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ORIGINAL ARTICLE

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Water information: what is it good for? The use of information in transboundary water management

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Abstract Consistent and relevant information on the status of water systems is indispensable for rational and cost-effective water management. This statement has general validity for all types of river basins, but is particularly relevant for transboundary water regions. Information is used to support decision-making and to evaluate the effects of water resources management decisions. Information production however lags behind developments in water management, which becomes clear from the fact that information still focuses on ecological components of water bodies and largely ignores the importance of socio-economic data stemming from human activities taking place in the river basin. Production of improved information is hindered by strong boundaries between different disciplines that are not easily overcome. Moreover, consideration of information needs and the goals of information dissemination prior to producing information is insufficient and the relevant actors are often reluctant to participate in these processes as they are time consuming. Differences in institutional behaviour also hinder cooperation between institutions, while organisational structures are insufficiently tuned to the needs of the external environment. All these issues hinder the use of information as the basis for decision-making. This paper provides an overview of relevant aspects of information from a broad range of perspectives and establishes the need for changes in the production and use of environmental information in support of water management. The paper is largely based on the outcomes of a closed multi-disciplinary specialist meeting on the role and use of environmental data and information in transboundary water contexts held in Arendal, Norway, September 2002.

Keywords Water information · Transboundary water management · Communication · Institutional behaviour

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Introduction

Water management faces an increased number of pressures on water use while the impacts of these water management problems stretch out further and further in space. As these problems cross borders, the importance of cooperation between countries and regions sharing water resources is growing. The significance of environmental information as a basis for water management and an essential part of cooperation is consequently mounting. Therefore it is essential to know the role of environmental information in the context of transboundary river basin management and its use in decision-making.

Botterweg and Rodda (1999) have pointed out that transboundary water management is a complex process with many actors at different levels. They note that both the development and the implementation of the actual work has to be conducted at a local level, and that national authorities, as well as the international agreements, are dependent on the compliance of actors they cannot force by traditional government measures. As the success of management initiatives in systems that are difficult to regulate is dependant on persuasion, incentives, and the flow of information between these actors, analyses of the ways in which networks of actors and institutions interact and communicate internally and externally is vital. As there is no single actor capable of forcing all actors to comply, these networks and their communication of information play a crucial role in management processes. Huisman et al. (2000) note this, and point out that most transboundary commissions cannot force the member states to adopt laws, or companies to use the best available technology; their role is often simply to advise the governments.

In this paper, we try to capture the relevant aspects of information from a range of perspectives, largely based on the outcomes of a closed multi-disciplinary specialist meeting on the role and use of environmental data and information in transboundary water contexts, held in Arendal, Norway, September 2002. Each of the information perspectives describes a part of the issues that have to be accounted for when dealing with water management information. The challenge lies in connecting all different elements in order to produce information that is effective in supporting water management decision-making. In this paper we describe how the use of information and knowledge in decision-making is influenced by mindframes. We argue that participatory processes can be helpful in the mutual understanding of each other's mindframes through a social learning process. However, there are several limitations and preconditions that have to be met to enable participation of stakeholders. This concerns issues like the exchange of information through information networks, especially in a transboundary water management situation, institutional behaviour, information production and dissemination, and the freedom of access to information. The paper provides an overview of research that has been done in different disciplines and links the different aspects together to come to conclusions about the use of information in transboundary water management. However, as authors with mindframes that have their initial academic platform in the natural and technological sciences, in our pursuit of an interdisciplinary view upon environmental information issues, we are well aware that we may have overlooked specific subtleties in the socio-economic and legal domains.

In the paper we use the terms 'information', 'water information', 'environmental information' and 'river basin information' as synonyms. Although these terms emphasise slightly different aspects they all essentially encompass information that concerns matters having an impact upon water quality or quantity. Furthermore, although structured according to a set of key concepts or perspectives, we openly admit that many of these are highly compounded. Still, we believe that they all offer a sufficiently unique angle into matters to justify their inclusion.

The question of rationality

Generally, information is considered to be an essential basis for decision-making. Communication involves a flow of information. A premise is that decision-makers need access to reliable and understandable information on environmental and water-related issues in order to make functional, logical and rational decisions (Gooch et al. 2003). Communication of scientific information from the scientific and technical community to politicians and civil servants should function according to previously agreed-upon, and predominantly rational, criteria (Gooch 2004). In this view, individuals are conceptualised as self-regarding rational actors who have stable, exogenously defined preferences. They order the possible outcomes of any decision-situation according to their preferences and choose the strategy that maximises expected utility (Ehin 2003). This view assumes that decision-making is largely a rational process.

The use of information in decision-making has however proven to be rational only up to a certain point. In the political sciences discipline, environmental problems are defined as being basically social problems. As the World Bank noted, environmental problems are "at their root, social problems", and it is necessary to "develop competent rule and institutions to address environmental, social and economic problems" (World Bank 2002). Or: "Environmental planning and decision-making are essentially conflict analyses characterised by socio-political, environmental, and economic value judgements" (Lahdelma et al. 2000). The nature of such problems is partly built on norms, values and beliefs of the individuals involved. Individuals will act based on these values, which to a certain extent is rational. When individuals are cooperating, they will appreciate information on environmental problems in different ways. The use of information will consequently be dissimilar, depending on the user of the information, and will be less rational. In a social context, next to these two dimensions of rational and value-based use of information, the social-practice model appears where the role of culture and habits, i.e. the dominant societal norms and values, are emphasised as driving people's behaviour (Ehin 2003). We conclude that the use of information is not unambiguous, containing elements of rational, value-based, and cultural and habitual behaviour. This behaviour is explained in the following section through the concept of mindframes.

Dealing with mindframes

Evidently, different people view the world in different ways. For example, the world of a biologist is focussed on nature and wildlife, while an economists may be focussed on finances and monetary terms. Ross expresses this tendency as follows: "When I talk to people who want to spread the messages, they tend to think in terms of their own expertise and experience. The pollution control person wants to talk about stopping pollution. The economist wants to talk about treatment costs versus source protection. The planner wants to talk about siting. The public health people want to talk about parasites ... and on and on" (Ross 2001). Or, as Harremoës states: "The dilemma is that experts to be recognised as such often become highly specialised. The consequence is a narrow interpretation of what the issue is, a specialised terminology and a tacit misunderstanding of concepts, problems and solutions within the expert community. It is a constant

source of misunderstandings, misinterpretations and misinformation in the sense that communication is difficult between disciplines'' (Harremoës 2002). Thus, experts from the different disciplines have different viewpoints that are difficult to integrate. Generalising, economists seek to maximise human welfare within the constraints of existing capital stock and technologies, ecologists stress preserving the integrity of ecological subsystems, and sociologists emphasise that the key actors are human beings, whose patterns of social organisation are crucial for devising viable solutions to achieving sustainable development. There is no doubt that each viewpoint is valuable, and attempts are made to come to an integration of the different views. There is however the difficulty of seeing the concerns through one another's eyes.

The metaphor used here for this perception is the mindframe. The mindframe is the window through which people view the world. It is an assembly of our cultural background, professional training, character, experience, expertise, roles and responsibilities, etc. (see for instance de Boer 1999; van der Werff 1999). We all see the same world, but our view is limited by our mindframe. Difficulties in communicating are partly based on different mindframes; we assume that we discuss the same world, but each person may see things that others may not see, especially when people from different disciplines are communicating.

As discussed, someone from a natural sciences education will take a different viewpoint as compared to for instance a scientist with a socio-economic background. An issue like flood protection, for example, is likely to start off as an issue of the height of dikes to a civil engineer, a matter of perception of safety to a sociologist, a problem of ecological damage to a biologist, and a cost–benefit matter to an economist. A team of people with the same disciplinary background could easily overlook one or more of these other viewpoints, and even if not, would be unable to cope with them. This was illustrated in a project on the setting up of a monitoring plan for the evaluation of restoration of saline gradients in estuaries. This project was initiated and supported by ecologists, which can be explained from the gains in ecological diversity from such projects whereas the gains in the socio-economic sector are not clear. This ecological starting point turned the initial bias of the project towards monitoring of ecological parameters. Involvement of, among others, regional waterboards, who are originally strongly affiliated with agricultural groups, led to the inclusion of socio-economic parameters in the project (Timmerman et al. 2001). Moreover, Gerlach (1993) shows that when technical specialists disagree among themselves, they say this is chiefly because they begin with different assumptions, use different scientific procedures, or do not yet have enough data. In reality however, they interpret the data through the cultural filters of their respective groups. This however, does not diminish the fact that data do matter in decision-making.

All in all we can conclude that there is no such thing as a neutral, objective approach towards water management issues. Every observer, analyst, or decision-maker will have explicit or implicit biases and blind spots as a result of professional belief systems, religion, responsibilities, core normative and casual beliefs, etc. (that together form the mindframe) and none can singly encompass the whole system (see also Funtowicz et al. 1999; Newson 2000; Rivett 1994). The use of information is therefore limited by the mindframe and people that do not understand or share the decision-makers' mindframe may not understand the rationale of the decisions.

Understanding in this situation can only be built when one is aware of the existence of these mindframes and consequently of the limitations in communicating. This opens up the opportunity of trying to get an understanding of the others' mindframe. Such understanding is used for defining management actions that ultimately lead to reduction of the problem situation (Doody et al. 1998). The implication is that information can lead to understanding only if it is input to the problem analysis and as such adds to our knowledge base. Only when information fits the mindframe of the receiver, can it be accurately used to change the situation. Therefore, scientists from the social, economic and natural sciences should work together on the issues, each being aware of having blinkers that may hinder their full view (Timmerman and Cofino 2001). Thus, as was concluded during the workshop on driving forces and incentives for change towards sustainable water development at the 11th Stockholm Water Symposium where the concept of mindframes was introduced: ''the sharing of mindframes can help in raising awareness and involves active communication and understanding of the key interests of different actors'' while ''the understanding and establishment of shared mindframes is one way to raise awareness among scientists about decision-making processes, and which would make it possible to better link physico-chemical and ecological aspects with socio-economic considerations that are often more relevant and understandable for decision makers'' (Takahashi et al. 2002). This lies at the basis of the social learning process that will be discussed later.

The use of knowledge

The ''knowledge gap'' hypothesis or 'science–policy gap' is a subset of the different mindframe metaphor that is focused on the communication mismatch problems. It attempts to explain discrepancies and problems in the communication of scientific information by looking at cognitive differences among scientists, policy-makers, and stakeholders. A basis for this gap can be found in the situation in which *''scientists are trained to achieve increased understanding and managers to manage problems and create policies''* (Boogerd et al. 1997). The hypothesis

then postulates that well-educated people learn more from information, and that differences in knowledge then lead to increases in the knowledge "gap" between the sources and receivers of information (see for instance Bernstein et al. 1993; Bradshaw and Borchers 2000; Gooch 2004; MacDonald 1994). The technical language used by scientists must be "translated" into lay terms for the information to be useful, to fit the mindframes of the receivers. The question is how to communicate without oversimplifying highly technical information stemming from different science disciplines to decision-makers and other stakeholders to ensure that this information will be adequately understood and accepted as relevant and reliable, and be utilised in the policy development and implementation process; how to ensure that this multi-discipline scientific information will be synthesized into "usable knowledge"? The mechanism of "translation" of the raw data should ensure that the information users receive "usable knowledge." This is easy to use/understand, accurate and relevant, tailor made information preferably included in maps and constructed to meet the needs of the general public (Roll 2004). It cannot be provided without policy—makers specifying their information needs (and for that matter, translating their policy into lay terms).

The receiver's beliefs and cognitive frames of reference, as part of the mindframe, will influence and determine both which information is accepted, and the ways in which the accepted news is integrated into the receivers' perceptual structure. Here, the content as well as the appreciation of the information plays a role. The impressions that most easily fit into the mindframe of the individual or group, or into the social representations of society will be most easily accepted, while preconceptions often prevent the reception of information. Deviant impressions and views will be rejected, and ambiguous impressions will be treated as if they are compatible with the established mental frames of reference (Gooch 2004).

One important issue here is to avoid immediate rejection of information by building awareness of differences in viewpoints. As we discussed in the previous section, this requires sharing of mindframes through interaction of the various actors. But before we come to this participatory process, we take a look at the availability of information for the different actors.

Information exchange

Despite the seemingly limited rational use of information by policy—makers, they need access to reliable and relevant integrated information and assessment in order to meet the challenges presented by water management. This includes information both on the physical attributes of water systems and river basins, and also on the special political and administrative conditions, cultures, and institutional contexts that characterise transboundary water policy-making and implementation (Gooch 2004). For scientists, the practical challenge of producing integrated information and assessments may be best referred to as making a shift from multi-disciplinarity to interdisciplinarity, where multi-disciplinary implies that a study starts off from different mono-disciplinary angles while interdisciplinary implies that studies start off from the problem that has to be addressed (Hisschemöller 2004). A multi-disciplinary or preferably, as stated, an interdisciplinary setting in which close and regular contact between scientists of different disciplines and even between scientists and decision—makers will probably deliver the best results in terms of addressing the environmental (and socially perceived) problem. This integrated approach also requires integration over administrative structures, especially in transboundary water management. Each administrative compartment will only overlook a part of reality and make single-purpose decisions. The larger perspective and consequences can only be overlooked when administrative boundaries are neglected (Falkenmark 2000; Funtowicz et al. 1999; Timmerman and Cofino 2001).

Water resources management requires negotiating conflicts and differences between different stakeholders with different mindframes. Conflict is in such a situation often a clash of paradigms. People act and rationalise things in a way that does not make sense to others because they are operating with a different set of assumptions, values and beliefs, as stated earlier. In resolving such conflicts, those involved need to make their paradigms explicit and see others' paradigms. For this, facilitation is critical (Woodhill 2004). One such conflict in transboundary river basin management is that especially the upstream countries have a tendency to restrict information exchange, as it is not in their direct interest to give full access to the available information. This is partly related to the power connected to the possession of information. As the lack of information can hinder proper definition of a situation or hamper appropriate action, control over information gives an advantage over those who do not have this information. Also, information can be used as a 'weapon' by directing blame at other parties and by validating claims that it is the other party that is polluting the water or causing floodings (Timmerman 2004). Further, information can be used as a commodity when it contains a certain value and can be subject to trade (Timmerman et al. 2003). These different powers of information are generally recognised and they can be used to hinder cooperation, not only between countries but also between different stakeholders. Only when a common understanding of the situation is reached and common interests are recognised, can cooperation take shape. Underlying common understanding is mutual trust that diminishes the aspect of power. But building of trust, both within and between groups, is a lengthy process (see also Paldam 2002). Here we end up in a vicious circle in which common understanding needs sharing of information but sharing is only felt to be safe when there is mutual trust. A participatory process can not only help to develop both trust and

sharing, but is also a prerequisite for present water management, as we argue in the following section.

Public participation

Although not explicitly using the term Public participation, the EU Water Framework Directive (WFD) promotes the active involvement of all interested parties in the process of water management (European Commission 2000). Parties that are distinguished in this respect are professionals, local groups, and individual citizens, farmers and companies representing themselves (WGPP 2002). The WFD in this way provides a unique opportunity for public participation, especially with the view to implementing sustainable development. Approaches for public participation range from inclusionary processes where stakeholders are informed and consulted, to fully fledged deliberative participatory processes in which stakeholders are equal partners in the decision—making process (Turner 2004). There is a growing need to involve the public in a deliberative participatory way, since there has been a change in consultation as people are becoming more and more involved. Current trends indicate that three processes are going on, which have caused the growing importance of public participation (Lise et al. 2004):

1. There is a general feeling of democratic deficit. Some governments seem no longer to deliver the results as desired by the public, and public trust in political decisions has fallen dramatically without recovering, causing a crisis of legitimacy. If policy—makers pretend that there is consensus on values or certainty on what knowledge is relevant while this may not be the case, the legitimacy of measures may drop in the eyes of the stakeholders. They may feel that their values or knowledge are not taken into account in the programme (Hisschemöller 2004). On the other hand, governments are constrained by global economic interests and by multi-lateral obligations, and so are no longer able fully and freely to meet the many and frequently conflicting local needs of the people.
2. Nowadays people want to be able to shape their own futures. A society has developed where, mainly through ICT, information is opened up to an ever-wider audience, enabling people to coordinate and direct actions. It is now possible to visualise images of future flooding, landscapes or coastal patterns to allow stakeholders to see for themselves how future patterns of landscape and policy may evolve.
3. There is a growing awareness among governments that decisions are often no longer acceptable without participation of the public in the decision-making process. Without this public consensus, decisions may fail.

The shift from mere consultation of stakeholders towards participation in decisions requires individuals to recognise and accept the values, responsibilities and obligations of citizens. Since multiple stakeholder interests and perspectives are commonplace, water resources management will involve trade-offs informed by a range of decision criteria, some of which will be conflicting (Turner 2004). To support participation, the information not only has to be made available, but has also has to be communicated among the various actors. The following section deals with this.

Information networks

Communication of information is a process often with many different actors that each process and transfer information. The type of network the actors perform within can for instance determine if the information reaches the appropriate actors. In a transboundary situation, the role of the 'communication gateway', the formal or informal connection between the countries, is very important in the process of conveying information.

Decision-making and management takes place on different levels, ranging from the local to the international level. The abovementioned information and communication issues play their role on each of these levels as well as between the levels. Regime theory, dealing with international cooperation between two or more states in specific issue areas explains some of these communication issues. However, policy and implementation processes are no longer monopolised by central government agencies; instead, a system of multi-level governance is developing in which representatives of trade and industry, local communities, and NGOs play an increasingly important role, as explained in the previous section. Governance is replacing government, and the different societal spheres, politics, business, and civil society, are becoming increasingly intertwined and interdependent. The traditional regime theory has been supplemented to accept that in the case of transboundary water management, power and national interests may be central, but central state actors are not the only ones involved in the policy and implementation processes. State-centric theories such as traditional regime theory can be complemented by the theory of multi-level governance. This theory stresses the importance of civic and business institutions and their interplay and interdependence with political and administrative institutions at various levels. Especially in the case of transboundary water management, this can contribute to our understanding of the processes (Gooch 2004).

Additionally, each level collects and disseminates information on a different scale, complicating comparison of information on the different levels. This implies that good communication can only take place in an interactive process where the perception of information is tested after it is transferred. Therefore, more attention needs to be given to the ways in which the systems of actors and institutions involved in water management are changing.

We have seen the importance of sharing information between different actors to enable cooperation and building of trust. But the concept of mindframes also influences the way information is produced.

Information production

Transboundary cooperation as stated requires exchange of information. Expert commissions will have to disseminate information and perhaps produce information that can be understood by different stakeholders and users (Barreira and Kallis 2004). Production of information has historically taken place in a situation where the producers of information at the same time also have been the users of that information. As these 'prod-users' usually have a natural science background, emphasis in information production lies with physico-chemical and biological information. Due to the common scientific and technical background there is no science–policy gap between producers and users of information in such contexts. As the producers mostly present their own data and knowledge, their information is considered highly reliable and therefore well accepted. However, ''prod-user'' information practice also has some disadvantages. As there is no great need for ''translation'' of knowledge some of the information produced remains expert information in so far as the reported data are hard to understand for non-specialists (Schröder 2004). This technical/scientific paradigm appears to dominate in transboundary water regimes. It is visible in the information needs that are mainly defined with the water commissions' own requirements in mind, in the data collection dominated by environmental state and impact information, and in the communication with stakeholders and the public, which mainly are done through passive channels (Nilsson and Langaas 2004). The significance of socio-economic information for decision-making is, as a result, generally underestimated. Environmental data is used in the decision-making process when it shows a direct and clear connection between, and impact of, the physico-chemical and biological conditions to changes in the economic and social situation in a given transboundary water region. If this is not acknowledged, the efforts put in to information production are insufficiently used (Timmerman et al. 2003).

The essential elements in the process of producing information are depicted in a generic model—the information cycle (Fig. 1) (Timmerman et al. 2000). The cycle links the information production process to water management through two elements: specification of information needs as the basis for the information production, and information utilisation as the translation from 'raw' information to 'usable knowledge'. The information cycle also has its limitations, since it does not support the flow of information through the process of transboundary river basin management as represented by stakeholders and actors on a wide variety of levels.

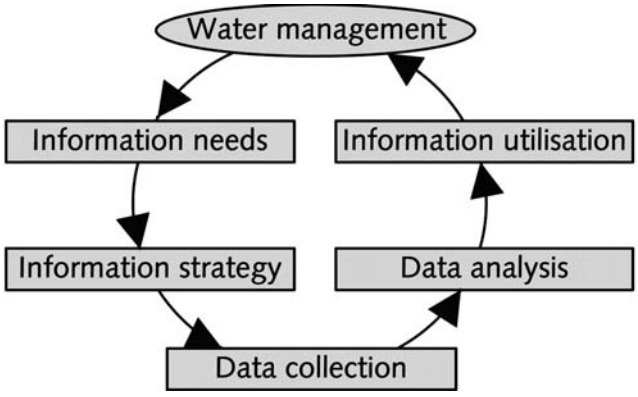

Fig. 1 The information cycle

The specification of information needs should ensure a thorough thinking through of what information is really needed, while assumptions that different stakeholders have of the value of certain types of information are made more explicit. In addition, determining the goal of producing and disseminating information should even precede determining what information should be produced (Timmerman 2004). The significance of linking information to policy—making is widely acknowledged in the literature and the specification of information needs is promoted as a means to achieve this (among others, Adriaanse et al. 1995; Brett 2000; Timmerman and Cofino 2001; van Luin and Ottens 1997; WCMC 1998). This notion has been worked out in a methodology that allows management as the process of specifying information needs and that provides the questions and schemes needed (Timmerman et al. 2001; Timmerman and Mulder 1999). Cooperation in information requires an interactive approach involving the relevant actors in defining the (environmental) goals and determining what information should be produced. This approach is needed to account for the differences between the actors in interests, values, and cultural background. As the actors may perform at different levels, information has to account for these different levels and the scales connected to the levels.

We now turn to information utilisation. The impact-of-information chain model is a representation of the flow of environmental information as a continuous process from its origin to a real-life improvement of the environment, and it clearly argues that information is best managed in a comprehensive manner (Fig. 2). This means that all essential elements of the chain, from monitoring to packaging and disseminating information, to its interaction with decision-making processes need to be taken into account. Successful long-term planning should be driven by information objectives rather than supply-driven, starting on the side of communication strategies rather than production. Unfortunately this is more often not the case. (Denisov et al. 2004).

One channel to get information to the public is through the media. A major fear among some scientists

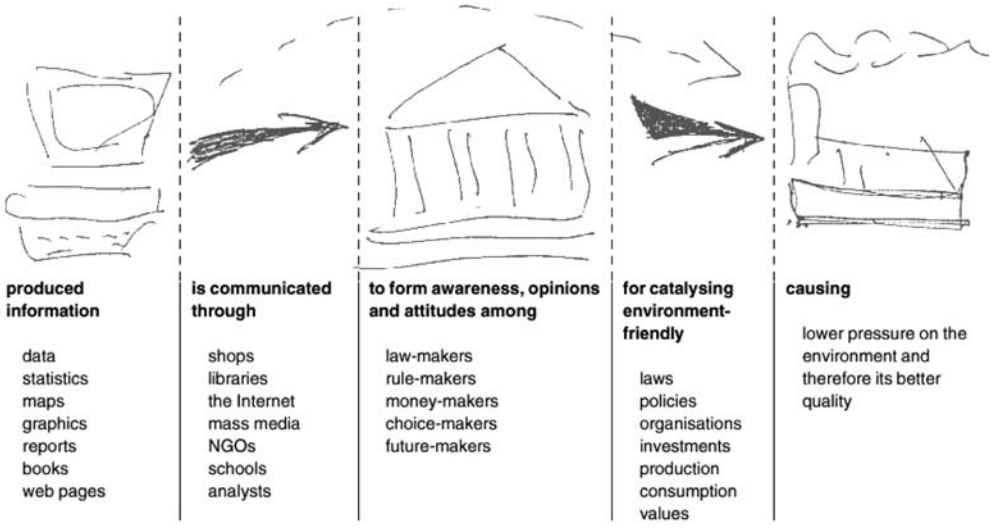

Fig. 2 Impact-of-information chain (Denisov and Christoffersen 2001)

for bringing out information through the media is that the sender loses control over the message. On the other hand, if there is a clear message to convey, it cannot be changed easily.

The use of indicators can be imperative to communicate a message. Indicators should simplify the situation at hand, appeal to the non-scientists and give meaningful information. The high transparency of indicators can, on the other hand also hamper their use in the policy process. An indicator that is too specific, rigid and not ambiguous enough may not be accepted by policy (Lorenz 2004).

(Transboundary) River Basin Information System (RBIS)

It is now widely known that effective river basin management requires participatory approaches. Information needs among stakeholders that influence water quality and quantity are diverse and different from those found in the commonly small and well-defined group of "water or river basin managers" (Langaas et al. 2004). Thus, a key ambition should be to develop the RBIS as a public good to meet the information needs of the multi-level actors that in various ways modify the biogeochemical cycles so that water quality or quantity changes. Technology-wise, such an RBIS could be a combination of Geographical, a Web server and a Map Server. Many of the RBIs Districts (RBD) to be established in 2003 under the (WFD) will be of transboundary nature (Nilsson et al. 2004). The requirements upon WFD implementation are somewhat relaxed relative to national RBDs given that competent international authorities of international RBDs are not obliged to implement EU legislation. Still, several transboundary river commissions have committed themselves to take on the task of developing the transboundary river basin management plans, and accordingly to develop and use GIS database for this and other purposes.

Such an RBIS should be a politically initiated non-rival and non-excludable information system that provides easy and non-restricted access to adequate river basin information. For this, the information system must enable public access to the data, while the heart of the transboundary RBIS should be a harmonised, multi-thematic GIS database that is adequate from the perspectives of awareness raising and decision-making. The database should have a legal status that makes it possible to re-use and re-distribute the database in the raw or slightly modified form. As the GIS data and information itself is the core or heart of an RBIS, and the relevant data is found at many institutions, the issues related to costs and copy-right of data are not easy to resolve. An acceptable financing solution needs to be found as it critically influences data producers' incentives to cooperate (Langaas et al. 2004). This brings us back to the importance of institutional cooperation and the difficulties that are encountered there.

Behaviour of institutions

Water management institutions can range from distinct organisations to networks of people. Whatever form an institution has, usually there is a legal framework that sets the context of the institution. Such a framework is a significant driver for institutional behaviour and the professional activities within an institution. Gooch (2004) distinguishes among rational, bureaucratic and political institutional behaviour. The use of information within these respective types of organisations can respectively be orderly and rational, procedural, or disorderly. Differences in these types of institutional behaviour within countries or on either side of the border can hinder cooperation.

The ever-changing external environment requires institutions to adapt their organisational structures to create an enabling ambience that can cope with the new

situation. But most institutions have a legal framework, a history, and a cultural background that makes them work as they do and this history makes it difficult for institutions to change. As a result, the external environment changes more rapidly than institutions can. One consequence of this may be that institutions cannot deliver the required information. Next to that, in a transboundary setting, cooperation between institutions is not easy and will require extensive time. One corollary of differences between institutions is the reluctance to give access to information. As discussed, reasons for this can be for instance lack of understanding, fear, ignorance, lack of motivation or need for power. An example of this reluctance is that although the objectives of the Portuguese-Spanish Water Convention are integrated with the majority of principles established by the WFD, including river basin management, it does not explicitly require joint management (Matos 2004). Especially in the political institutional model where information is used strategically (Milich and Varady 1999), information will be regarded as a source of power, which will in turn lead to secrecy. Such secrecy will impede building of trust that is, as stated, a precondition for cooperation.

Next to institutional behaviour, institutions can have different perspectives on the best societal response to the water issues of concern. The technical perspective relies on the scientific discovery and technical solutions—for example new agronomic practices that are more water efficient. The economic perspective tries to solve problems through markets and the valuation and pricing of goods and services. The interactive perspective brings people into negotiation with each other over their values, goals, differing interests and the development of collective interests and common strategies for action. Each of these perspectives will lead to some result. However, it is the interactive perspective we must turn to when existing ways of thinking and institutions prove inappropriate for solving the problems of our time. Through this approach, social learning as a form of interactive dialogue and decision-making can be developed. The most obvious institutional requirement for social learning is the creation of some form of platform that enables different actors to come together and which give legitimacy to a process of interactive learning (Woodhill 2004). Again here, the need for sharing the available information is apparent. We now turn to the legal aspects.

Free access to information

The Aarhus Convention (UNECE 1998) and recent EU legislation (European Commission 2003) endorse the principle of public and free access to environmental information for all citizens. However clear the free access may seem, there are some restraints to it. Firstly, the question has to be answered of what the law requires to be provided and by whom? Linked to this are issues of terminology and definitions like those of environmental information and public authority. Secondly, how must the information be provided, and what structures are in place to ensure meaningful access. Thirdly, what level of detail should be made available, which is partly depending on the intended users. Ideally all the detailed background and technical data should be in the public domain, with only the most stringently managed exemptions—but in addition, there must be simplified analysis and non-technical summaries to ensure that the public at large, as well as the involved professionals, can make meaningful use of the information. All of these questions must be addressed and answered when legislation is being drafted, taking account of best practice (Hendry 2004). Furthermore, there is the issue of human rights. This relates to the way in which the law protects freedom of thought and access to essential data, but also, how does the law protects privacy of personal data? And do public authorities have the duty to protect citizens against misinformation? Secondly, there is the issue of intellectual property rights. This relates to the way in which the law empowers authors/inventors to capitalise their know-how (author's rights, industrial and commercial secrets) and if public authorities have the right to profit from the data they own under the umbrella of author's rights and industrial and commercial secrecy? And could the fact of information being withheld lead to an impediment for the authorities to make well-balanced decisions? Thirdly, there is the security issue. This relates to the way in which the law protects information vital to national security, strategic national interests and international relations and whether public authorities can withhold information that is vital for assessing sustainable development? And can dissemination of information also enhance security? Not only do all three issues have a significant impact on the way we are dealing with information; in practice, they are substantially interfering (de Villeneuve 2004). Therefore, sharing of information is important but not unlimited.

Integrated assessment

Coming now to the issue of supporting decision making through information, we can state that transboundary river basin management nowadays demands an integrated approach. Such an integrated approach has to account for different stakeholders and different disciplines as well as differences in spatial scale and time scale as the various disciplines and stakeholders work on such dissimilar scales. Integrated assessment, i.e. the evaluation of all facts and values considered relevant for decision-making, therefore not only requires a collaboration among scientists from different disciplines (the interdisciplinary approach, touching upon ecological as well as socio-economic interests), but also a dialogue between scientists and stakeholders about the different meanings attached to knowledge and the interests that may be served by certain scientific interventions (Hisschemöller 2004). Setting up a collaborative framework

among experts with different scientific backgrounds and experiences is often a time consuming procedure. Participants have to get used to and acquainted with each other, overcoming different uses of language, and their often fundamentally different ways of thinking, before their work can actually be put together in a meaningful and coherent way (Turner 2004). This preparatory work is often disregarded as being of minor importance compared with the 'real' work of doing the actual scientific analysis within one's own discipline. An integrated approach conversely entails extensive preparation to ensure that the right problem is addressed in the right way. The need for this preparation cannot be overemphasised.

Cooperation among disciplines is needed in transboundary river basin management as expertise in isolation can limit the capacity to solve problems. Such cooperation has to overcome the mismatches between the disciplines, of which the issue of scale is an important one. Another mismatch that is easily overlooked is the difference in definitions. The same term can have a different, but often closely related meaning in another discipline and that may hinder correct understanding of each other's information.

Sharing international water resources requires that common goals are set. Sustainable use of water is an internationally acknowledged goal in this context, but a further working out of sustainability gives a wide range of outcomes based on various assumptions of socio-economic effects. One of the basic differences in this discussion is the difference between 'weak' and 'strong' sustainability. Weak sustainability means that we can replace or duplicate natural materials and services with manufactured goods and services. Strong sustainability means that natural materials and services cannot be duplicated. In this light it should be emphasised that there is economic support for strong sustainability, aiming at maintenance of the ecosystem integrity, as the basic assumption for river basin management. If strong sustainability is the goal, an integrated approach has to be followed in which the functional diversity of water resources is taken into account. Integration of the functional diversity necessitates participatory processes that include stakeholders and the public. If stakeholders and the public are given the right to participate, this should include the right to full and free access to information in order to certify a balanced dialogue.

A next step in giving access to information will be a response to information needs as expressed by stakeholders and the public. The dialogue resulting from the participatory process can become a social learning process that eventually encourages the production of better information. The dominant technical/scientific bias in many transboundary commissions however, often hinders such involvement of stakeholders and the public (Timmerman and Langaas 2004).

Internationally shared interests facilitate sharing international water resources. Countries that share the same water body, use the water in a similar way and encounter the same problems will be more likely to cooperate as a joint effort is less costly and provides better results. International lakes management may, from this perspective, be more effective than transboundary river management as the water management problems of a lake are shared by all bordering countries while in rivers the downstream problems are often not of direct concern for the upstream country. Although international legislation works to solve this problem, in practice the upstream–downstream inequality hinders cooperation.

Conclusions

Even though scientifically better information may be produced, the use of information will still be limited as long as no account is taken of different valuation of information by people with dissimilar mindframes (beliefs, values, norms, and different cultural habits), asymmetric access to information for all actors, insufficient communication channels, and insufficient coordination between the different levels and scales of governance. Furthermore, cooperation in transboundary water management is hindered by differences in legal frameworks, historical backgrounds, technical abilities, and cultural backgrounds on either side of the border. In this situation, cooperation in information production and dissemination should also account for the differences between the countries. Finally, strong boundaries exist between different disciplines that are not easily overcome. In addition, expertise limits the capacity to solve problems through its bias.

To improve this situation towards an integrated, sustainable water management situation, participation is inevitable. Participation of the relevant actors in defining information requirements to help in decision-making will support creating insight into the existing mindframes and will create better understanding of the situation at hand. Adopting the concept of mindframes is helpful in this respect as the awareness of different mindframes opens up the possibility of exploring them. Next, testing the perception of information after it has been transferred will enable improvement of the production of environmental information.

The goal of strong sustainability entails looking into the wide range of functional diversity of water management. This again calls for a participatory process where the interactive dialogue and decision-making must be actively facilitated to promote social learning. Then, a participatory process cannot be realised without being supported by better information, i.e. information tailored to support this process.

All this will require tuning of organisational structures in such a way that they allow creating an enabling environment. The needed participatory processes will be time consuming as it takes time to define and structure the problems, but they are likely to better cope with the problems and finally be in time. Nevertheless, it is

essential to be aware of the existence of both institutional and individual mindframes to deal with the communicational problems.

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