boards, rather than legislation, have been the drivers for innovation. The implementation of new management regimes will always entail a certain risk that has to be critically evaluated, but should not block innovation. Hence, transitions will require a careful design of participatory stakeholder processes and a careful analysis of the context, i.e., governance, including legislation, environment, and technical infrastructure, in which they are embedded.

Processes of social learning need not lead to a consensus among all the stakeholders involved. However, social learning is a prerequisite to understanding why there are different perspectives, and dealing with them constructively. The notion of social learning implies that the social capacity of a group is enhanced during the interaction process. Hence, a process in which the recognition of different perspectives leads to even larger conflict and polarization would be called a failure from the perspective of social learning. Social learning is an important factor needed to recognize why there are different perspectives, and it needs to be considered to constructively deal with these differences.

METHODS TO FACILITATE SOCIAL LEARNING PROCESSES

Over the past years, the combination of participatory approaches and formal modeling techniques such as group model building or scenario development have gained increasing importance in environmental management (Pahl-Wostl 2002, Walker et al. 2002, Hare et al. 2003). The actors who are supposed to later use the models for decision making and strategic planning participate and contribute to the entire modeling process. They contribute to the development of a model that is representing “their” system and their own behavior. Therefore, models, and the entire process of model development, become part of a process of social learning. One key assumption is that the way in which a model is developed is as important for supporting learning and decision-making processes as the factual knowledge included in the model and the model simulations finally produced. This is in accord with the social learning concept represented in Fig. 1. It is not that such an approach to stakeholder involvement differs considerably from the approaches based on decision theory, in which actors update their prior beliefs in a process of Baysian learning in the likelihood of an event. Decision-making approaches largely neglect the dynamics of social framing, reframing, and the ambiguities that are essential to understand the construction of a problem domain.

Elicitation of mental models

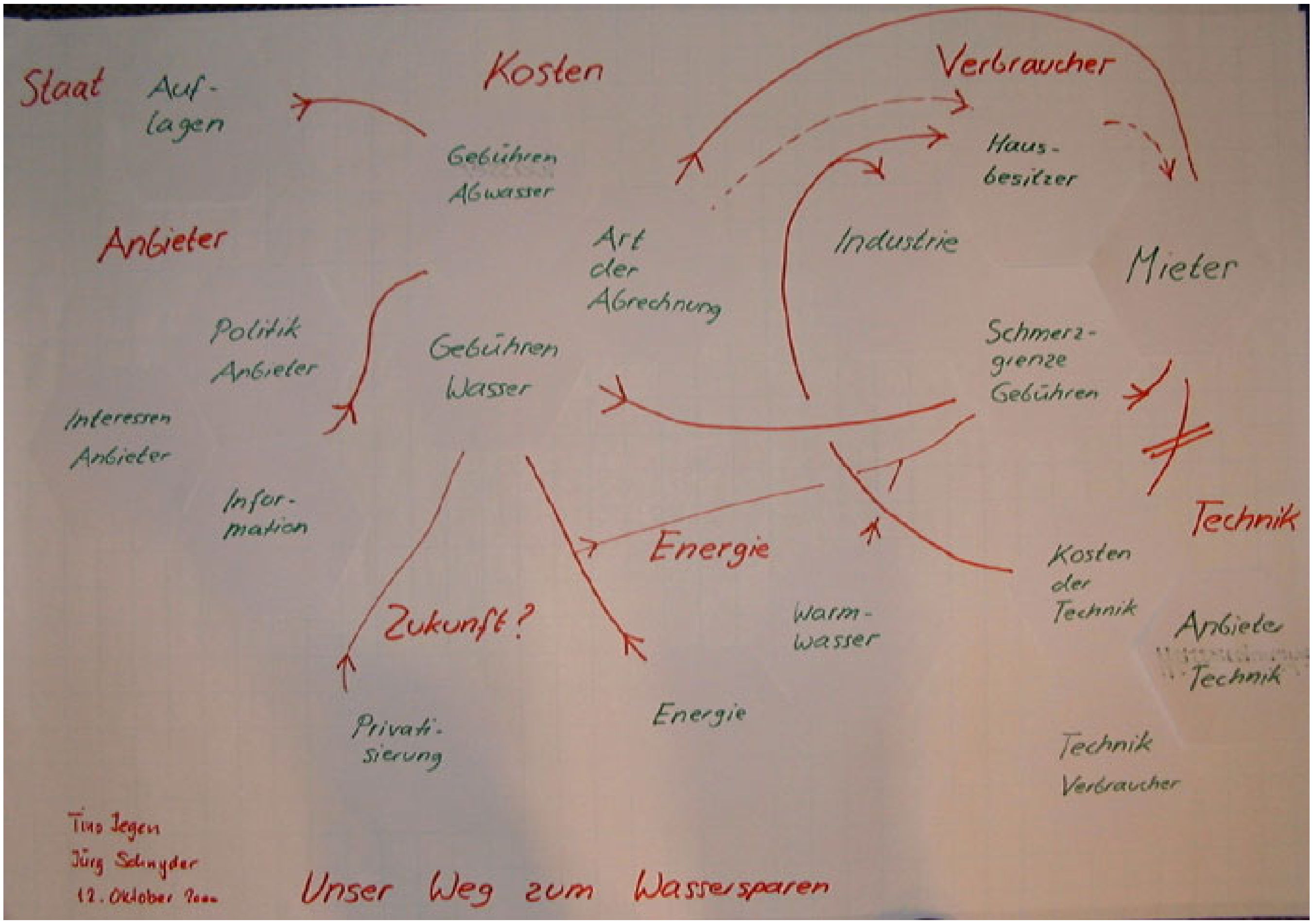
Pioneering approaches in this field of group model building have their origin in system dynamics (Vennix 1996, 1999, Sterman 2000). Knowledge about the structure and cause-and-effect relationships of the system representation of the management problem under investigation is elicited with specific techniques such as hexagon modeling (Hodgson 1992). This is a straightforward method that can quickly elicit ontological, relational, and general structural knowledge about systems from groups or individuals, and it incorporates it directly into a graphical model, ready for discussion (Hare and Pahl-Wostl 2002).

The hexagon method involves asking actors to write out on separate hexagonal cards key system concepts that relate to the problem situations under consideration. The stakeholder is then asked to group the hexagons into semantically contiguous groups, and to provide these groups with a category label. Figure 2 illustrates a completed mental model elicited from one of the stakeholders. The dotted box overlayed onto the model highlights one such cluster of hexagons, i.e., *Gebühren Wasser* (water charges), *Gebühren Abwasser* (waste water charges), *Art der Abrechnung* (type of water bill), relating to the group category *Kosten*, i.e., key concepts related to consumers' water costs.

Once clusters have been formed using a maximum of 15 hexagons, then the stakeholder is asked to draw links, i.e., arrows, between the hexagons or clusters that denote the most important relationships, causal or otherwise, between concepts. An example in Fig. 2 is the link between *"Privatisierung"* and *"Gebühren Wasser,"* which suggests that the stakeholder believes that the privatization of the water utility will have an affect on water charges for the consumer. Finally, the stakeholder provides a descriptive name for the model, in this case *"Unser Weg zum Wassersparen"* (our way to water saving). In this way personal perspectives about the concepts and inter-relationships of the system are elicited.

In subsequent group sessions, the mental models of individual stakeholders are aggregated and serve as base to develop one or more structure models of the total system. Figure 3 illustrates one structure model for the scenario "Water Saving". The different boxes refer to different categories such as impacts or norms. In each category one or two representative

Fig. 2. Example for a mental model elicited with the hexagon method.



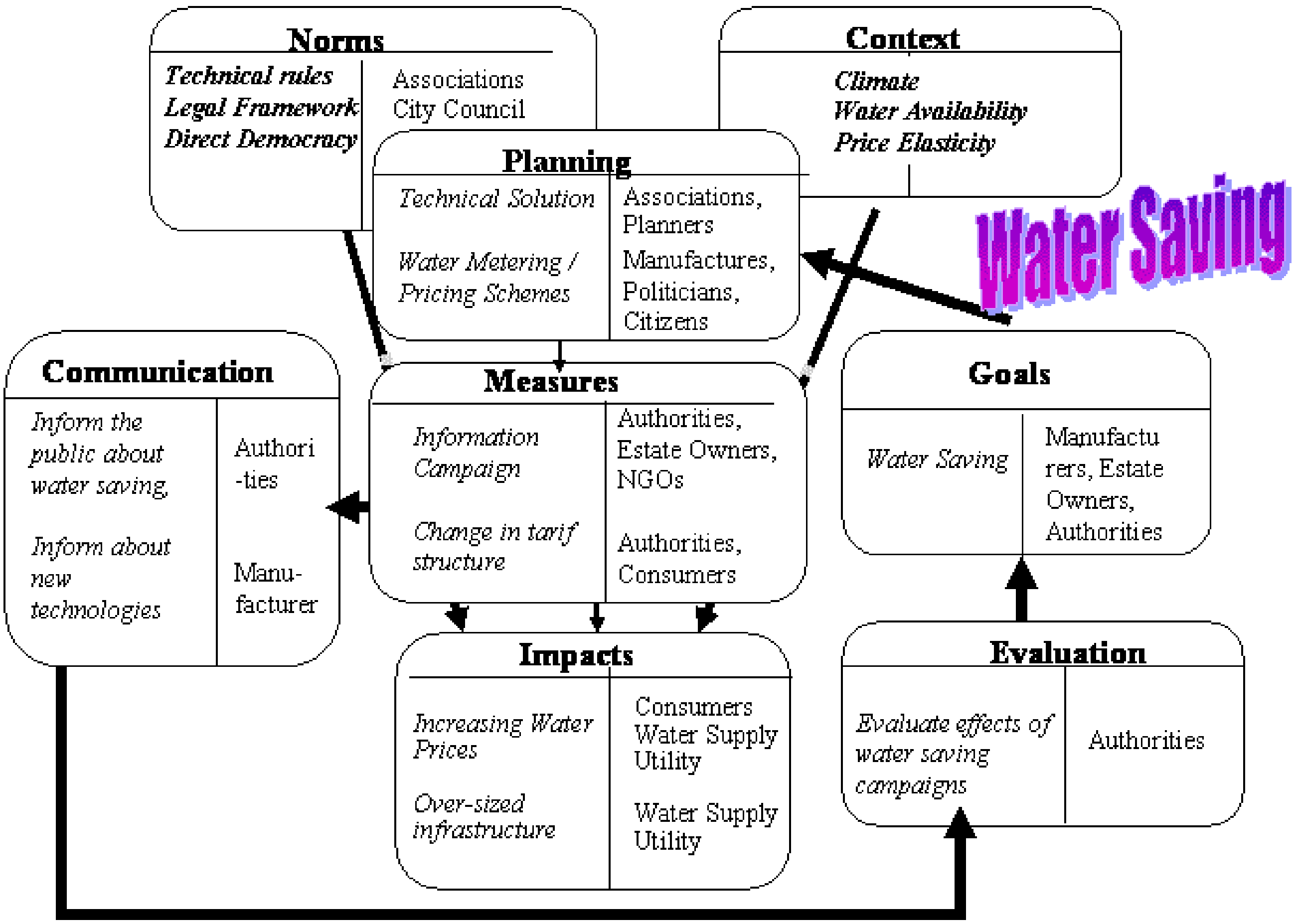
examples are given. The right column refers to the most relevant stakeholder groups with respect to the issue listed in the left-hand column.

Mental models thus derived serve as a basis from which to develop a qualitative, conceptual model, and subsequently, a computer model of the system from a number of iterations. In the process of doing so, actors reflect on their assumptions about cause-and-effect relationships in the system, and potential feedback effects that are often neglected (Doyle and Ford 1998, Pahl-Wostl and Hare 2004). The process reveals possible differences between the mental models of different actors. If mental models are factually wrong, expert advice should be sought to correct them. However, if uncertainties are high, more than one possible interpretation of the system structure may be possible, and different models may feed into a process to identify crucial uncertainties in structural assumptions and their implications for understanding system behavior.

Participatory model development and actors' platforms

In comparison with group model-building techniques based on system dynamics approaches, participatory agent-based social simulations place more emphasis on the individual actors who are to be represented in the models. Knowledge elicitation techniques are used to capture subjective

Fig. 3. Example of a structural model for a water savings scenario derived during group sessions from individual mental models.



perceptions and expectations, and to implement them in the model. This allows the actors to use the model as a medium by which they can represent and reflect upon their own and others' goals, beliefs, and expectations. Behavioral simulations and role-playing games can be used to support such processes.

One approach to participatory model development are the so-called "actors' platforms" on which representatives from different stakeholder groups are assembled (Pahl-Wostl and Hare 2004). The groups to be involved on the platform are identified in a prior institutional analysis, characterizing all stakeholder groups of relevance for the problem under consideration. Their organizations, roles, and interactions are determined from interviews and document analysis. An actors' platform follows the tradition of participatory action-research in which the stakeholder process serves as a tool for both scientific analysis and problem solving. A wide variety of knowledge elicitation and participatory model-building techniques may be used. In particular, role-playing games and simulation models are often combined (Barreteau et al. 2001, Duijn et al. 2003, Pahl-Wostl and Hare 2004). In such gaming approaches, the social interactions among the participants are the driving force behind the simulations. By adopting a role other than the one played in real life, actors may start to improve their understanding of the perspectives of other actors. These games enable the participants to reflect on the ways in which decisions are made, and to identify needs for change. At the same time, it provides the analyst with valuable insights into the social processes, expectations, and interests of the actors involved. Such processes may be linked to a formal decision-making context, but more often, these processes are open. The outcome of such a process could be a joint action plan that may even lead to the development of a new, formal institutional setting.

The approach sketched above assigns a major importance to the processes in the stakeholder network. One can view this as an extension of the experimental approach to adaptive management that has been derived from within ecology (Holling 1978, Richter 2003), to the human dimension that has been neglected for a long time in adaptive management (Lee 1999). Participatory processes and experimental settings are designed and facilitated based on hypotheses regarding social and environmental relationships. During the process, both the analyst/facilitator and the actors involved in the process learn about social interactions, individual interests, and expectations, thus, uncertainties and ambiguities are both reduced. During the process, trust and social capital are developed that enable actors to implement institutional change and to solve conflicts. Such an approach takes into consideration the complexity and limited predictability of socioecological systems (Pahl-Wostl 1995, *in press*).

To bring about a change in the governance structure, multiparty participatory processes must be embedded in a wider social context. For example, an actor's platform includes representatives from stakeholder groups who interact with their constituencies. Here, the nature of boundary management plays a major role. Finally, one should be aware that the research outlined in this paper also requires innovation at the science-policy interface, and requires new ways of interdisciplinary cooperation in the scientific communities. New approaches are currently explored in the NeWater project on Adaptive Water Management Under Uncertainty (NeWater 2005).

The role of social learning in transdisciplinary research

The following section summarizes the preliminary experiences with the processes of social learning in the big inter- and transdisciplinary project, NeWater.

The NeWater project aims at a paradigm shift in water resources management in both research and practice. NeWater will develop new methods for integrated water management taking into account the complexity of the river basins to be managed and the difficulty in predicting the factors influencing them, e.g., climate, socioeconomic developments. NeWater will focus, in particular, on the transition from current regimes of water management in a river basin to more integrated, adaptive approaches with strong stakeholder participation. The project has case studies in Europe, Africa, and Central Asia, in which new methods are developed and tested in participatory settings. The project involves 40 partner organizations comprising a wide range of disciplines such as resource management, political science, economics, sociology, psychology, climatatology, hydrology, ecology, engineering, etc. All disciplines have their own scientific frames and their own concepts and practices.

Knowledge integration in the NeWater poses a particular challenge. One approach quite often chosen for integration is the development of integrated simulation models. However, such an approach constrains the type of knowledge that can be included in the integration process. To develop a shared base for interdisciplinary cooperation and new practices for knowledge integration, NeWater has started to organize interactive workshops for joint concept development. The following are some of the first results and constraints:

- Processes generate a shared understanding for project goals;
- The process supports the establishment of trust and mutual respect;
- Process is time consuming without immediate tangible results;
- The incentive structure in science promotes individual achievement and territorialism

rather than the development of joint products; and

- Development of new shared practices by preserving the diversity of scientific approaches, e.g. combining different types of knowledge in developing indicators for the adaptive capacity of socio-ecological systems.

One example for a new shared practice that has been developed in such interactions and has already matured into a more established methodological approach is participatory model development, which is introduced in this paper. By choosing such new ways of interdisciplinary cooperation, and by promoting, at the same time, a strong exchange between stakeholder and research process, part of the results finally obtained are an emergent phenomenon of the whole process. It is argued here that such situated and context-dependent knowledge is a prerequisite for dealing with the complexity of real-world problems, and for bridging successfully the science-policy gap.

CONCLUSIONS

In summary, the following steps are recommended to implement a participatory process that facilitates social learning and institutional change, and leads to an adaptive management strategy for the restoration of multifunctional riverine landscapes:

1. Perform profound stakeholder analyses based on document analysis and interviews to select all stakeholder groups;

2. Establish a shared problem perception in a group of relevant actors who have the ability to communicate about different points of view. This may involve role playing, knowledge elicitation, and group model-building techniques (Vennix 1996, Pahl-Wostl and Hare 2004). It is not required to achieve a consensus, rather social learning implies that differences in opinion are recognized in order to deal with them constructively;

3. Build trust for self-reflection to recognize individual mental frames and images, and the ways in which they pertain to decision making. This requires good facilitation and the need to recognize potential sources of mistrust;

4. Recognize mutual dependencies and interactions;

5. Develop possible scenarios regarding the future state of a multifunctional landscape and new management approaches;

6. Identify barriers for change and possible solutions to overcome them;

7. Engage in collective learning and decision processes in a stepwise and iterative fashion;

8. Implement joint action plans and consider institutional change and innovation if needed; and

9. The management of the process of change must be adaptive and lead to changes that will enable continued adaptive management of riverine landscapes according to the principle “managing to learn in order to learn to manage.”

Responses to this article can be read online at:
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Acknowledgments:

Jan Sendzimir and Maja Schlüter provided helpful comments on earlier drafts of the manuscript. The further development of the social learning concept profited from numerous discussions with colleagues in the HarmoniCOP project. The work reported from the HarmoniCOP project has been financially supported by the European Commission under contract number EVK1-CT-2002-00120.

LITERATURE CITED

Bandura, A. 1977. *Social learning theory.* Prentice-Hall, Englewood Cliffs, New Jersey, USA.

Barreteau, O., F. Bousquet, and J-M. Attonaty.

2001. Role-playing games for opening the black box of multi-agent systems: method and lessons of its application to Senegal River Valley irrigated systems. *Journal of Artificial Societies and Social Simulation* **4** [online] URL: http://www.soc.surrey.ac.uk/JASSS/4/2/5.html.

Borowski I., editor. 2004. Public participation in the Elbe Basin. Case study report of work package 5 of the HarmoniCOP project. [online] URL: www.harmonicop.info.

Bouwen, B., and T. Taillieu. 2004. Multi-party collaboration as social learning for interdependence: developing relational knowing for sustainable natural resource management. *Journal of Community and Applied Social Psychology* **14**:137-153.

Craps, M., editor. 2003. *Social learning in river basin management.* Report of work package 2 of the HarmoniCOP project. [online] URL: www.harmonicop.info.

Craps, M., and S. Prins. 2004. *Participation and social learning in the development planning of a Flemish river valley.* Case study report of work package 5 of the HarmoniCOP project. [online] URL: www.harmonicop.info.

Dewulf, A., M. Craps, R. Bouwen, T. Taillieu, and C. Pahl-Wostl. 2005. Integrated management of natural resources: dealing with ambiguous issues, multiple actors and diverging frames. *Water, Science and Technology.* **52**:115-124.

Doyle, J. K., and D. N. Ford. 1998. Mental models concepts for system dynamics research. *System Dynamics Review* **14**:3-30.

Duijn, M., F. A. Immers, F. A. Waaldijk, and H. J. Stoelhorst. 2003. Gaming approach route 26: a combination of computer simulation, design tools, and social interaction. *Journal of Artificial Societies and Social Simulation* **6** [online] URL: http://jasss.soc.surrey.ac.uk/6/3/7.html.

International Secretariat of the Dialogue on Water and Climate (DWC). 2002. Dialogue on water and climate in the Netherlands. Wageningen, The Netherlands.

Funtowicz, S. O., and J. R. Ravetz. 1993. Science for the post-normal age. *Futures* **25**:735-755.

Gray, B. 2003. Framing environmental disputes. Pages 11-34 *in* R. J. Lewicki, B. Gray, and M. Elliott, editors. *Making sense of intractable environmental conflicts: concepts and cases.* Island Press, Washington D.C., USA.

Gray, B. 2004. Strong opposition: frame-based resistance to collaboration. *Journal of Community and Applied Social Psychology* **14**:166-176.

Hanke, R., B. Gray, and L. Putnam. 2002. Differential framing of environmental disputes by stakeholder groups. AoM Conflict Management Division 2002 Mtgs. No. 13171. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=320364.

Hare, M. P., R. A. Letcher, and A. J. Jakeman. 2003. Participatory modelling in natural resource management: a comparison of four case studies. *Integrated Assessment* **4**:62-72.

Hare, M. P., and C. Pahl-Wostl. 2002. Stakeholder categorisation in participatory integrated assessment processes. *Integrated Assessment* **3**:50-62.

Harmonizing Collaborative Planning (HarmoniCOP). 2003. *Learning together to manage together&#82-12Improving participation in water management.* University of Osnabrück, Osnabrück, Germany. [online] URL: www.harmonicop.info.

Hodgson, A. M. 1992. Hexagons for systems thinking. *European Journal of Operational Research* **59**:220-230.

Holling, C. S., editor. 1978. *Adaptive environmental assessment and management.* John Wiley, New York, New York, USA.

Hughes, F. M. R., editor. 2003. *The flooded forest: guidance for policy makers and river managers in Europe on the restoration of floodplain forests.* Floodplain Biodiversity and Restoration (FLOBAR2), Department of Geography, University of Cambridge, Cambridge, UK.

Lee, K. N. 1999. Appraising adaptive management. *Conservation Ecology* **3**:3-16.

NeWater. 2005. *New approaches to adaptive water management under uncertainty.* University of Osnabrück, Osnabrück, Germany. [online] URL: www.harmonicop.info.

Orr, P., J. Colvin, and D. King. *In press.* Involving stakeholders in integrated river basin planning in England and Wales. *Water Resources Management.*

Pahl-Wostl, C. 1995. *The dynamic nature of ecosystems: chaos and order entwined*. Wiley and Sons, Chichester, UK.

Pahl-Wostl, C. 2002. Towards sustainability in the water sector: the importance of human actors and processes of social learning. *Aquatic Sciences* **64**:394-411.

Pahl-Wostl, C. *In press.* The implications of complexity for integrated resources management. *Environmental Modeling and Software.*

Pahl-Wostl, C., and M. Hare. 2004. Processes of social learning in integrated resources management. *Journal of Applied and Community Psychology* **14**:193-206.

Pahl-Wostl, C., C. Jaeger, S. Rayner, C. Schär, M. van Asselt, D. Imboden, and A. Vckovski. 1998. Regional integrated assessment and the problem of indeterminacy. Pages 435-497 *in* P. Cebon, U. Dahinden, H. Davies, D. Imboden, and C. Jaeger, editors. *Views from the Alps: regional perspectives on climate change.* MIT Press, Cambridge, Massachusetts, USA.

Richter, B. D., R. Mathews, D. L. Harrison, and R. Wigington. 2003. Ecologically sustainable water management: managing river flows for ecological integrity. *Ecological Applications* **13**:206-224.

Röling, N. 2002. Beyond the aggregation of individual preferences: moving from multiple to distributed cognition in resource dilemmas. Pages 25-47 *in*: C. Leeuwis, and R. Pyburn, editors. *Wheelbarrows full of frogs: social learning in rural resource management.* Royal Van Gorkum, Assen, The Netherlands.

Sterman, J. D. 2000. Business dynamics: system thinking and modeling for a complex world. McGraw-Hill, New York, New York, USA.

Tippett, J., B. Searle, C. Pahl-Wostl, and Y. Rees. 2005. Social learning in public participation in river basin management. *Environmental Science and Policy* **8**(3):287-299.

Vennix, J. A. M. 1996. *Group model building: facilitating team learning using system dynamics.* Wiley, Chichester, UK.

Vennix, J. 1999. Group model-building: tackling messy problems. *System Dynamics Review* **15**:379-401.

Walker, B., S. Carpenter, J. Anderies, N. Abel, G. Cummings, M. Janssen, L. Lebel, J. Norberg, G. D. Peterson, and R. Pritchard. 2002. Resilience management in social-ecological systems: a working hypothesis for a participatory approach. *Conservation Ecology* **6**(1):14 [online] URL: http://www.consecol.org/vol6/iss1/art14/main.html

Wenger, E. 1998. Communities of practice: learning, meaning, and identity. Cambridge University Press, Cambridge, UK.