# BRIDGING THE WATER INFORMATION GAP

## STRUCTURING THE PROCESS OF SPECIFICATION OF INFORMATION NEEDS IN WATER MANAGEMENT

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**Jan Goos Timmerman**

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*Voor mam en pap*

Les rivières ne sont pas à leur aise dans le Midi. Elles souffrent qu'on dirait, elles sont toujours en train de sécher. Collines, soleil, pêcheurs, poissons, bateaux, petits fossés, lavoirs, raisins, saules pleureurs, tout le monde en veut, tout en réclame. De l'eau on leur en demande beaucoup trop, alors il en reste pas beaucoup dans le lit du fleuve.

Louis-Ferdinand Céline, Voyage au bout de la nuit (1932)

# PREFACE

When I entered the National Institute for Integrated Water Management and Waste Water Treatment (RIZA) in 1991 the question how to improve the information production process was an emerging issue in the monitoring and information department. The 'data-rich-but-information-poor' syndrome had to be countered. Gradually this issue entered my day to day activities. The dominant approach towards the 'data-rich-but-information-poor' syndrome was to make the information scientifically more sound and to make the representation of the information more attractive and comprehensive; a natural science approach. My background in information science helped me to focus on the process of defining the information needs in which users and producers work together. In social science, much work is done on so-called 'boundary' issues: the connection between science and policy. Differences in people's mindframes are specifically targeted in this research. The major challenge was to find a merger between the natural science and the social science approach.

Organising a series of 'Monitoring Tailor-Made' conferences as well as work under the UNECE Water Convention on monitoring and assessment enabled me to work on these links. The first result to fight the 'data-rich-but-information-poor' syndrome was the rugby-ball structure that I developed together with Wim-Herbert Mulder. This model was very useful in the process of specifying information needs but did not support the structured analysis of the policy objectives into information needs. I considered such structuring necessary to develop a link between users and producers of information. Some projects emerged that enabled me to further such a structure and to test it. However, with the EU Water Framework Directive coming into force, political attention shifted towards implementing the monitoring requirements of that Directive. These requirements are described in much detail in the Directive and the idea of producing information that meets the needs of decision makers faded.

Despite the decreasing attention, my personal fascination for the issue did not fade and the idea grew to turn my expertise into a PhD thesis. With much of the material already available, the major challenge was to make the work scientifically sound, both from the natural science and the social science perspective. With little time to spend next to my regular job and with little literature on the subject available, this turned out to be a significant challenge.

It is obvious that I would not have been able to develop this work without the support of many different people. I would like to express my gratitude to Wim Cofino and Euro Beinat who have guided me from the very beginning, and to Katrien Termeer who entered later in the process and helped to include the social science perspective into the work. Many thanks to Wim-Herbert Mulder with whom I developed the rugby-ball framework, Bertien Broekhans for commenting on an early version of this thesis, Andrea Houben-Michalkova for commenting on Chapter 2 and for her moral support, during the progress of the work and especially during the ceremony, Theo Robbertsen who collected all the data for the analysis of the MWTL in Chapter 2, Matthijs Hisschemöller and Joop de Boer for their support in developing the integrating decision-model that formed the basis for the structured breakdown, John Schobben for co-leading the process to test the rugby-ball framework as described in Chapter 6, Robert Ward, Rainer Enderlein and Martin Adriaanse for their inputs and the fruitful discussions on the information cycle, Sindre Langaas for his support in linking information to different disciplines, and Hero Prins for giving me time to work on the thesis. I thank my parents for their continuous support and faith, Michiel, Elize and Christine for giving me their love and joy, and Charlotte for always supporting me.

The practical work and some of the theoretical work was done at the former Institute for Inland Water Management and Waste Water Treatment (RIZA) under the Department for Public Works and Water Management (Rijkswaterstaat). Rijkswaterstaat is gratefully acknowledged for providing this opportunity. Some of the theoretical work was performed within the framework of the MANTRA-East project, which was supported by the European Commission under the fifth framework programme (contract No. EVK1-CT-2000-00076). The European Commission is acknowledged for their financial contribution.

Lelystad, October 2011

# CONTENTS


VISTA MAR

# CHAPTER 1

# INFORMATION IN WATER MANAGEMENT

## 1.1 Introduction

Water is an essential natural resource. There is plenty of water on the earth and in the ground, but it is not distributed evenly over the earth's surface and in time. Many people have too little water to grow their crops, while floods frequently threaten lives and harvests. Also, the quality of the available water is often poor and access to safe drinking water is lacking. Natural systems are under severe pressure from competing with human demands while economic and demographic developments as well as climate change put extra pressure on the available resources (Cosgrove and Rijsberman 2000; Hinrichsen 2003; Saeijs and van Berkel 1995; Serageldin 1994; WWAP 2009). The challenge in water management is to deal with these issues.

Effective water resources development and management is not possible without adequate information and benefits from improved information (Boyle and others 2001; Dinar 1998; Gouveia and others 2004; Healy and Asher 1995). Information on relevant characteristics supports and guides decision makers to determine the best ways to proceed and is the basic source to evaluate the effects of specific policies (Allen and others 2001; Haklay 2003). Vast effort is hence put into the collection and dissemination of environmental information, especially by governments and government related institutions (Lovett and others 2007).

Monitoring to collect information for water management started in the 1950s (Meybeck 1998). Over time, water management faced a growing complexity of emerging environmental issues (Meybeck and Helmer 1989) and had to find a balance between ecological, economic and social issues (Lorenz and others 2001; van Kerkhoff 2005). Water monitoring developed from measuring a few simple parameters to a complex process where many different parameters in various frequencies on various locations are measured. Despite the unprecedented amount of information that is currently available to decision makers, they are not satisfied with the information they get, the criticism focusing on scientists not providing the right information and on providing too much information (de Jong and others 1996;

Lindenmayer and Likens 2009; Vaes and others 2009; Wesselink and others 2009). This has led to frustration from the information producer's side because their efforts appear not to be appreciated while the information users feel frustration because they seldom get exactly the information they want to have. The dissatisfaction is acknowledged in literature (Lovett and others 2007; Strobl and Robillard 2008) and is something that I have encountered in my daily work on improving the information production within the Rijkswaterstaat [1] organisation.

The mismatch in water monitoring between information users and producers is a specific part of the policy-science gap (see below) that I call the water information gap. Within the broad context of the use of environmental information, of which water monitoring is only a small part, McNie (McNie 2007) notes that policy makers from around the world are calling for more 'useful' information. She states that scientists who produce too much information that is not considered relevant and useful by decision makers may cause this. Information users on the other hand may not be aware of the existence of potentially useful information. Information is considered useful when it is 1) salient and context-sensitive; responding to the specific information demands, 2) credible; perceived by the users to be accurate, valid and of high quality, and 3) legitimate; the production of information is perceived to be unbiased (Cash and others 2003; McNie 2007).

Analysis of the water information gap in the Netherlands, as described in Chapter 2, showed that vast effort is put into making the information production efficient by optimizing and reducing the networks to avoid producing too much information while the resulting information is used by a variety of users in several ways. The analysis showed that the credibility and legitimacy of the information was seldom challenged. The analysis also showed that due consideration of information needs takes place in designing monitoring networks. However, these information needs are largely based on existing regulatory reporting obligations with little or no involvement of information users. The information is as a result not considered salient.

From the analysis of the water information gap, it is concluded that there is a lack of communication between information user and producers which has grown over time with increasing complexity of water management issues and the resulting organisational divide. To bridge the gap, many scholars call for less quantity of data and more targeted, interdisciplinary, tailor-made information and suggest that a process is needed for determining the water management problem and the information needs related to it prior to producing information. Such a process should be a systematic effort to consider the purpose of data collection ahead of designing and executing a monitoring program, a scientifically sound information needs assessment methodology that involves the actual users of the information (Bernstein and others 1997; Giordano and others 2008; MacDonald 1994; Meybeck and others 1996; Steele 1987; van Dooren 2004). The process includes accounting for multidisciplinary or interdisciplinary information production that supports Integrated Water Resources Management (IWRM) (Gooch and Stålnacke 2006a; Greeuw and others 2000; Hisschemöller and others 2001).

The ultimate aim of the process is to better manage the communication between users and producers of information (McNie 2007) through close interaction (Sarewitz and Pielke 2007). Better communication does not equal more

[1] Rijkswaterstaat is an agency under the Ministry of Infrastructure and Environment that is, a.o., responsible for the water monitoring of the large rivers and lakes as well as the sea in The Netherlands.

communication but implies respectful interactions between policymakers and scientists in which they are willing to learn from and deal with their different interpretations that are rooted in different mindframes (Timmerman and others 2010b; Timmerman and Langaas 2005). Clarifying the differences, defining the water management problem and the information needs related to it, starts by structuring or framing the problem. This involves a concerted effort to focus on the actor's understanding of a problem (Dewulf and others 2005). This study aims at narrowing the water information gap by developing and structuring the process through a methodology that enables assessment of the information needs prior to the information production.

## 1.2 Key concepts

This study is done with specific concepts in mind. These are the notion of what information needs are, what monitoring is, what information users and information producers are, and what information is relative to data and knowledge. Moreover, the study also builds on notions about the policy-science gap. This section describes these concepts.

### 1.2.1 What are information needs?

To be able to assess information needs we need to know what information needs are (Figure 1). According to the UNECE Guidelines on Monitoring and Assessment of Transboundary Rivers an information need is a precise question on the basis of which a monitoring and assessment system can be developed (UNECE TFMA 2000b). The information need has an explicit relation with the use of the information to make the information salient. This is for instance the policy statement from which an information need is derived. Also, reference to an information producing system, which includes a monitoring and assessment system, is appropriate to make the information in the end credible and legitimate. An information need is defined here as follows:

> *An information need is a precise question within a clearly defined context, specified to such an extent that an information producing system can be designed.*

The outcome of the information needs specification process is a set of information needs that decision makers recognise and appreciate as useful, representing their requirements, and from which scientists are able to develop an information producing system. An example of an information need is the question: 'Does the water quality at the intake comply with the standards put down in the Council directive of 15 July 1980 relating to the quality of water intended for human consumption (80/778/EEC)?' The Directive in this example is the context and the question can be further specified through the prescribed determinands, measuring frequencies and standards in the Directive. An information producing system can be designed from these requirements.

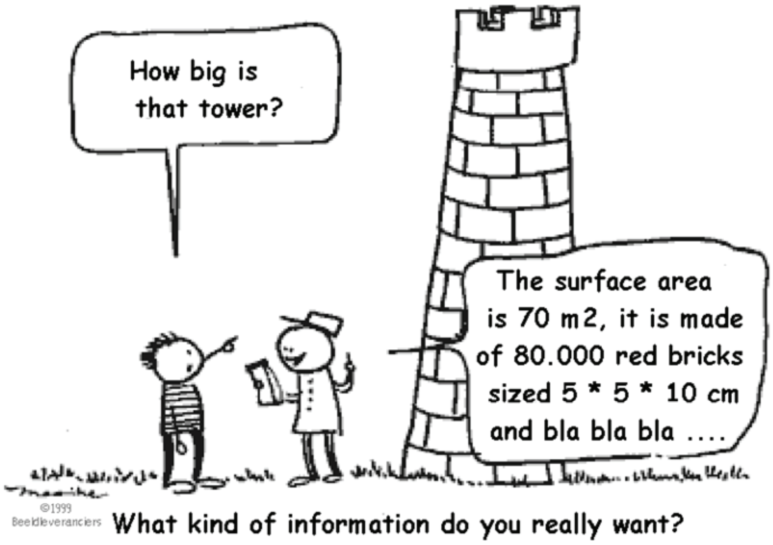


Figure 1.1 Information needs: posing the right question, giving the right answer.

### 1.2.2 What is monitoring?

An important part of the information production is done through monitoring, where monitoring in this thesis refers to collection of information within the framework of water management. Monitoring is defined here as the process of repetitive observing, for defined purposes, of one or more elements of the environment according to pre-arranged schedules in space and time and using comparable methodologies for environmental sensing and data collection. It provides information concerning the present state and past trends in environmental behaviour (UNECE TFMA 2000b). The purposes of monitoring are defined through specifying the information needs. Environmental information is any information on elements of the environment as well as activities or measures, including policies, legislation, plans and programmes (UNECE 1998).

### 1.2.3 What are information users and information producers?

In this thesis, the terms information users and information producers are used as generic terms. There is no strict distinction between the two groups as, over time, everyone is both a user and provider of information (UNCED 1992). Nevertheless, people can be identified that predominantly work on producing information as well as people that mostly use information for their work. Information users are people from a broad spectrum of groups ranging from water managers, decision- and policy-makers to stakeholder-groups like NGO's and the 'public'. In this thesis the central group for whom information is produced is the water management organisation, more precisely the decision-makers in such an organisation. Information producers are the people/departments/organisations that manage the monitoring network and decide how the information is collected, analysed and presented. In this study, the term 'information producers' refers to organisations responsible for monitoring or information collection that report to decision-makers in a water management organisation.

### 1.2.4 The difference between data, information and knowledge

A vast body of literature exists on the definition of information and the differences between data, information and knowledge (Capurro and others 1999; Gudmundsson 2003; Ouwersloot 1994; Scott 2000). The concepts are not static; data can become information and information can become knowledge. In very simple terms, knowledge is described as the sum of experience, understanding and available information. Distinction is made in knowledge management literature between explicit and tacit knowledge. Explicit knowledge is knowledge that is more or less easily captured, codified and communicated. It is transmittable in a formal language and can be stored in databases, libraries, etc. Tacit knowledge on the other hand is linked to personal perspectives, intuition, emotions, beliefs, know-how, experiences and values that are not easily articulated and shared (Nonaka and Takeuchi 1995; Roll 2004a; Romaldi 2002).

Data, at the other end of the scale, is usually considered factual, for instance an output from a device in a numerical form. It is possible to challenge the choice to collect particular data (Vlachos 1994), the devices, and the methods and quality procedures by which data is produced. But once the quality of the data is considered acceptable, it is almost impossible to challenge the data itself.

Information, finally, is often described as something that emerges from an interpretation or processing of data and that is exchanged or communicated. Different processing methods or different interpretations may lead to different information, while the underlying data do not change. In contrast to data, information is therefore to a certain extent subjective and can be challenged. The transfer of water information from scientists to decision makers is in terms of the knowledge creation framework, a process where scientists externalise the knowledge they gain from the collected data and which they exchange and share with the decision makers. The decision makers then combine and internalise this knowledge. The term information will be used in this thesis as the general concept of something (knowledge or data) that adds to the knowledge of the receiver and is the tangible part of knowledge that can make a change.

### 1.2.5 The policy-science gap

Robust scientific knowledge and information is generally considered necessary to enable informed decision-making (Dilling and Lemos 2011; Liu and others 2008). In the decision making process however, choices are a sum of various stakes that interact or even counteract and where societal norms and values are as important as interests (Bemelmans 1989; de Leeuw 1988; Ehin 2003; Hollick 1981; WCMC 1998). This is a general issue that decision makers do not use knowledge and information the way that scientists expect them to, an issue that is called the policy-science gap (Boogerd and others 1997; Bradshaw and Borchers 2000; Milich and Varady 1999; Reyers and others 2010).

Looking specifically at information, the way information is interpreted is largely determined by the actor's worldview; an assembly of cultural background, professional training, character, experience, expertise, professional role, and so on (de Boer 1999; Gooch 2004; Kolkman and others 2007). Difficulties in communicating between information users and producers find their root in these different mindframes (Takahashi and others 2002). People discuss the same world, but each person sees things that others may not see, especially when people from different disciplines are communicating (Dewulf and others 2005). Besides this, every scientist or decision-maker will have blind spots and none can singly encompass the whole extent of a complex system, such as water resource and the environmental-social-economic system that relies on it (Funtowicz and others 1999; Newson 2000; Rivett 1994).

Different people perceive information in different ways (Braman 1989; Rowley 1998), assign distinct roles to information and use it in diverse manners (Roll and Timmerman 2006). Decision-makers as information users in general are inclined to consider information as either beneficial or dangerous and use the information they receive in accordance to their estimate. Scientists, often information producers, in general would consider information as something that can bring new insights and will value information as a support in confirming or rejecting their hypotheses. Diverse perceptions are linked to different characteristics of the monitoring process and the decision making process as shown in Table 1.1. Information producers as a consequence have limited insight in the work and needs of information users and vice versa. As both groups have a task to fulfil, this unawareness leads to reluctance when it comes to investing efforts in communicating about mutual needs and interests, a process that can be time-consuming and troublesome.

Table 1.1 Characteristics of monitoring and decision making (after Bradshaw and Borchers 2000; Hoppe 2005)

| **Monitoring** | **Decision making** |
|---|---|
| Problem complexity reduced along disciplinary boundaries | Dealing with complex real problems |
| Time needed for quality control | Quick results |
| Probability accepted | Certainty desired |
| Problem oriented | Service oriented |
| Discovery oriented | Mission oriented |
| Replication essential for belief | Beliefs are situational |
| Clientele diffuse, diverse, or not present | Clientele specific, immediate, and insistent |

## 1.3 Goal of the study

The goal of this study is to bridge the water information gap by improving the salience of water information. Improving the communication between users and producers of information, focusing on the process of specification of information needs, is considered the best means to achieve this. Such a framing process entails not only the design of a structure to manage the process but also a structure to organise the problem at hand (Bardwell 1991). To be able to develop and test such an improved process, the following research questions were defined:

1. What is the exact nature of the water information gap?
2. How does the process of information production link to the water management process?

3. How can specification of information needs be structured; how can the process be structured and the problem situation be organised?
4. Can the water information gap be narrowed by structuring the specification of information needs?
   - Does managing the process narrow the gap?
   - Does organising the problem narrow the gap?

Answering the first question is needed to be sure that the right problem is targeted. Roughly, this research should answer the question if the perception of the information not being useful is attributed to the credibility, the salience, the legitimacy, or a combination of the three. The water information gap exists between the process of water management and the information production process and therefore the relationship needs further investigation. The focus of the second research question will be on if and how assessing the information needs is able to connect between the two processes. After the nature of the gap and the relationship between the processes becomes known, the third research question focuses on how the process of information needs specification can be structured; what aspects that cause the gap need to be targeted and are these related to the managing of the process or organising of the problem? This finally leads to the fourth research question; does structuring of the process narrow the gap and is this related to managing the process, organising the problem or to both? With the answer to this question, we can determine if we are able to reach the goal of this study, namely to bridge or at least narrow the water information gap.

## 1.4 Approach of the study

To study the nature of the water information gap, a literature analysis was carried out to determine the developments and changes in the Dutch national water quality monitoring network as well as to investigate how information users were involved in the development of the network. Also, studies into what information from the network was used and how this related to the existing policies were used. Next to that, an analysis of the metadata from the DONAR database, the database that stores all the data from the national water quality monitoring network, was made to determine the number of measurements for the various parameters over the years. With this information, the actual network could be compared with the network planning. Studying the link between the information production process and the water management process was done on the basis of literature combined with practical experience.

Structuring the process of specification of information needs was based on what Schön calls Reflection-in-Action (Schön 1991); by interaction between ideas and practice, experiences develop that help to improve both. First, different concepts and approaches from literature were analysed to derive approaches for structuring policy problems that entailed both elements to structure the process and elements to organise the problem. A range of theories from strategic planning, information management, policy- and decision analysis, and indicators was analysed to this end. A selection was made from the various approaches to form a coherent methodology. They were aimed at detecting the nature and impact of the water information gap.

The methodology presented in this thesis was refined on the basis of the experiences from the case studies described in this thesis. The case studies as real life situations revealed the usability and usefulness of the methodology relative to the common practice in monitoring.

My role in the case studies can be described as participant observer, which is generally practiced as a form of case study that concentrates on in-depth description and analysis of a phenomenon (Jorgensen 1989). Next to participating in the case studies, I also had a role in steering the process. The case studies in this thesis are considered quasi-experiments in which no control groups are included (Dehue 2001; Roos 1975). The observations from the case studies were complemented through individual and group interviews with evaluations of both the process and the contents (Jorgensen 1989). These evaluations provide a source of evidence to determine and qualify any improvement that can be attributed to the methodology relative to a situation where information needs are specified without the use of the methodology.

## 1.5 Design criteria for the process to bridge the gap

The hypothesis as described above is that structuring the process of specifying information needs will narrow the water information gap. From the analysis of the water information gap, design criteria for the process have been developed. The process is expected to be able to narrow the gap if these design criteria are met. The actual bridging of the gap is achieved if the information user is satisfied with the result. The design criteria are described in this section.

A participatory character is crucial for the process of specifying information needs, which implies that multiple actors with different stakes and from different management levels are involved in an interactive and collaborative way to ensure an exchange of mindframes. This includes transparency of the process for a more effective communication that allows the actors to become aware of their own role as well as the roles of other actors. Also, transparency of the process, the people involved, and the translation of policy statements into information needs makes the information production process accountable. The process responds to the dynamic nature of policy problems by making the translation from policy statements into information needs, linking to the different phases of the policy life-cycle where different information is needed in each phase. The process structure needs designed in a way that appeals to people with different approaches towards problem solving; 'design' and 'development' people, where different actors may be active in different phases of the policy life-cycle. Making the process interdisciplinary enables dealing with different types of information like social, economic, and ecological information. The process is finally structured in a way to allow and promote anticipation to identify long-term developments and to enable recognition of change, progress in, and futures of the policy problem (Timmerman and others 2010a). The following set of criteria that determine if the gap is narrowed is derived from the above:

Focusing on managing the process:

1. Involve multiple actors with different stakes and from different management levels;
2. Support interaction and collaboration to ensure the exchange of values that enables a common understanding, especially between information producers and information users;
3. Enable actors to become aware of their own role as well as of the roles of the other actors;
4. Create transparency about the process, the people that were involved and the translation of the policy into information needs;
5. Support non-linear and flexible approaches that account for differences in mindframes;

Focusing on organising the problem:

1. Respond to the policy problem environment thereby linking to policy objectives;
2. Enable translation from policy statements into information needs;
3. Enable analysis of the policy problem from multiple perspectives at least supporting balancing between uses, problems and measures, thus clarifying the policy statements;
4. Deal with connecting different types of information like social, economic, and ecological information, information about the implementation of measures, and information about the degree to which the policy objectives are reached to enable recognition of change;
5. Include progress in, and futures of the policy problem;

## 1.6 Design of the study

The structure of this thesis is represented in Figure 1.2. The study started off from the recognition of the existence of the water information gap. To study the nature of the water information gap, a literature analysis was carried out to determine the developments and changes in the Dutch national water quality monitoring network from the 1950s onwards. The study also entailed an investigation into how information users were involved in the development of the network. Studies into what information from the network was used and how this related to the existing policies were used. Next to that, an analysis of the metadata from the database that stores all the data from the Dutch national water quality monitoring network was made to determine the number of measurements for the various parameters over the years. With this information, the actual network could be compared with the network planning. Combined with findings from wider literature, Chapter 2 describes and articulates the water information gap.

Chapter 3 describes a literature analysis to study the links between the water management process and the information production process. Policy analysis literature and monitoring literature were studied and compared and together with results from conferences and practical experience in water information management, the information cycle was developed. The information cycle depicts the respective steps in the development, implementation and evaluation of monitoring networks.

Chapter 4 describes the Reflection-in-Action process that was used to structure the process of specification of information needs; it describes how the case studies influenced the structuring of the process and describes the methodology that was the result of this process. Chapter 5 describes the case of specifying information needs for Dutch national policy evaluation, where the focus was on managing the process. Chapter 6 describes the case study of the development of a monitoring system for the monitoring of gradients in the Dutch coastal zone. Here, a conceptual model was used to organise the problem. Chapter 7 describes three pilot projects in which transboundary monitoring networks were developed. In these pilot projects, a more detailed conceptual framework was used to structure the breakdown of policy objectives into information needs. The conclusions that can be drawn from the work as described in this thesis are detailed in Chapter 8.

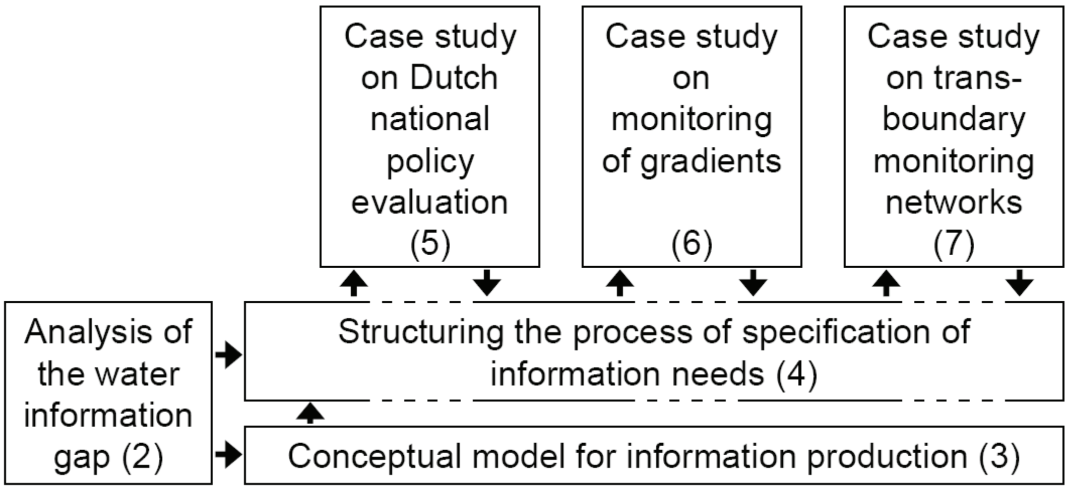


Figure 1.2 Schematic representation of the structure of the thesis (in brackets are the numbers of the respective chapters).

# CHAPTER 2

# ANALYZING THE DATA-RICH-BUT-INFORMATION-POOR SYNDROME IN DUTCH WATER MANAGEMENT IN HISTORICAL PERSPECTIVE

## *Abstract*

*Water quality monitoring has developed over the past century from an unplanned, isolated activity into an important discipline in water management. This development also brought about a discontent between information users and information producers about the usefulness and usability of information, in literature often referred to as the data-rich-but-information-poor syndrome. This article aims to gain a better understanding of this issue by studying the developments over some five decades of Dutch national water quality monitoring, by analyzing four studies in which the role and use of information are discussed from different perspectives, and by relating this to what is considered in literature as useful information. The article concludes that a ''water information gap'' exists which is rooted in different mutual perceptions and expectations between the two groups on what useful information is, that can be overcome by improving the communication. Such communication should be based on willingness to understand and deal with different mindframes and should be based on a methodology that guides and structures the interactions.*

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## 2.1 Introduction

Over time, a steady increase in the need for information in support of water management can be discerned. In this article, water quality management will be taken as example. Water quality management was virtually non-existent up to approximately 1850, by which time locally poor environmental conditions with bad smelling, deoxygenated water were encountered as a result of industrialization (Perry and Vanderklein 1996). Regular water quality monitoring was however not established before the 1950s in the USA, the former USSR and in a few European countries and extended to Canada and most of Western Europe in the late 1960s and 1970s (Meybeck 1998). After their inception, water quality monitoring programs have evolved substantially owing to the identification of new environmental issues, illustrated by Meybeck and Helmer (1989) who give an overview of some of the major pollution problems arising over the years in industrialized countries, and the subsequent need to develop policies and keep track of the effectiveness thereof.

Nowadays each year a large amount of information is collected by water management organizations to support the evaluation and development of water management and water policy. At the same time, a discontent between information users and information producers about the usefulness of information grew. Ward and others (1986) called this the 'data-rich-but-information-poor' syndrome; a situation in which data is collected without a clear view of what information is to be produced out of it. They state that this follows from a situation where information expectations are insufficiently evaluated while on the other hand the expectations of information users may be higher that the monitoring system is capable of providing. Also, data are collected that are not used to produce useful information.

To tackle the data-rich-but-information-poor syndrome, much of the literature in monitoring network design emphasizes a process of determining about the water management problem and the information needs related to it as the first step in the design (Boyle and others 2001; Giordano and others 2008; MacDonald 1994; Meybeck and others 1996; Timmerman and Langaas 2005). Other scholars emphasise the need to aggregate and present the information in an easy to understand form (de Jong and others 1996; Denisov and others 2004; Laane and Ten Brink 1990; McBride and Smith 1997). Besides this, some scholars emphasise the need for multidisciplinary or interdisciplinary information production that supports Integrated Water Resources Management (IWRM) to improve the situation (Giordano and others 2008; Gooch and Stålnacke 2006b; Hisschemöller 2004).

Within the broad context of the use of environmental information of which water quality monitoring is only a small part, McNie (2007) notes that despite these approaches, policy makers from around the world are still calling for more 'useful' information. She states that this may be caused by scientists who produce too much information that is not considered relevant and useful by decision makers. Users on the other hand may have specific information needs that go unmet, or may not be aware of the existence of potentially useful information. In this context, information is considered useful when it is (1) salient and context-sensitive; responding to the specific information demands, (2) credible; perceived by the users to be accurate, valid and of high quality, and (3) legitimate; the production of information is perceived to be unbiased (Cash and others 2003; McNie 2007).

This article makes a retrospective analysis of a Dutch water quality programme with the objective to analyze the nature of the gap between users and producers of information. For this purpose, the article will analyze if data is produced with sufficient consideration of the needs of the information users, if the data that is collected is used to produce information, and if the information that is produced is considered useful (i.e., salient, credible and legitimate). Also, the article will investigate if the users have realistic expectations of information producing systems and are sufficiently aware of the existence of potentially useful information. The analysis will focus on a specific, rather straightforward situation, namely the Dutch National Water Monitoring Program (MWTL) where information supply and demand are both situated within one Ministry. The developments in the monitoring network and the involved organizations will be put in a historical context to identify the circumstances and conditions that have shaped the current situation. After a brief introduction to Dutch water policy, the developments over some five decades of Dutch national water quality monitoring are studied. Three studies on the use of monitoring information related to the Dutch national water monitoring program as well as one Dutch case study into the relationship between policy and monitoring are presented. These investigations enable us to address the abovementioned issues regarding the ''water information gap'' from the point of view of the scientists as designers of the programs and from the perceptions of decision makers as the users of information. The analysis shows that the water information gap is rooted in different views from science and policy on what useful and relevant information is, and that better communication is needed between science and policy to bridge the gap.

## 2.2 Dutch water policy

The Netherlands has a long history of water management. The first dikes and dams were built in this country more than 2000 years ago. Many dikes and other water works followed such as the dams in the rivers Amstel and Rotte, where settlements were located that are currently known as the two largest towns of the Netherlands, Amsterdam and Rotterdam, respectively. Land-reclamation and construction of polders have led to a situation where large parts of the country are below mean sea level, with the lowest point at -6.7 m. These developments, together with a dense population and fast growth of economic interests, make good water management imperative. Moreover, the Netherlands are the downstream country of four international river basins, of which the rivers Rhine and Meuse are the most important. The Netherlands for instance draws around 65% of its freshwater supply from the Rhine River (Lindemann 2006). The quality of the Rhine River is therefore highly significant as is coordination with the upstream countries to secure the quality of the river water.

Water management of surface waters in the Netherlands is divided between Rijkswaterstaat (RWS), a part of the Dutch Ministry of Transport, Public Works and Water Management (V&W) and regional Water Boards. RWS holds responsibility for the large rivers, lakes and coastal waters, the so-called national waters. The Water Boards are responsible for management of the smaller waters within their respective region. Water management policy development is the responsibility of the Ministry of V&W. This article focuses on the national waters and will not discuss regional water management.

Fast developments in urbanization and industry after the Second World War in Western-Europe have led to deterioration of the quality of surface waters, which was especially apparent in the river Rhine. Here the load of inorganic and organic waste from the countries riparian to the river Rhine increased significantly in the 1950s and 1960s (RIZA 1965). The pollution situation of the river Rhine was at its worst in 1971 when the water lacked oxygen in the downstream sections and aquatic life was disappearing. This bad situation urged the riparian countries to take action leading to an improved water quality situation after 1971 (Huisman 1996).

Policy development was needed to face the challenges posed by this pollution. The first Dutch National Policy Document on Water Management that was published in 1968 addressed few water quality issues. The Pollution of Surface Water Act (Anonymous 1970) provided planning instruments for a water quality program. The major problem at that time was the emission of organic material; wastewater treatment plants were built to deal with this. Once major reductions in discharges of organic material had been achieved, the focus switched to heavy metals and organic micropollutants from industry. In the mean time, between 1975 and 1978, the European Union laid out legislation on surface waters describing lists of parameters to be monitored (Timmerman and others 2004). This is reflected in the second National Policy Document on Water Management (Anonymous 1984) which had an increased focus on water quality issues. The third National Policy Document on Water Management (Anonymous 1990) had a strong focus on water quality and contained a list of water quality standards and included attention for emissions from various sources: e.g. agriculture (phosphates, nitrates and pesticides), households (metals from gutters and water-pipes) and shipping (tar, oil and micropollutants). In the mid 1990s, the overall water quality situation had improved significantly as a result of an interaction between successful targeted policies and measures both nationally and international, and the related monitoring and research.

As a result of this improved situation, political attention towards water quality decreased. This is reflected in the fourth National Policy Document on Water Management (Anonymous 1998b) that maintains the existing water quality policy but changes the focus towards socio-economic issues. Next to that, the EU Water Framework Directive (WFD) (European Commission 2000), that entered into force in 2000, has led to substantial changes in Dutch water management, in particular by shifting the emphasis from the physicochemical composition of water-bodies to ecological characteristics and by putting public participation more at the forefront.

## 2.3 Developments in water quality monitoring

The Dutch National Monitoring Program (MWTL) is the program for the upkeep of a baseline set of information called ‘basic information’, encompassing hydromorphological, chemical and ecological characteristics of the so-called national waters. Collection of this ‘basic information’ is a task of Rijkswaterstaat (RWS). Two advisory and research institutes within RWS were, next to other tasks, responsible for managing the MWTL. The Institute for Waste Water Treatment (later Institute for Inland Water Management and Waste Water Treatment) (RIZA) was responsible for the freshwater part of the MWTL, the Institute for Marine and Coastal Research (RIKZ) for the salt and brackish parts. This article describes the developments in the

MWTL network over the period from 1952 up to 2005 for the freshwater quality data.

The flow of the rivers Rhine and Meuse is not unidirectional to the sea. After entering the Netherlands at Lobith, the Rhine River splits up into several branches to the north and the west. The southernmost branch is again connected to the River Meuse. Furthermore, tidal movement influences freshwater flows upstream and flows are consequently complex. Water quality monitoring of these rivers is therefore not straightforward but requires a rather dense network of monitoring locations to be able to keep a good overview.

All water quality- and quantity-monitoring data collected by RWS are stored in the so-called DONAR database. The data presented in this section are selected from this database, including all inland chemical water quality data available from MWTL labelled as RIZAMON_LAN (the label for the national water-quality monitoring network) as the owner of the data. Literature (mainly in Dutch language) like RIZA year reports and monitoring optimization studies were used to further specify and explain the developments in locations, parameters and frequencies.

The growing importance and growing complexity of water management over the years (Rittel and Webber 1973) becomes visible in the increasing number of staff at RIZA. RIZA was founded in 1920 and started off with a staff of 5 people. By the year 2000, there were some 450 people employed by RIZA (Bosch and van der Ham 1998). This increase in number enabled employees to become more specialized. Meanwhile, an organizational divide grew as the monitoring people were organizationally separated from the policy people within RIZA through the creation of different departments. The physical distance to the policy people within the Ministry was extended when RIZA was moved to another town in 1975. Specialization together with physical and organizational separation reduced thus interactions between monitoring and policy.

## 2.4 Evaluation and optimization of the monitoring network

The network design, that is the exact monitoring locations, choice of parameters, and sampling frequencies, is determined each year and put down in a monitoring schedule. Such schedules are based on the preceding years and usually include only minor changes, which can over time constitute substantial alterations compared to the original plan. Therefore, evaluation of the MWTL network has been carried out regularly to determine whether the actual information needs were still met and whether the network was designed and operated in an efficient manner.

Optimization and evaluation studies to improve the MWTL network were carried out in 1965 (RIZA 1966), between 1978 and 1981 (Schilperoort and others 1982), 1984 (Cappon 1984), 1991–1992 (Adriaanse 1992; Breukel and Schäfer 1991), and 1996 (Hesen and others 1998). All studies comprised a statistical optimization of the network to judge the efficiency of the network in terms of statistical correlations of results between locations and the quality of the information, leading to changes in frequencies and number of locations. Also, the lists of parameters were evaluated and adapted on the basis of new legislation.

From the optimization studies it becomes clear that the changes in the monitoring network are initiated and decided upon by the information producers.

Decision-makers as information users were informed about the changes. In-between the optimization studies, sometimes, new analytical methods or changes in legislation led to changes in the network. Such changes are however sparsely documented.

Quality assurance and quality control programs targeting various parts of the monitoring cycle like sampling methods, chemical analysis methods and data assessment protocols have also been carried out to improve the credibility of the information. These lie outside the scope of this article.

## 2.5 Monitoring locations in the network

Figure 2.1 provides an overview of the monitoring locations in the network in the years 1952, 1961, 1972, 1978, 1990, and 1996. The river Rhine is under regular study on 4 locations in the Dutch part from 1952 onwards within the framework of the International Rhine Commission (IRC, in the late nineteen-nineties the commission was renamed into the ICPR, the International Commission for the Protection of the Rhine) (RIZA 1954). Between 1959 and 1961, the Dutch estuary (Nieuwe Maas - Nieuwe Waterweg) was added as well as locations along the river Meuse and in the Delta of both rivers. These additional locations were primarily selected to study the influence on the water quality of tributaries of the river Meuse (in the south-east part of The Netherlands) and the influence of industry around the harbor of Rotterdam (western part). In 1965, several existing regular studies were integrated into one routine monitoring program covering the whole network of the Dutch large rivers. The choice of the exact location was done largely on a logistical basis; the possibilities for transportation of samples like vicinity of a road or bridge and vicinity of suitable laboratory facilities were important qualifiers for the suitability of locations (RIZA 1972). It should be mentioned that most locations are merely sites where samples are taken and adding or deleting locations change the operational costs but do not include investments.

The number of monitoring locations increased to 61 in 1971. In this year, the expression ''rijkswateren'' (national waters) is used instead of ''grote rivieren'' (large rivers) in the yearly report, indicating that the water quality studies of other national waters besides the large rivers has become urgent and consequently these other waters are included into the national inland monitoring network (RIZA 1973). In 1972, locations in the central lake area (Lake IJssel, Markermeer and the lakes bordering the Flevopolders) and the other national waters are included (RIZA 1975) and reaches a maximum of 224 locations in 1978 (RIZA 1979). On the basis of an optimization study, the monitoring network was reduced to 149 locations in 1982. The effects of the 1992 optimization study are remarkable; statistical analysis of the data showed that almost the same information could be derived from concentrating monitoring efforts on few locations because data from several locations showed high statistical correlations.

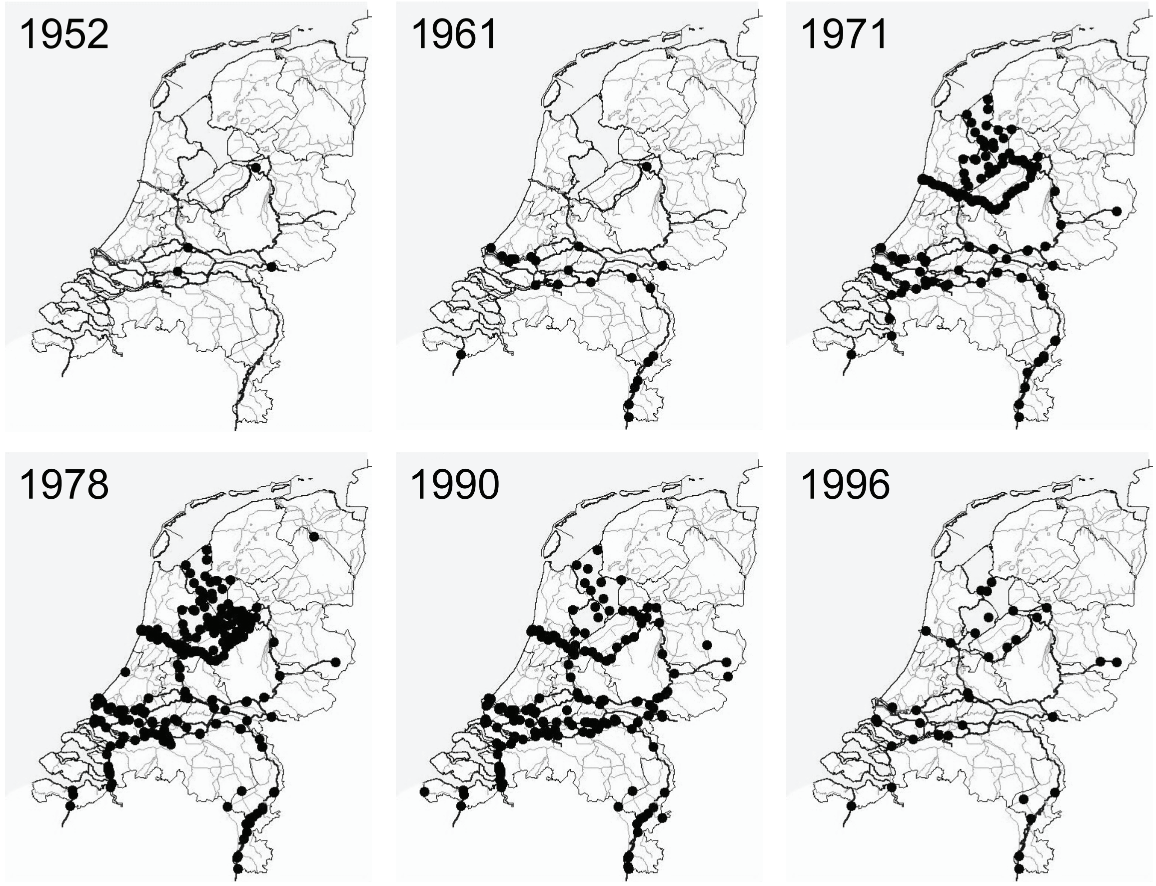


Figure 2.1 Changes in monitoring locations in the network

## 2.6 Choice of parameters

The growing information need from newly arising water quality problems that come to the fore as reflected in the expanding regulations and policy documents is illustrated in the number of parameters included in the MWTL network. The number of individual and composed parameters has shown a tremendous increase over time, starting from 13 parameters in 1952 to over 285 in 1997. In Figure 2.2 the number of different parameters included in the monitoring network is displayed, divided into several groups. Individual parameters within these groups are singular parameters like pH and cyanide, or BOD (Biological oxygen Demand) and DOC (Dissolved Organic Carbon), but also composite parameters such as the sum of 1,3 xylene and 1,4 xylene, or sum of several PAH's (Polycyclic Aromatic Hydrocarbon).

Until 1956, water quality analyses were carried out using general parameters like temperature, suspended solids, oxygen balance, and chloride. Between 1957 and 1971, the number of parameters slowly increased, starting with parameters to measure eutrophication and radioactivity, and later on, metals and organic pollution. Consecutive national Acts and European Directives led to the inclusion of additional groups of parameters like pesticides in 1972 (Pollution of Surface Waters Act 1970) and organic micropollutants in 1976 (Aquatic Environment Directive 1976). The third National Policy Document on Water Management (1990) and the Dutch Environmental Management Act (1993) led to an increase in, mostly, pesticides and (other) organic micropollutants. After 1999, in line with the WFD list of priority substances, additional organic micropollutants and pesticides are added to the network. Figure 2.2 in this way obviously links to the notion of Meybeck and Helmer (1989) that newly arising issues lead to new monitoring efforts.

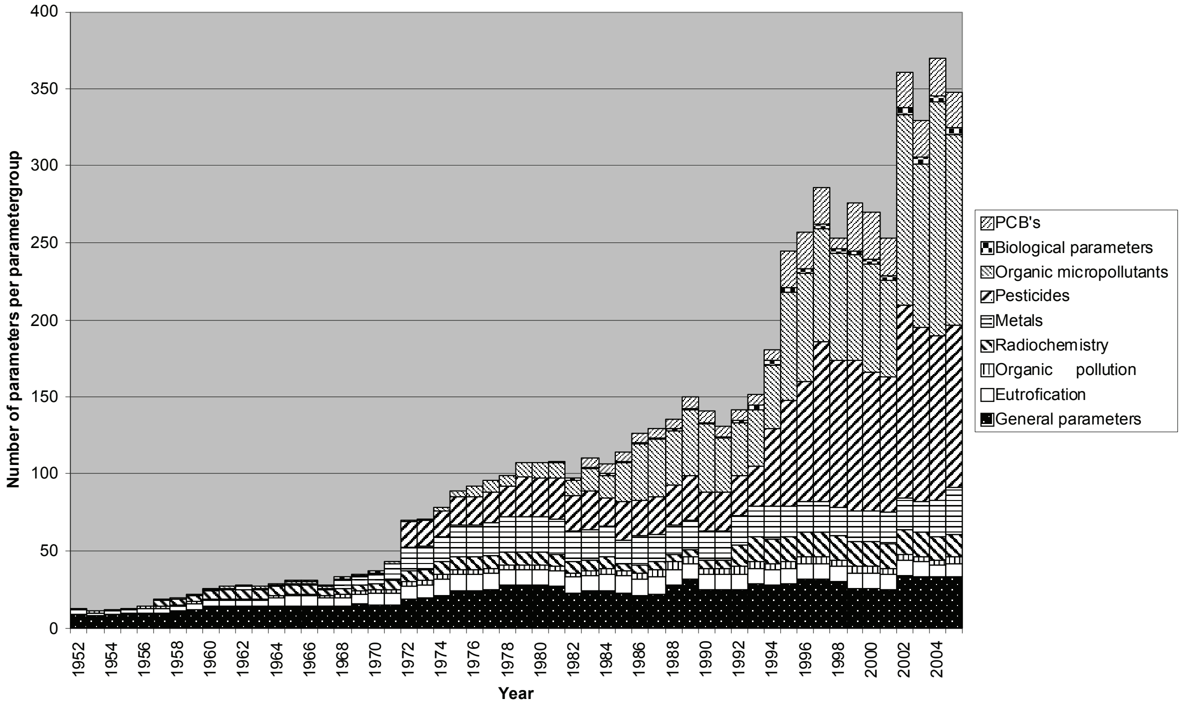


Figure 2.2 Number of parameters per parameter-group included each year in the national monitoring network (arrows indicate the years that evaluation studies were performed) (Timmerman and others 2004)

The various optimization studies had effects on the number of parameters. Reconsideration of the parameters led to the conclusion that some parameters did not provide the information that was anticipated or were no longer required as a legal obligation. In 1967, 1982 and 1998, after the evaluations, a reduction in number of parameters is effectuated. After the 1985 optimization study however, there is an increase in the number of different organic micropollutants and after 1993, next to other organic micropollutants, several new pesticides were added as described above. Sometimes parameters are added because new analysis techniques enabled the measurement of a wide spectrum of contaminants in addition to the target compounds at little additional costs.

## 2.7 Discussion of trends in Dutch monitoring

Developments in the Dutch national monitoring network can be described from the above as a period of growing awareness and try-outs, followed by a more critical view on the work. As can be derived from Figures 2.1 and 2.2, roughly every decade there are substantial changes in number of monitoring locations and/or number and types of parameters included in the monitoring network that can be described as a phase in the development in the thinking about monitoring.

From the start of the monitoring network in 1952 until 1959, monitoring was performed to meet the objectives of the IRC. The network was largely driven by the international effort to improve the water quality situation, especially with regard to drinking water production.

As the monitoring network provides useful information, the monitoring network is slowly expanding from 1960 until 1971 to cover the large rivers. Few parameters are added.

From 1972 until 1981, the monitoring network is expanded to cover all the national inland waters of the Netherlands. The number of parameters rapidly increased to cover most of the pollutants present and known at that time. More knowledge about the importance and possibilities of monitoring is building up.

The monitoring network only slightly changes between 1982 and 1992. Ample attention is given to the goals of the network, and the frequencies and numbers of locations are optimized to meet the goals. Along with analytical possibilities, the number of parameters is slowly increasing.

From 1993 onwards, the goal of the monitoring network is restricted to the national status of the water quality. The monitoring network is reduced to what are considered the minimum requirements. Automated analytical instruments provide the opportunity to include many parameters relevant for policy and management, without adding (much) extra cost.

After 2000, the WFD influences the monitoring network. The definite network was not operational in 2005, but some of the parameters from this EU Directive were already included at that time.

From the overview of optimization and evaluation studies it becomes clear that the specification of information needs was done in a combination of regulatory/standard-driven and technical/scientific way. The choice of parameters was based on policy documents and regulations (legislation as well as (international) agreements). The number of monitoring locations is statistically optimized after a period of expansion and operation. The period of increase in the network can be labelled as a learning period. The optimization study of 1981 is a turning point; the availability of data for that study made it possible to (statistically) reduce the number of locations and frequencies enabling extension in terms of parameters without raising costs.

A study of the national and international legislation as well as international agreements was done to determine how many of the parameters included in MWTL were related to this legislation (Timmerman and others 2004). For each of the 364 parameters that had been measured in the period between 1952 and 2001 it was verified if there is a piece of legislation or international agreement for which the parameter was included. The study concluded that only some 10% of the selection of parameters is not directly attributed to a specific law or agreement. This 10% can be explained in terms of analysis methods that provide data on additional parameters that are presumably policy relevant and that are included at virtually no cost or parameters that are needed for data interpretation, for instance organic carbon in sediments. Few parameters that are included in legislation are not or no longer included in the monitoring network.

From the above it can be concluded that the information producers have put ample effort into producing useful information. Together with various quality assurance programs, the regular evaluation studies have promoted the credibility of the information; accurate, valid, and of high quality. Next to that, the information was legitimate in the sense that it was produced in a transparent way a.o. by describing the reasons for the information production and through yearly reports describing the network design as well as the results from the data collection. Both legitimacy and credibility are not challenged by information users.

The salience of the information is however not clear. On the one hand there is due consideration of information needs by the information producers. The information providers consider policies and regulations to infer the information demands of the information users. Decision-makers were however not involved in the design and evaluations of the network and it is consequently not clear if they consider the information salient. The following section will look into the degree to which the data and reports are used, which may provide answers about the salience of the information.

## 2.8 Studies into the use of monitoring results

Four studies will be discussed here that have looked at the role and use of information from different perspectives and show different aspects of the water information gap. The study by Sam and Smit (1996) started from the hypothesis that there is a gap between information needs as described in policy documents and information produced by monitoring. The study tries to quantify this gap in a specific region. The study by van Kerkhoff and van Riel (1996) took the information user's satisfaction as a starting point and tried to specify the reasons why information users are not satisfied. The study by RIKZ (RIKZ 2000) was done from a monitoring perspective and looked at the use of monitoring data in reporting. The study by Stevers (2003) finally examined the perceptions of the different actors to define appropriate action to improve the monitoring.

### 2.8.1 Policy and monitoring in the Wadden Sea

Sam and Smit (1996) conducted a desk-study to determine if monitoring in the Dutch Wadden Sea satisfied the information needs of the policy makers for that area. Their hypothesis was that there is a discrepancy between the policy information needs, the possibilities of monitoring, the design of the monitoring networks, and the actual realization.

The study comprised an inventory of policy- and management plans for the Wadden Sea and the policy statements included in these plans. The plans included in the study were national policy- and management reports as produced by the Dutch Ministry of Defence, the Ministry of Spatial Planning and Environment, the Ministry of Transport, Public Works and Water Management, and the Ministry of Agriculture, Nature and Fisheries. In total, 27 reports were selected. From these reports an inventory was made of policy statements that were relevant for monitoring. 135 policy statements were identified in total. These policy statements were divided into three categories, namely clear statements like 'no more than' and 'constant', vague statements like 'sufficient' and 'possibly', and unclear statements like 'pursue' and 'in principle'. Next, the monitoring networks in the Wadden Sea, the Dutch MWTL program, the Trilateral Monitoring and Assessment Program agreed between Denmark, Germany and The Netherlands, and the OSPAR Joint Monitoring Program, were studied and the parameters measured were listed. Then, a comparison was made between policy statements that could be related to parameters and the actually measured parameters. The MWTL network is predominantly based on legislation as described above. The two other networks are the result of international agreements. The monitoring networks can therefore be considered to be entirely based on regulations.

Sam and Smit concluded that 35% of the policy statements are unclear and can consequently not be evaluated through monitoring in a meaningful way. No parameters are measured for 36% of the policy statements in the categories clear and vague that can be evaluated and for which monitoring is possible. That leaves 29% of the policy statements that are supported by information (also see Figure 2.3). If the statements labelled as unclear are excluded from the total number of policy statements, the percentage of policy statements supported by information rises to approximately 46%.

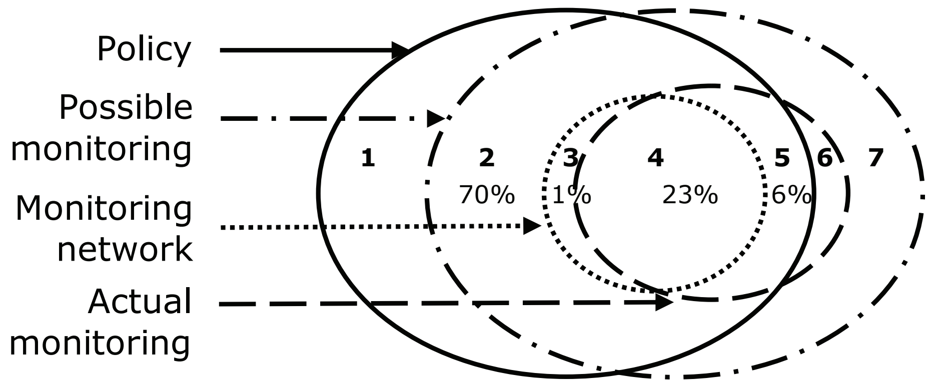


Figure 2.3 The differences between the policy information needs, the possible monitoring, the design of the monitoring networks, and the actual monitoring. (1) Policy for which no monitoring is possible, (2) policy for which monitoring is possible, (3) policy supported by a monitoring program, (4) monitoring executed based on a monitoring program, (5) monitoring executed that was not originally designed in the monitoring program but that is usable for policy, (6) monitoring executed that cannot (yet) be used for policy because the information does not fit into the existing policy, and (7) all other possible monitoring (redrafted from Sam and Smit 1996)

The assumptions in the study of Sam and Smit are that information needs of decision-makers are put down in policy statements and that all policy statements should be evaluated through monitoring. This is the similar regulatory/ standard-driven approach that is followed in the design of the national monitoring network. They consider information to be useful if it can be linked to policy documents and (inter)national agreements. Although these assumptions are debatable, Sam and Smit make a point that apparently of all policies that can potentially be monitored only one third is actually monitored. As decision-makers were not involved in the study it is not clear if they would also consider the information useful. Nevertheless, from this study it is concluded that decision-makers can be right to say that they do not get all the information they need.

### 2.8.2 Customer satisfaction of monitoring products

Van Kerkhoff and van Riel (1996) performed a study on the satisfaction of users of monitoring products, termed 'customers' in the study. They focused on the appreciation of products and services (do they satisfy the user?) of three specialist departments of RWS, thus aiming to determine about the usefulness of the information coming from the MWTL network. The products and services included yearly data-overviews, water quality reports, compliance reports, reporting of data to national and international organizations, daily reports about water levels and navigation, and various thematic reports. Issues that were discussed in determining the appreciation of the customers were related to aspects like quality, timeliness, frequency, presentation, reliability, and flexibility of the products and services of the departments.

The study focused largely on customers within RWS. The study comprised 300 questionnaires, 35% of which were returned. The response group was heterogeneous, ranging from decision makers to researchers in specialist departments. The answers to the questionnaires were clarified in more detail through 25 interviews with a similar mixture of interviewees, both group-wise and with individuals. From the study it was concluded that the customers were positive about the expertise and knowledge of the specialist departments, thus acknowledging the credibility of the information. Next to that, the legitimacy of the information was not questioned. They were, however, not satisfied with the products. The main criticisms derived from the study, in aggregated form (qualitative, the report does not give any quantification), were:

1. The information is too much aggregated.
2. The amount of information is too much and too general.
3. The information is not presented aiming at a region or target group.
4. Trends and well-founded predictions are missing.
5. Delivery of information is slow.
6. The underlying (analytical) data are not accessible.
7. Employees are hard to contact.
8. Agreements are not met.
9. Communication with the customer before, during and after activities is insufficient.

Information products were accepted because they contained enough information for the customers, although they sometimes had to further process the data, or because there are no alternatives to get the information. The first four bullets indicate that the information is not salient, not tailor- made to the needs of the information user or context specific enough. The last five bullets are not so much related to the content of the information as produced, but indicate insufficient customer orientation of the information producers in the process of bringing the information to the users.

The assumption of van Kerkhoff and van Riel in this study is that if the information user is satisfied, the information brought to him/her is the right information. From this study it can be concluded that the data that is collected is used to produce a range of information products but that the information in these products is often not considered salient although users are able to produce their own (salient) information from the data and information provided. The monitoring network does not target individual users and if different information users use different parts of the information presented they may all feel that there is too much information, but it may well be that overall all of the information is used. The institutional embedding of the monitoring organization implies that the network does not target one specific user.

### 2.8.3 Use of monitoring data in policy documents

RIKZ (Institute for Marine and Coastal Research, part of RWS) conducted a study in 1999 to determine to what extent data and information from the MWTL network is used in policy documents, management plans, vision reports, brochures, atlases, and policy- and management reports (RIKZ 2000). An inventory was made of a set of documents from these categories issued between 1992 and 1999, and these were analyzed for their use of monitoring data. In this way, the study provides insight into the usefulness of the information that is produced in the MWTL network. In total, 95 documents were analyzed.

The study showed that in 75 out of the 95 reports data from the MWTL-network was used. In many reports however, the source of the data was not referenced in the report. Interviews with authors of the reports were conducted to reveal the source of the data. From these interviews it was concluded that the MWTL network was considered useful, sensible and of high quality, not in the least because of its long-term history of data. The interviewees however considered the accessibility of the data to be low and suggested that this was to be improved. They also noted that the network was not widely known, and improved communication about the existence and contents of the program was advised.

The assumption in this study by RIKZ was that information from the MWTL network is widely used but that this is not always acknowledged. This assumption proved to be correct for many of the studied reports. The MWTL network provides a substantial amount of information that is used in many different reports. The authors of the reports studied consider the information useful and include it into their work. From the interviews it followed that the interviewees were little aware of the source of the information. They did not realize that they make use of the monitoring programs, which may lead to low appreciation of such programs. Moreover, this lack of awareness can also lead to a situation in which users are not making use of existing information that could lead to improved decisions as Callahan and others (1999) documented for regional hydrological forecasts (also see McNie and others 2007).

### 2.8.4 The organization of the information market

The final study that will be discussed in this context is a short study by Stevers (2003), who examined the implementation of the long-term vision document on the RWS program ‘basic information’, three and a half year after finalization of this strategic document. The RWS program is responsible for providing information in support of policy evaluation and development and is largely realized through the MWTL network. The vision document was intended to improve the organizational structure around the production of ‘basic information’ in order to increase the effectiveness and efficiency in terms of management, costs and organization. There was general disappointment about the yields of the organizational changes, and Stevers performed the study to determine the reasons for this disappointment and to decide about the way forward. The study was based on one meeting and interviews with, in total, 15 people involved in the program.

Stevers (2003) in his study discerns four actors in the process that each apparently fail to improve the existing situation; (1) the demand side (users) of the information, the decision-makers who take basic information as a constant factor that just ‘‘has to be there’’ and does not need much attention from them, (2) the supply side (producers) of the information, the operational measuring services in the regional departments within RWS that are, according to Stevers, generally not much inclined to change their practice, (3) the commissioners for the program, that are expected to actively connect the demand and supply but do not feel this responsibility themselves, and (4) the high level management of the various departments that, according to Stevers, are not addressed at the right level and in the right, 'management' language.

Stevers concludes that the vision document and its continuation were not discussed or embedded at the correct management level and were not formulated in the language of the higher management, leading to minimal attention from the higher management. Also, the demand side values basic information as unimportant and does not see its role as steering or determining the type of information produced. The supply side on the other hand is introverted, working from their own mindframes, while the commissioners are not able to change this situation. Stevers calls this situation the 'dynamics of stagnation' that should be broken. He advises to do this in an organizational/managerial way by appointing a high-ranking, authoritative official not coming from the information production sector to lead the process. The focus in the process should be on the interface between demand and supply. The supply side should direct their attention towards data accessibility, data presentation and data mining. The commissioners should try to define their own role. The top-managers should reflect on paying proper attention to the process. The demand side finally should become a party in the process.

Stevers assumes that information production is a market in which there is demand from decision makers and supply from information producers. He however overlooks the fact that this is not a free market, but that decision makers decide about budgets for information production and in that capacity carry responsibility for the information that is produced. Decision makers mostly view expressing their information needs not as a high priority issue, which leaves their demands and needs diffuse. They have unrealistic expectations when they state that 'the information just has to be there' without any input from their side. The information producers follow the route of basing their work on regulations and policies, including reporting obligations as documented, and there is insufficient consideration of the information needs of the users. The mutual frustration in this situation stays in place.

## 2.9 Discussion and conclusions

In the field of environmental information, information users are usually not satisfied with the information that is produced and information producers are criticized for producing too much data that yields little information that is of use. The discussion focuses on what makes information useful. Useful information is defined by McNie (2007) as information that is credible, legitimate and salient. This article aims at analyzing the water information gap, the basis for the dissatisfaction in the field of water quality information, building on literature and several studies that were done related to the Dutch National Water Monitoring Program (MWTL) and reviewed the studies in light of these three characteristics.

From the studies described in this article it follows that the credibility of the information from the MWTL network is not disputed. Ample efforts through quality assurance programs and regular evaluations are undertaken to produce high quality data. These efforts are generally acknowledged in the studies, where information users state that the information is of high quality and the information producers are considered to have sufficient expertise. Also, the legitimacy of the information is not disputed; the information from the MWTL network is not perceived as biased or providing only part of the relevant information. The discussion therefore concentrates on the salience of the information; does the information respond to the needs of the users?

This question can be divided into the question if information that is produced is used and the question if information users have information needs that are not met. The RIKZ study (RIKZ 2000) and the study by van Kerkhof and van Riel (van Kerkhoff and van Riel 1996) showed that information coming from the MWTL network is used in a range of reports. The study by Sam and Smit (Sam and Smit 1996) suggests that information users may have questions that are not included in monitoring networks. This leads us to the question why this information is not produced.

From the description in the previous section, it becomes clear that there are regular evaluations of the network and that these evaluations include considerations of information needs. This is however done with little or no involvement of information users. Stevers (Stevers 2003) states that the demand side should be more involved but immediately asks the question: ''Maar kan dat van jullie gevraagd worden? (But can this be asked from you?)''. He thus illustrates that decision makers that need information are little inclined to invest into what they believe to be uninteresting 'technical details'. As a consequence, the monitoring network is designed with little consideration of the needs of information users.

But is this a typical Dutch situation or is the situation comparable to other countries? Some studies looking at the use of information in several international commissions in Europe showed that the information needs for these international commissions are usually based on treaties that regulate the work of that commission while the monitoring networks are largely based on national legislation from the respective countries. In all of the cases little attention is given to ensure that the information collection is linked to the actual priorities and needs of the decision-makers or stakeholders and improved communication between information producers and users is recommended (Langaas and others 2002; Nilsson 2006). The Dutch situation is consequently not unique and can act as an example for a general problem.

The analysis in this article showed that due consideration of information needs takes place in designing monitoring networks. These information needs are largely based on existing regulatory reporting obligations. Also, vast efforts are regularly carried out to make the information production efficient by optimizing and reducing the networks to avoid producing too much information. Then, information from the MWTL network is used by a variety of users in several ways. However, policy objectives can be distinguished about which no information is produced. Also, information users consider the information as produced not salient.

This situation has developed as information users are hardly involved in the specification of information needs. An essential reason for this is that information producers have a limited insight in the work and needs of information users and vice versa. As both groups have a task to fulfil, this unawareness leads to reluctance when it comes to investing efforts in communicating about mutual needs and interests, a process that can be time-consuming and troublesome.

To bridge this ''water information gap'', the link between users and producers of information needs to be managed (McNie 2007) through close interaction (Sarewitz and Pielke 2007). Better communication between the two groups is needed.

However, better communication does not equal more communication. Investing only in more communication runs the risk to strengthen the 'dynamics of stagnation'. Instead, respectful interactions are needed between policymakers and scientists in which they are willing to learn from and deal with their different interpretations that are rooted in different mindframes (Timmerman and Langaas 2005). It also implies that users' information needs must be identified prior to producing information (Timmerman and others 2000).

To manage this improved communication between policy and science, a methodology is needed that guides and structures the interactions in order to come to meaningful information production. On the basis of the analysis of the water information gap as described in this article, such a methodology is developed (Timmerman and others 2010a) and tested (Timmerman and others 2001; Timmerman and others 2010c). Results show that a methodology guiding the communication is an efficient way to manage the link and improve the interaction between science and policy and supports narrowing the water information gap.


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# Chapter 3

# The information cycle as a framework for defining information goals for water-quality monitoring


## *Abstract*

*The necessity to tailor information becomes increasingly urgent as the information revolution continues to generate ever-increasing flows of data and so-called information. From European experiences, a new approach for monitoring system design is suggested in this paper. In this approach, careful and detailed specification of information needs is a major contributing factor to the effectiveness of information products. To develop better specifications for information products, the process of collecting and transforming data into useful information requires careful thought and guidance. A dialogue between information users on one hand and information producers on the other is essential. This dialogue can be based on the information cycle, describing the continuous process from specifying information needs for water management and a strategy to collect information through data collection and data analysis up to utilization of information by water management. By following the respective steps in the information cycle, the process of information gathering can be completed. The cyclic character provides a quantitative means of connecting monitoring system design and operations with the information expectations and/or products required by management.*



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## 3.1 Introduction

Over the last two decades, water management has changed from a focus on distinct sectors, dealing with one or two interests at a time, to integrated water management, interrelating different aspects of the water system like physical planning, ecology and emissions. In the future, comprehensive water management will integrate various water management functions into an interactive framework of ecology, sociology, and economy (de Jong and others 1994; Raskin and others 1997). In addition, increasing knowledge of the complexity of processes in water systems has led to a growing demand for information. Water system problems are becoming more complex and diverse, and require more specific knowledge and integration across various disciplines, sectors, countries, and societies (Somlyódy 1994). This growing need to integrate disciplines also brings about the need to integrate large sets of data and information. Moreover, computers provide numerous possibilities to store, retrieve, and analyze data, thus enlarging the availability of data and information. Nowadays, policy-makers and water managers are overwhelmed with data and information that may or may not be of use to them. Ward and others (1986) described this ''data-rich but information-poor syndrome.'' Therefore, there is a call today for less quantity of information and more targeted, tailor-made, information (Adriaanse and others 1995; Adriaanse and Broseliske 1998; Ongley 1998; see, e.g.,Ten Brink and Woudstra 1991; Ward 1995).

*Information* is defined as the communication or reception of knowledge or intelligence in Webster's Ninth New Collegiate Dictionary published in 1983. As in the above definition, the word ''information'' in this paper is used in a broad sense of exchanging material that is more than mere data or facts. Production of information in this paper therefore implies collecting and processing data in such a way that the recipient of the information is able to draw a conclusion from it.

In this paper, a new way of approaching information collection is suggested, specifically emphasizing water quality monitoring system design. This approach has evolved from two international conferences on monitoring (Monitoring Tailor-made, 1994 and 1996), from experiences in drawing guidelines for water-quality monitoring and assessment of transboundary rivers (Timmerman and others 1997), and from Dutch experience in designing and optimizing monitoring networks (e.g., Adriaanse 1992). The paper presents and discusses a framework that assists information producers in developing tailor-made information that is sized to fit the needs of the information users. The next two sections will continue with considerations on difficulties in formulating questions and devising strategies to obtain answers. In the next section some examples of monitoring system design strategies from literature are discussed, and the proposed framework is presented. The following sections go into detail on application of the framework and its respective steps.

## 3.2 What is the question?

The major challenge in monitoring and assessment is making the information obtained fit the information needed (Adriaanse and others 1995). ''All too often, monitoring projects are initiated with a minimum of forethought, and result in a collection of poorly documented data which are never analyzed, provide little or any feedback to resource managers, and contribute little or nothing to our understanding of the systems being monitored" (MacDonald 1994). MacDonald states that formulating the specific objectives of the monitoring project is the most important and most difficult step in the entire monitoring process. In this paper we suggest that the information need is the crucial step in the information-producing process and the determining factor to specify monitoring objectives. In the Netherlands, in redesigning the national monitoring network, monitoring objectives had been defined, without specifying information needs first (Adriaanse 1992). Although attempts have been made since then to improve this situation, it is still felt that the monitoring network does not fully meet the information needed. Defining what information should be produced, what is really the question or the problem, is not easy to do, however. How a problem is defined determines the understanding and approach to the problem and thus the possible solutions to the problem (Bardwell 1991).

The information objectives should be identified by managers in consultation with technical staff (MacDonald 1994), but management issues tend to be vague and loosely specified. Policy-makers, politicians, the public, and other information users tend to pose questions of the form: Is this country safe against flooding? or What will be the consequences of dry years for agriculture? (Hofstra 1995). These questions are not easily or simply answered, and they even raise new questions. The first question above, for example, generates the questions: What is "safe"? Maybe a statistical chance of one in 10,000 years is safe? Does this count for the whole of the Netherlands or just for one area? And against what cost?

On the other hand, experts (researchers, scientists, and other information producers that generate information) tend to provide answers like: The maximum water level is 34.6 m above mean sea level; or pH is 7.8. Many information users may find it difficult to relate those answers to their questions (Timmerman and Ottens 1997). Lack of interpretation against a clearly understood information need prevents the data from becoming tailor-made information.

These questions and answers reflect different worlds of thinking. Information producers often do not speak the same language as information users (Helsel 1997) Information users tend to oversimplify and have unrealistic expectations, whereas information producers fail to address the management needs (MacDonald 1994). These two worlds need to be linked together through communication. A dialogue is needed between information users and information producers to develop the connecting questions—questions that are clearly articulated and understood by both information producers and users.

In addition to formulating these questions, it is important to determine how the answer should be presented and the level of detail and precision to be included in the answer. Given the question on safety, it may be agreed that safety will be expressed as a statistical chance. In this way, safety is defined as a feature that may be calculated from existing data. Another option for expressing safety is to present a number of scenarios with consequences that are connected economically (e.g., costs of measures and impacts), sociologically (e.g., half of the village will disappear in building a dike of several meters high), and ecologically (e.g., valuable nature reserves will disappear).

The way a question is formulated and stated depends on a number of factors, such as the legal/management context, environmental conditions, and, also very important, the latest concepts in water management. A good example of changing concepts may be found in the development of water management policy in the

Netherlands. In the first national policy document (published in 1968), water quantity was the central issue. The second national policy document (published in 1984) added a relation with economy and brought about attention to water-quality aspects. The third national policy document (published in 1989) portrayed water as a system and ecology was valued next to the economy (Anonymous 1991; Blom 1995; Wisserhof 1994). The trend in water management today is toward integrated water management—a balance between economics, ecology and sociology (Raskin and others 1997; van Rooy and de Jong 1995). These aspects are integrated in the main aim of the fourth national policy document: ''To have and maintain a safe and habitable country and to develop and maintain healthy and resilient water systems which will continue to guarantee sustained use'' (Anonymous 1998a).

Thus, today economics, ecology, and sociology together are key to forming and stating the questions to be answered, but only the right question will lead to the right information to make decisions (Adriaanse 1997).

## 3.3 How to get the answer

If the question is clear and well understood, the next step is to look for ways to find the answer. This shaping of the answer must also be part of the dialogue between information users and information producers. There may be different strategies to collect information. For example, in our flooding example, water levels may be monitored and the height of dikes and dams can be measured precisely. If the level of public support must also be taken into account in a decision relating to height of dikes and dams, one method to measure social support could be a questionnaire. The measurement systems combine physical and social variables to produce information.

With technical knowledge, the technical possibilities can be derived, and using equations and models, chances for calamities may be calculated. But then the question becomes: How exact should the answer be? An exact answer will require extensive inventories of the existing situation, collection of large amounts of data from different dimensions of the question, and detailed data analysis and interpretation in order to provide as exact an answer as possible. Thus, a balance must be struck between the level of detail of the answer and the necessary effort. For this balancing, the term ''relevant margin'' is important. The relevant margin may be defined as the information margin that is of concern to the information user. If, for example, the critical level of a pollutant lies at 10 µg/liter, it is no use to provide information in nanograms per liter. The relevant margin may be about 5 µg/liter in such a case (Adriaanse 1995).

In determining how the answer to the question will be presented, it is important to define the preparation and presentation of data with both information producers and users. How data are analyzed and presented may influence the way data are collected. Calculation of trends, for instance, is a different monitoring objective and requires a different monitoring strategy than compliance with standards. Thus, again, the nature of the question being asked will result in different approaches to the design and implementation of monitoring programs. Factors that are influenced by the question are the selection of variables to be measured, the frequency and location of measurements, the additional information needed for interpretation, and the way in which information is generated and presented (Bartram and Ballance 1996). In fact, these choices define the monitoring objectives and consequently are the prerequisites for the collection of data.

## 3.4 A common framework

As stated before, a dialogue is needed between information users and information producers. To facilitate this dialogue, a common basis, or framework, is needed to ensure that all parties involved share the same notion of the process at hand. Such a framework should appeal to both information users and information producers. Since most information users are not interested in technical details, the framework should preferably be easy to understand yet describe all essential steps. The concept of developing a common basis for approaching the design of water monitoring systems is well established in the water monitoring literature. Several of these approaches will be examined from the perspective of incorporating the desires of information users into the approach being proposed.

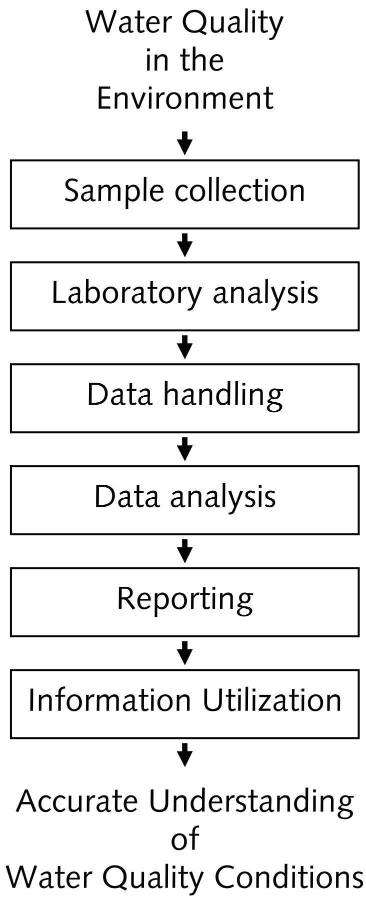


Figure 3.1. Flow of information through a monitoring system (Ward and others 1990).

Ward and others (1990) define the monitoring system as containing a number of tasks to convert a sample of water in the environment into accurate understanding of it (Figure 3.1). Ward (1995) stresses the need to customize monitoring efforts. In other words, we must define what information we want and then design the monitoring system to produce it. Such a process should be clear to both information users and information producers. However, in the steps in Figure 3.1, there is no clearly defined role for information users.

MacDonald (1994) notes that little attention is given to the explicit and iterative process necessary for the efficient design and execution of monitoring projects. He suggests 12 key steps in this design and execution (Figure 3.2). These steps are rather descriptive and will not easily be reproduced by information users. Nevertheless, MacDonald (1994) emphasizes the involvement of management as information users in defining monitoring objectives and describes the significance of feedback of monitoring results to management (Figure 3.3). In this feedback loop the individual steps become clear and also the role of management is clear.

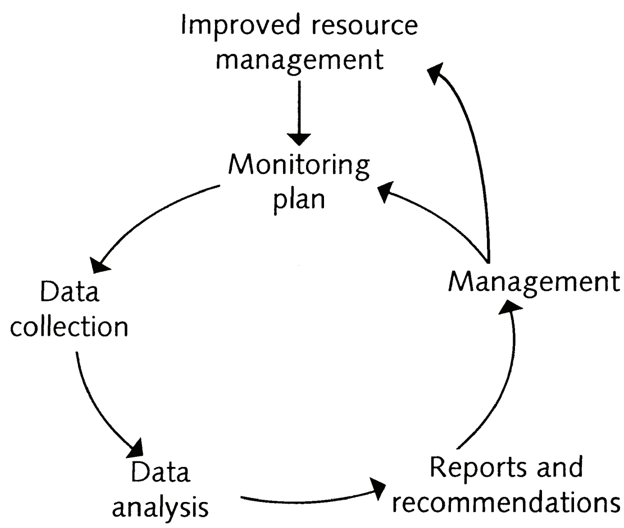


Figure 3.2. Key steps in the design and execution of a monitoring project (MacDonald 1994).

1. Propose general objectives
2. Define approximate budget and personnel constraints
3. Review existing data
4. Define specific objectives and hypotheses
5. Determine variables to be monitored, sampling locations, sampling procedures, and analytic techniques
6. Evaluate hypothetical or a comparable set of real data
7. Reassess the specific objectives and compatibility with available resources
8. Initiate monitoring on a pilot basis
9. Analyse and evaluate data from the pilot project
10. Reassess monitoring objectives and compatibility with existing resources, and modify the monitoring project as appropriate
11. Continue monitoring
12. Prepare regular reports and recommendations

Figure 3.3. The monitoring feedback loop (MacDonald 1994).

In Chapman (1996) key elements of an assessment program are described (Figure 3.4). The possible types of water-quality assessment programs are numerous and should be designed or adopted according to objectives. These objectives should be set on the basis of environmental conditions, water uses (actual and future), water legislation, etc. (Meybeck and others 1996). However, in this framework the objectives are not explicitly related to the needs of information users. The emphasis is still on the information production side, with little concern for managerial issues.

In this paper, the information cycle (Figure 3.5) is presented as a general framework that describes the essential steps in the process of information collection. In the information cycle, information collection is inextricably bound up with water management. The information cycle incorporates water management in the frameworks described (MacDonald 1994; Meybeck and others 1996; Ward and others 1990; Ward 1995) and adds specification of information needs and developing of an information strategy. A monitoring plan can be the outcome of the information strategy, but this is not inevitable. Thus, the information cycle may be used as a generic framework for designing information collecting systems.

1. Objectives
2. Preliminary surveys
3. Monitoring design
4. Field monitoring operations
5. Hydrological monitoring
6. Laboratory activities
7. Data quality control
8. Data storage treatment and reporting
9. Data interpretation
10. Water management recommendations

Figure 3.4. Key elements of an assessment program (Meybeck and others 1996).

In going from information required to information obtained, the following steps can be distinguished: (1) Information users, as part of the information cycle, should, in cooperation with information producers, decide upon the characteristics of the information that is needed. (2) Information producers will, in cooperation with information users, decide upon the best way (i.e., strategy) to collect information. (3) The actual collection of data is the next step in the information cycle. (4) The collected data are analyzed and the results interpreted relative to the information sought; information statements are made. (5) The resulting information is presented and transferred to the information users in a proactive manner.

Unfortunately, too often the information presented as a result of the above actions does not satisfy the information users. Why is this the case? Reasons include: (1) Specification of information need is insufficient. (2) The information need as specified is not the "real" information need (too little effort went into the process of defining the information need). (3) The strategy to collect information has not produced the right information. (4) The obtained information generates new questions, making the originally agreed upon information appear to be inadequate. (5) The situation has changed (e.g., new policies), causing other information to be needed. (6) New methods have been developed.

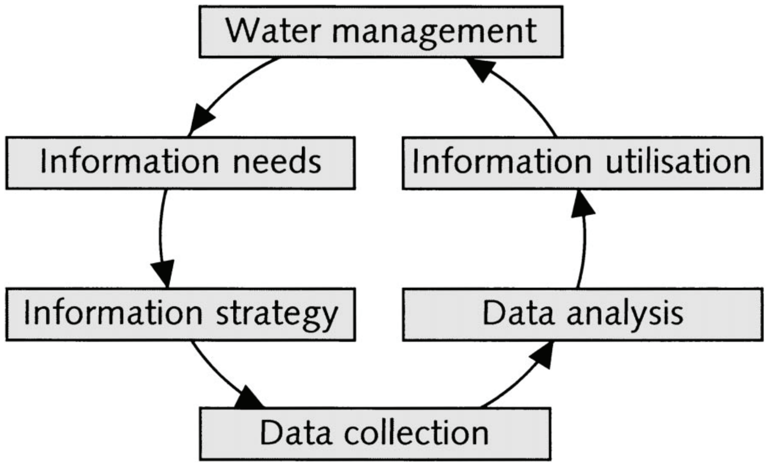


Figure 3.5. The information cycle.

Generally, the conclusion is that new information is needed. The new (i.e., changed) information need must be determined and the process starts again, but from a new position. Because we have learned from the previous process, this next cycle should lead to better tailored information. By continuous evaluation and feedback, the cycle becomes a spiral, leading to a constantly improving quality of the information. The cycle thus represents a continuously adjusting information system that can be presented as a spiral towards a better information product (Figure 3.6).

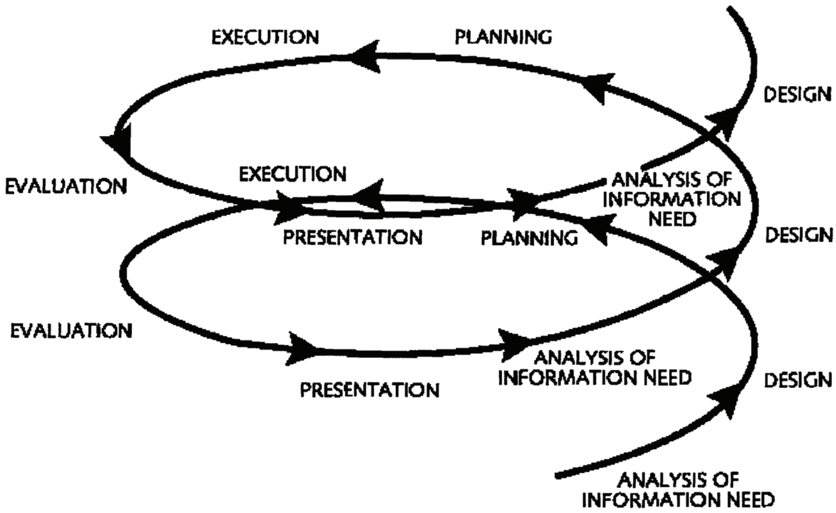


Figure 3.6. A spiral towards better tailored information (Cofino 1995).

Each step in the information cycle puts requirements on the previous step of the cycle. If, for example, a trend with a defined reliability has to be calculated, sampling has to take place with a certain frequency, depending on the variability of the data. Thus, data analysis puts requirements on data collection. Furthermore, each step limits the following steps. For example, if the sampling frequency is too low, no reliable trend can be calculated. By theoretically going through the information cycle both clockwise and counter clockwise, formulating the prerequisites and restrictions of every step, these requirements and limitations may be made explicit.

## 3.5 Application of the information cycle

The information cycle is a framework stating the essential steps in the continuous process of information production. Each of these steps has to be elaborated, depending on the required information and the strategy to collect this information. Monitoring, for instance, may require methods of data analysis different from modelling. Thus, for different purposes, the information cycle may be adjusted. In the Guidelines on Water-Quality Monitoring and Assessment of Transboundary Rivers (UNECE 1996; UNECE TFMA 1996), the notion of an information network being a cycle of activities was added to the steps that Ward and others (1990) described. This resulted in the monitoring cycle as shown in Figure 3.7.

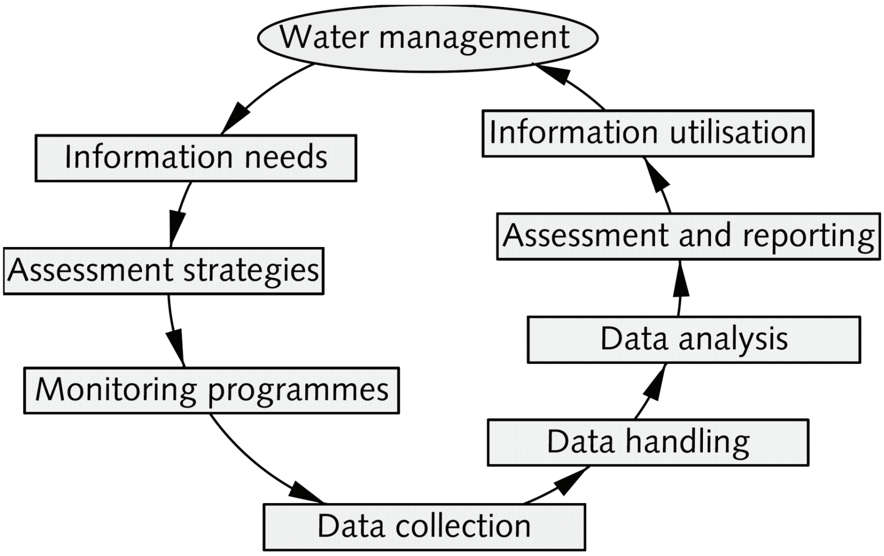


Figure 3.7. The monitoring cycle (UNECE TFMA 1996).

The monitoring cycle shows the different steps that have to be defined to be able to specify all requirements for a (chemical) monitoring system. Information for one step is used to develop and define information for the next step. The resulting information as produced by the monitoring system is the sum of a chain of activities. When the quality of the information in one of the steps is poor, it will, in turn, affect the quality of the resulting information. The strength of the cycle is thus determined by its weakest link (Stroomberg and others 1995).

Monitoring is defined as the long-term, standardized measurement and observation of the aquatic environment in order to define status and trends. A survey is defined as an intensive program of finite duration to measure and observe the quality of the aquatic environment for a specific purpose (Meybeck and others 1996).

The monitoring cycle can be adapted for other types of monitoring. For biological monitoring, for instance, the steps ''sample collection'' and ''laboratory analysis'' may be supplemented by the step ''field observations.'' In the Guidelines on Monitoring and Assessment of Transboundary Groundwater (UNECE TFMA 2000a), ''quantity measurements'' is added, replacing ''sample collection'' and ''laboratory analysis.''

## 3.6 Issues to consider in specifying information needs

In specifying the information needs for integrated water management, it is suggested (UNECE TFMA 1996) to approach the task from a triangle of core elements: functions and use of the water, problems and threats for this use or function, and measures that may be taken (Figure 3.8). For example, a large part of the Dutch shoreline consists of dunes that protect the land behind it against flooding (function). During storms, parts of these dunes are washed away (problem). The damage is repaired by supplying sand (measure). Another problem for this function is changing of erosion and sedimentation patterns due to, e.g., land acclamation in the sea near Rotterdam. As a measure, small dams are constructed along the shoreline to prevent washing away of sand. By elaborating problems and measures of all function, a comprehensive analysis of the situation at hand is made.

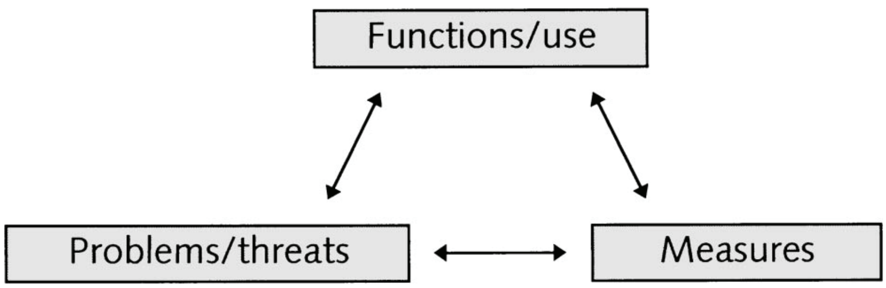


Figure 3.8. Core elements in water management (UNECE TFMA 1996).

The next element in specifying the information needs may be a division into the necessary information categories (CIW 1996):

1. Information for policy evaluation. This information should be linked to the policy as defined. The starting point is the existing or desired function. The resulting information should show to what extent problems are still relevant and measures have had the intended effect. Indicative variables may be useful in this respect to keep track of problems. If there is evidence of deterioration in water quality, additional information is needed to be able to (re)define measures.
2. Information for policy preparation. Policy preparation needs information on present status and future developments. Major sources of information include experiences from other parts of the world and extrapolation of progress, e.g., in pollution reduction. Regular inventorying of the status of the water also is needed. This information should be related to its direct environment, to previous inventories, and to information from other regions or countries.
3. Information for operational water management. Operational water management needs direct usable information. For intake of drinking water, for example, the exact concentration of substances may be less important than whether they are above or below certain levels. For an overview of water quality, biological alarms may be sufficient. Flood forecasting at first instance requires rough measurement of rising or falling of the water level but when critical levels are reached, each centimeter becomes important. Essential information for operational water management is real time availability to allow for instant reactions.

A next important factor in specification of information needs is quantification. Information needs should best be stated in terms such as: ''Twenty percent reduction of pollution in the next five years,'' or ''No more interruptions in the intake of drinking water within two years.'' An element of relativity (percentage reduction of ..) or quantity (no more ... or less than ...) can also be useful in the specification. Next to that, an element of time (... within two years) should be included. ''By the year 2000 the ecosystem of the river Rhine should be improved to such an extent that higher species, such as the salmon, may become indigenous'' (Hogervorst 1993) is a statement that can be measured. There is an element of quantity (a more or less stable population of salmon) and an element of time (the year 2000). Naturally, the quantity element must have a link to water management measures. In this case, the element of quantity should be expressed in terms of a specific water-quality variable(s) and to physical factors such as suitable spawning grounds and the possibility of migration. When these criteria are quantified, the information need can be converted into an information strategy (Timmerman and others 1996).

When specifying information needs, it is also important to look at information utilization, in other words, what will be done with the information once it is collected. This is a determining factor for the information need (de Jong and Timmerman 1997).

## 3.7 Indicators and information needs

Indicators can be helpful to further define the information needs and may facilitate going through the steps of the information cycle. Indicators are useful in communicating between the different worlds of information users and information producers, because they can present information in a condensed/aggregated format and are often linked to specific problems or issues, which are in turn based on specific management needs. Simplification and quantification of information on the water system under consideration makes this information accessible and comparable to other water systems.

Indicators are defined here as an observable or measurable quantity, variable, or parameter, representing a process in the environment and having significance beyond its face value (Bakkes and others 1994; OECD 1993). The construction of an indicator is a means of achieving reduction in data volume while retaining significance for particular questions. Suitable indicators provide for the three core elements (Figure 3.8). As an example, in international river basin programs such as Salmon 2000 and the return of the beaver in the Elbe, the species are the indicator of a greater goal. They are measurable variables, representing processes in the environment by putting requirements on physical and chemical conditions of the water, thus also having significance for the total ecological functioning of a river. These species also embody the core-elements function (ecological function), problems (water quality and land use), and measures (reduction of emissions, ecological restoration). Moreover, they are very suitable in communicating to policy-makers or the public. Because of this, return of popular species is often stated as an objective of ecological restoration measures, facilitating increased social acceptance of these measures (Timmerman and Ottens 1997). When indicators are further aggregated, the term ''index'' is used. This can be a set of aggregated or weighted parameters or indicators describing a situation (OECD 1993).

Indicators may be developed on the basis of different perspectives. Van Harten and others (1995) distinguish indicators on the pressure on, state of, and impact on a water system and the response of the socioeconomic system (Figure 3.9). This classification is based on an ecological stress–response chain (Friend and Rapport 1979). A pressure indicator describes the intensity of human activities that cause changes in quality and/or quantity of the water system. The state indicator describes the status of the quality and/or quantity of the water system. A pressure may result in a new state. The impact indicator describes the influence of the state of the water system on functions and uses of the water system. When functions or uses are affected, a societal response may be expected. This is described by the response indicator. The response aims at a new balance of the water system and the protection of functions and uses.

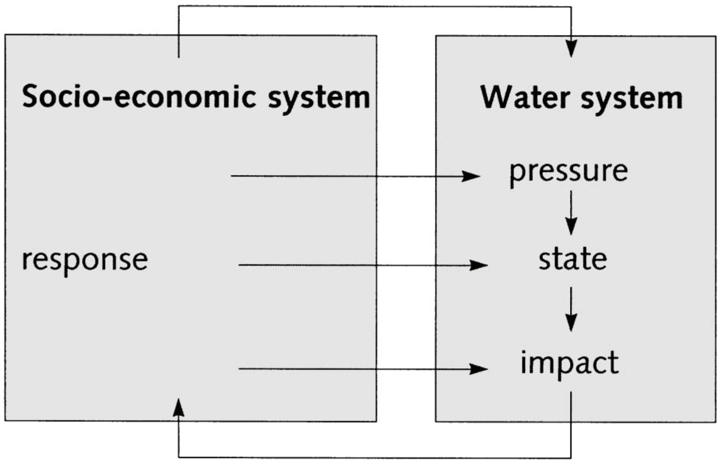


Figure 3.9. PSIR concept (after van Harten and others 1995).

The PSIR (Pressure state impact response) chain can be related to the core elements in water management (Figure 3.8). Impact indicators reflect the way function and use of a water system is influenced, while status indicators illustrate the level of functioning. Problems and threats may be quantified by pressure indicators where response indicators describe the measures taken. By providing surveillance for the different functions and uses of water systems, with often conflicting demands, indicators can help in the management of this complex situation.

When problems are recognized, information is first needed on the source of the problem and the level of effect on the use of the water system. This information may be provided by pressure and impact indicators. When the problem is fully recognized and measures are formulated, the focus will be on the measures taken and the present situation in the water system. Status and response indicators provide for this information. Generally starting from issues, for policy evaluation or preparation, the information need will concentrate mostly on pressure and response indicators. For operational water management, focusing primarily on functions of waters, status and impact indicators will provide the greater part of the information.

As an example, suppose the issue is the influence of liquid manure on a groundwater system in relation to the use of groundwater as a source of drinking water. An indicator for the pressure on the groundwater system could be the nitrogen load of the soil. The $NO_3$ concentration in shallow groundwater can be selected as an indicator for the state of the system. The impact indicator may be the suitability for use of the groundwater as a source of drinking water. A response indicator could be the percentage of the total amount of liquid manure produced that is processed in a way that is not harmful to the environment. If the issue is fully recognized, policy makers will focus mostly on status and response indicators.

## 3.8 Defining an information strategy

After defining the information need, it is important to recognize that the information cycle involves defining a strategy for collecting this information. The information strategy chosen is a mixture of the information need and the best practical way to collect information.

Integrated water management requires integrated information. To provide such information, many different sources are needed. In water management, usually monitoring is used to collect data. Often models are used to make predictions on the basis of the monitoring data. Surveys are used to provide insight into specific issues. Other sources of information may be data from other disciplines such as agriculture, recreation, sociology, ecology, and economics. The information cycle suggests that only after specification of information needs, can it be determined what part of the information needed will be collected from what source. Incorporated into the information cycle, different sources of information as well as different ways of collecting and analyzing data are shown in Figure 3.10.

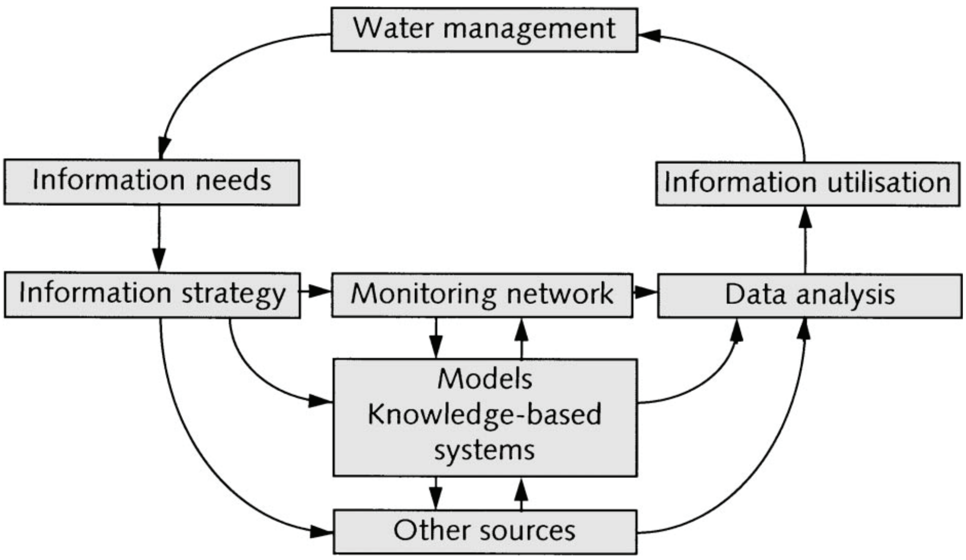


Figure 3.10. Sources of information (UNECE 1996; UNECE TFMA 1996).

When information is collected from monitoring, some general strategies in water quality monitoring are (UNECE TFMA 1996; van Luin and Ottens 1997; Witmer 1995): (1) Variable oriented: collecting data of individual variables. This strategy is useful when the number of potentially harmful substances is limited or for examination of specific processes. (2) Effect oriented: data collection is focused on indicative variables that point out if something is going wrong. If there is an indication of some kind, specialized investigation may point out exactly what is going on (CIW

1996). Ecotoxicological testing, for instance, may reveal effects that highly exceed the toxicity accounted for by chemical analysis (Kristensen and Krogsgaard Jensen 1997). This strategy is useful when there are no dominating problems that may be related to a limited set of variables. (3) Source-oriented: collecting data of sources that cause adverse effects. This strategy may be used, e.g., for licensing (effluent monitoring) or policy preparation but is also indicative for pressure on a water system. (4) Achievement-oriented: collecting data on a policy goal that is set to be achieved within a given time period. The strategy aims at pointing out the distance to the goal or the effectiveness of measures. (5) Predictive: data collection on events that are expected to happen. This strategy is used in flood forecasting and for policy analysis. The use of models is imperative in this strategy. (6) Knowledge-building: data collection to understand specific processes in the water. Usually this strategy is performed on a short-term basis. (7) Tiered testing: a Stepwise approach in which additional data are collected only when available data provide insufficient information (Figure 3.11). (8) Investigative: collection of data of which the relevance is not yet clear. This may be done for instance by storing samples that have not been analyzed. If some event (e.g., a fish-kill) occurs, these samples may be analyzed to trace back the source of the event.

These different strategies are mostly interrelated. They are also closely related to the information need and choosing a strategy may lead to rethinking of the information need.

## 3.9 Other steps in the cycle

The information need and the strategy chosen determine the way data collection, data analysis, and information utilization are conducted. The resulting information should fit the information need, but as stated before, there are reasons why there could be a mismatch. Therefore it is important that in designing these steps, choices made are traceable. In case there is deviation of the information obtained from the information need as specified, the process by which the information was produced is known (Timmerman and others 1996; UNECE TFMA 1996).

Some aspects of the steps data collection, data analysis, and information utilization are usually recognized but in practice not always implemented in monitoring operations. In this section, these subjects will be highlighted; more detailed information can be found in Ward and others (1990), Bartram and Ballance (1996), and Chapman (1996).

In designing a monitoring network, choice of sampling frequencies or locations is important. When, for instance, water-quality data are available, use of statistics can minimize the number of locations through correlation between stations (Sanders and Loftis 1995). Knowledge of chemical, biological, and physical processes, of specific local characteristics or properties of the object of investigation, and of the analytical methodology and statistics also should be used in devising a program of measurements (Cofino 1993).

The collected data have to be stored in a way that they can be easily retrieved, but the data also have to be documented in a comprehensible manner. Data should be validated or approved before they are made accessible to any user or entered in any data archive (UNECE TFMA 1996).

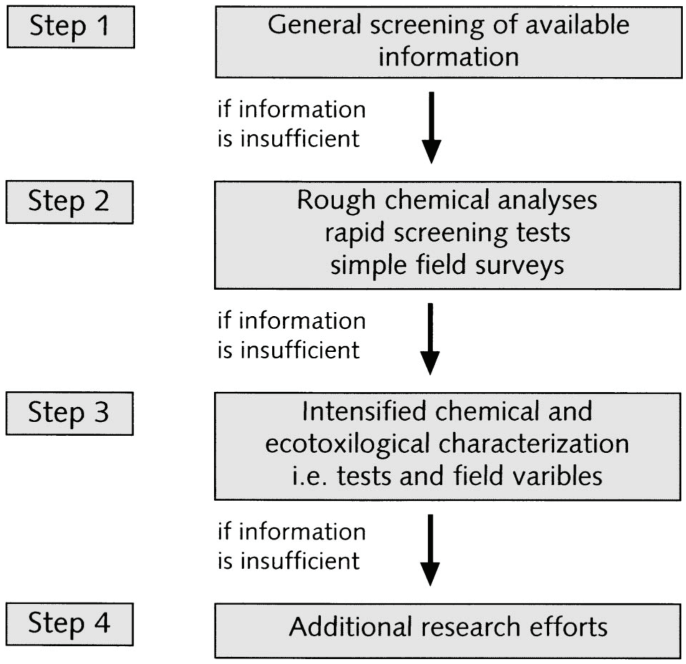


Figure 3.11. Tiered testing strategy (UNECE TFMA 1996).

One of the most important challenges is the aggregation of the huge amount of available data into clear information. To illustrate the volume of data, for each location on the Rhine River alone, the Dutch collect some 5000 data points on water quality each year. Various tools have been developed for analyzing water quality data. The Netherlands have developed the STOWA method for ecological judgment (Klapwijk and others 1995), the water dialogue (Latour and others 1997), and the AMOEBE (Ten Brink and Woudstra 1991). In New Zealand, a method has been developed for analyzing water-quality trends (McBride and Smith 1997).

## 3.10 Discussion

Because of a growing demand for information on processes in the water system and the need for integrated assessment of this information, information production for water management has become more and more complex. Since water-quality monitoring usually has a long-term character, decisions for developing a monitoring network have a long-term consequence. This increasing complexity, together with the possible long-term consequences, necessitates reassessment of the mechanisms of supplying information. The information cycle, as presented in this paper, provides a conceptual framework that incorporates the specification of information needs into the process of information gathering and provides possibilities to manage the quality of the process. By elaborating the steps in the information cycle, a better information product may be obtained. Each step puts requirements on the previous one and limits the following step. These requirements and limitations can be clarified by theoretically going through the cycle both clockwise and counter clockwise. The cyclic character comprises regular evaluation of the gathered information, thus quantitatively connecting the monitoring system design and operations with the information expectations and/or products required by management. In this way, up-to-date tailor-made information may be produced.

The information cycle offers a framework as a basis for the dialogue between information users on one hand and information producers on the other hand. It provides a method to direct the dialogue to those questions that must be answered if we are to formulate an information strategy and that is accountable for the information produced. The information cycle and its monitoring version were been introduced in the Dutch water management bodies in 1997 and have become a part of the common language since.

The information cycle may be adapted for its use, as is shown in the monitoring cycle. Through adaptation, the information cycle can also be used for specific types of monitoring as, for instance, groundwater quantity monitoring or for short term information production, as in surveys.

One of the major challenges is to define the element of information need. As discussed in this paper, questions may seem simple but on second thought appear to generate new questions—questions that must be answered in the process of designing a water-quality monitoring system. The actual information need has to be defined in a dialogue between information users and information producers. A method for specification of information needs is currently under development and is being tested in several pilot projects in the Netherlands and in some pilots under the ECE Task Force on Monitoring and Assessment in European transboundary rivers. First results from these pilot projects indicate that a better link of information to policy in a more integrated manner becomes possible.

# CHAPTER 4

# A METHODOLOGY TO BRIDGE THE WATER INFORMATION GAP


## *Abstract*

*The metaphor of the water information gap is used to describe the discontent between information users and information producers about the use of and need for specific information. This paper describes the rugby-ball methodology for specification of information needs that was developed on the basis of an analysis of the water information gap and insights from the literature on policy- and decision-analysis, problem-structuring, and information management. The methodology consists of a process-architecture to manage the process of assessing information needs and a structure to organise the information needs related to water policy objectives. The methodology was developed and enhanced through a Reflection-in-Action process in which interaction between ideas and practice leads to improved results. The paper describes the methodology and its development, and concludes both on the development process and on the abilities of the methodology to narrow the water information gap.*



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## 4.1 Introduction

In a simplistic linear model, information and knowledge flows from science to policy and is used to make better decisions. The relationship between science and policy is however generally considered more complex. The transfer of knowledge and information is seen as a gradual process in which it is uncertain if, where and how scientific knowledge and information is used in decision-making (Engels 2005; Sarewitz and Pielke 2007). The perceptions and viewpoints of the different groups involved differ as well as their responses and anticipation, and the behaviour of these groups is guided by the tasks, opinions, rules and language of their own organisation (Koppenjan and Klijn 2004; Roll 2004b). These differences in perception between scientists and decision makers are often referred to as the science-policy gap. This gap is defined as the difference in levels of confidence for a given scientific finding expressed by the scientific community and by society (Bradshaw and Borchers 2000) and is the result of information transfer and communication processes between scientists and decision makers.

A specific form of the science-policy gap within the domain of environmental information is the water information gap (Timmerman and others 2010b). A large amount of information is collected by water management organisations yearly to support the evaluation and development of water management and water policy. However, a discontent exists between information users and information producers about the use of and need for this information (e.g. Vaes and others 2009). This water information gap is generally acknowledged (Wesselink and others 2009) and many scholars suggest that a process of assessing information needs is needed to bridge the gap (a.o. Boyle and others 2001; Ward and others 1990). Such a process is regarded a systematic effort to consider the purpose of data collection ahead of designing / executing a monitoring program, through scientifically sound information needs assessment methodologies involving the actual users of the information (e.g. MacDonald 1994). This notion is further developed in the information cycle that describes the process of information production from specification of information needs to utilisation of the information produced (Timmerman and others 2000).

Analysis of the water information gap showed that the gap, in line with the generic science-policy gap (McNie 2007), is rooted in different perceptions and expectations between the two groups on what useful and salient information is and that better communication between decision makers as information users and monitoring people as information producers is needed to bridge it. These interactions need to be guided and structured (Timmerman and others 2010b). To this end, an information needs assessment methodology has been developed in which information users and information producers embark in a process of social learning that aids in developing an understanding of the policy process among information producers while information users gain understanding of the information production process.

This paper delineates the information needs assessment methodology. Firstly, the theoretical concepts used in its development are described. The methodology has been elaborated and enhanced through a process of Reflection-in-Action. This process is outlined in the second section of this paper. Thirdly, the methodology is dealt with. It is represented by the rugby-ball framework which is characterised by two components: approaches to manage the interactive process and a structured breakdown framework to organise the problem. The paper will conclude about the development process and application of the methodology.

## 4.2 Theoretical building blocks for the development of the methodology

Where different actors work together, they often have different interpretations of what is at stake and what should be done. These differences in the so-called frames of the different actors originate from different responsibilities or different scientific disciplines. To clarify the differences, defining the water management problem and the information needs related to it starts by structuring or framing the problem. This involves a concerted effort to focus on the actor's understanding of a problem (Dewulf and others 2005). According to Bardwell (1991), such a framing process entails design of 1) a structure to manage the process and 2) a structure to organise the problem. In developing the methodology, this division became apparent and will be used below to structure the arguments.

### 4.2.1 A structure to manage the process

The lack of communication, an important characteristic of the water information gap, is partly due to decision makers and information producers that are little inclined to invest in assessing each other's priorities and needs (Timmerman and others 2010b). Based on this observation, an approach was sought which supports and promotes interaction and collaboration between multiple actors with different stakes and with different mindframes. It is assumed that a platform on which the parties interact in an effective and targeted way by involving them at critical points in the process will improve the mutual awareness and acceptance of problems and measures in general, and will increase the legitimacy and accountability of decisions. The interaction becomes more effective when all parties involved are aware of each other's situation (e.g. Wesselink and others 2009). Therefore, a social learning process was included in the methodology to elucidate the participants' paradigms by enabling an exchange of views and stakes. Such learning processes are considered as a major aspect of problem solving in water management (Koppenjan and Klijn 2004).

People have different approaches towards problem solving that require different types of processes. One scale to describe these different approaches is between 'design' and 'development'. The *design* style includes a recording style of observation and an inclination to solve problems in an analytical way. 'Design' people emphasise formal rules and explicit knowledge of the trouble spot, and like approaches that are put down in handbooks. The *development* style people are more inclined to observe in a sensing way, accentuating intuition and implicit knowledge of the trouble spot. Emphasis is on developing ideas. Argelo and Boterman (1991) combined both design and development approaches in a hopscotch framework for information planning that combines the procedure and content as not all the elements need to be entered and one element can be entered several times. The hopscotch provides a flexible, non-linear approach towards the problem-solving process and serves as the basis for the process structure in the methodology; the rugby-ball framework. Different concepts and tools for interactive learning (Ridder and others 2005) have been assessed for (potential) application within the framework. Examples of such tools are given in the descriptions of the case studies. Experienced facilitators are needed to guide the process.

Particular attention was given to the institutional embedding of the process (Woodhill 2004). Support from higher management was secured. The importance and priority of the activities was acknowledged by including the methodology as part of the information (producing) cycle of the organisation (also see Mostert and others 2007). Such leadership is needed to ensure that the specification of information needs will be properly performed

An important issue is who to involve in the process, as the selection of information users and producers represents the mindframes that will be included in the process. A balance has to be found between inviting too many information users, leading to higher costs, prolonged consultation periods and introduction of extraneous issues, and too few information users leading to exclusion or overlooking of some groups which may result in resentment and non-cooperation (Ridder and others 2005). The CATWOE analysis as described within Soft Systems Methodology (Basden and others 2004; Tsouvalis and Checkland 1996) is useful in this respect. CATWOE stands for Customer (the immediate beneficiaries), Actor (the one who does the activities), Transformation (the conversion of input to output), Weltanschauung (the view of the world that makes the transformation process meaningful), Owner (the proprietor) and Environment (the (external) environmental constraints). CATWOE depicts the actors in the problem-solving process and their respective roles and perspectives, and the view on the problem and the transformation process that is envisaged. The CATWOE approach has been employed to select the information users and producers for the case studies.

### 4.2.2 A structure to organise the problem

Policies describe the goals and objectives for water management. Decision-makers know the reasoning behind the objectives and this tacit knowledge must be translated into explicit knowledge when deriving information needs from it. A translation from policies into information needs, which is the aim of the methodology, consequently entails deliberation about different values and discovering the reasoning behind the policy objectives to decide about the actors' values and their fundamental objectives (Keeney 1992).

This deliberation of values is supported by a structure like for instance a cognitive map, a hierarchy of objectives, or a (mental) model (Bardwell 1991; Keeney 1992). Such a conceptual model helps to keep participants aware of where they are in the overall planning process, summarizes a large amount of interrelated and potentially confusing information and portrays information linkages. The various units of information, through a well-defined structure, can be stored to be handled at the proper time. The conceptual model enables to frame a diversity of interpretations into a common frame thus simplifying the situation (Dewulf and others 2005) and is a way of limiting the information by focusing on a singular issue at a time, and to generate imagery (Bardwell 1991). The structured breakdown framework was developed from this concept.

## 4.3 Developing the methodology

The methodology to bridge the water information gap that is described in this paper is developed and tested through a process that Schön calls Reflection-in-Action (Schön 1991); by interaction between ideas and practice, experiences develop that help to improve both. On the basis of the above-described concepts from literature, the methodology was developed. The concept was subsequently tested in the form of case studies that provide experience and evidence. As specification of information needs is a time-consuming exercise testing a methodology to support this process cannot be performed in a series of randomised experiments with 'untreated' control groups. The case studies are in this sense quasi-experiments without control groups (Roos 1975). Experiences from case studies were used to improve the concept. Application of the methodology in the case studies was assessed and evaluated through participatory observations and by asking the participants in the case studies for their opinion about the studies.

Initial ideas for the methodology built upon the hopscotch framework of Argelo and Boterman (1991). A five-step process structure was developed that presents a logical order to be used as a hopscotch or route-planner in which the elements are filled in to attain the full problem description. The methodology was visualised through the image of a rugby-ball symbolising the initial diverging character of the process that at a certain point must converge into a coherent plan (see Belton and Stewart 2002).

The rugby-ball methodology was applied in a study to assess the information needs for the 4th National Policy Document on Water Management in the Netherlands. The case study is discussed in detail in Timmerman et al (Timmerman and others 2010b). Adoption of the Policy Document by the Dutch parliament in 1998 was the trigger to contemplate on the effects of this new policy on the information needed for management of the national waters, and consequently on the national monitoring networks, with the use of the newly developed rugby-ball methodology. The study substantiated that the methodology improved the communication between information users and information producers and the salience of the information through this involvement of information users. This conclusion was confirmed by an evaluation among the participants to the case study. The results were highly appreciated by both information users and information producers and were considered improved relative to the existing practice. The case yielded a comprehensive overview of information needs that however revealed an imbalance in level of detail between different policy fields. Although partly due to the level of policy development in the different policy fields, an important reason for this imbalance was the imperfect structuring of the information needs. It was concluded that the implementation of the Transformation (T) process, in particular the breakdown from policy objectives to information needs, was a weak component in the methodology and that a conceptual model was needed to facilitate this transformation.

Following the conclusion from this case study, the model of core-elements in water management (UNECE TFMA 2000b) was selected as the integrating decision-model. The model consists of three elements; functions/uses, problems, and measures, essentially the elements on which the water manager needs information. The model was the basis for the structured breakdown framework for the Transformation process. This case study is discussed in detail in Timmerman et al (2001). The development of a national policy for water gradients as well as a monitoring programme for these gradients in 1999 provided an opportunity to test this framework. The ruby ball methodology provided the steps in the process of the case study.

The initial breakdown from the policy objective on gradients concentrated on ecological and hydro-morphological aspects only. In a next step, socio-economic effects of measures were included leading to a more integrating decision-model. Through observations during the case study and responses to a questionnaire among the participants to the case study it was concluded that the ruby ball methodology together with the integrating decision-model was successful in improving the specification of the information needs. It was also concluded that in addition to the integrating model a structured approach to the breakdown of the policy gradient was needed for reasons of efficiency and transparency.

In a case study on a series of pilot projects on the UNECE Guidelines on Water Quality Monitoring and Assessment of Transboundary Rivers (UNECE TFMA 2000b) the Driving force - Pressure - State – Impact - Response (DPSIR) indicator framework for cause-effect relationships was tested as breakdown structure. This case study is discussed in Timmerman et al (Timmerman and others 2011). Three river basins were included in the case study; the Bug River between Ukraine, Belarus and Poland, the Mures/Maros River between Romania and Hungary, and the Morava River between the Czech Republic and the Slovak Republic. The DPSIR framework was used in these pilots on top of the integrating decision-model to identify and develop indicators that would provide the necessary information. The structured breakdown approach on the basis of the DPSIR framework accommodated a broadening of scope in the pilot projects. The analysis of functions, uses and issues within water management required the project teams to consider the whole basin and to assess the spatial distribution of functions and issues in relation to the main river and its tributaries. This provided improved insight into the relationships between the functions/uses, problems and measures. The framework also enabled to broaden the focus in monitoring from the classic physico-chemical elements to elements of socio-economic information. The structure supported a more integrated approach in the development of a monitoring network, thus improving the salience of the information. The information needs however showed a bias towards the problems in water management. As a result, little information would be provided about reaching the water management objectives or on the implementation and effectiveness of measures. From the case study it was therefore concluded that the DPSIR framework was suitable as extension of the ‘ problems’ element of the integrating decision-model but that additional structures were needed for the ‘functions/uses’ element and the ‘measures’ element. On the basis of this conclusion, the IWRM framework of balancing between the ecological, social and economic dimensions of a water management situation was selected to complement the ‘functions/uses’ element. The ‘measures’ element was complemented with the aspects ‘implementation’ and ‘effectiveness’ to guide further breakdown of the policy objectives into information needs. These structures are further described below.

## 4.4 The rugby-ball to manage the process

The overall process structure, based on the hopscotch framework, was given the form of a rugby-ball with five phases as shown in figure 4.1. The process starts from the left by exploring the scope of the study (Explore). This scope is discussed with the stakeholders in a workshop setting; the initiation phase (Initiate). Then, the problem structuring takes place in the third phase (Elaborate). The results of the problem structuring are discussed with the stakeholders, again in a workshop setting

(Conclude). Finally the process is described and a comprehensive overview of the problem structuring is developed that enables building an information network (Complete).

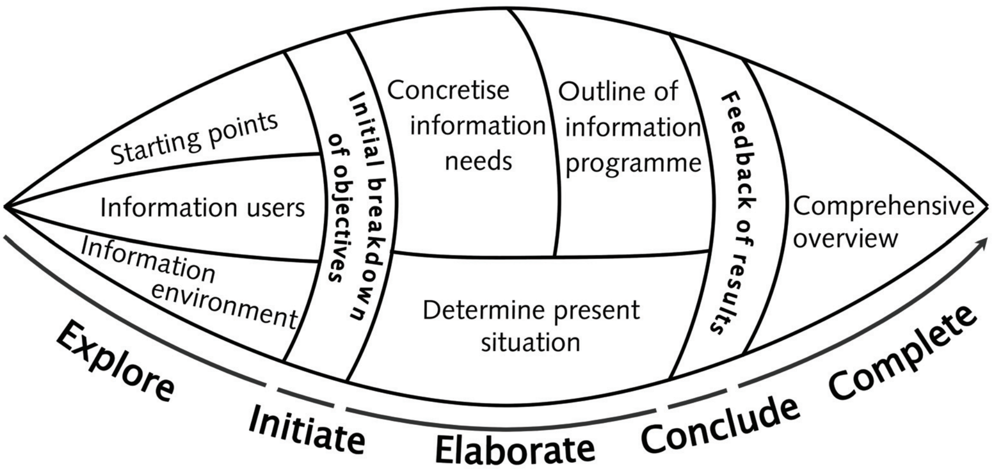



Figure 4.1 Rugby-ball for specification of information needs

*Explore* An intervention analysis is performed to establish the boundaries of the project. The *starting points* to delineate the project at hand include the Transformation (T), the way policy objectives are turned into information needs, and the Weltanschauung (W), the vision on what the information will be used for, of the CATWOE-analysis. The essential question here is "on what part of the policy should information be produced?" The selection of *information users,* the Customers (C), determines the outside world for the project. Who will be using the information once produced? The *Information Environment* analyses the organisation of the information production process; the Actors (A), and the Environment constraints (E). Actors (A) here are the information staff; the people that determine whether all requirements for information production can be met. The information environment or -strategy explains the way information is input to the policy process; what information is processed how and is input for what process. The relevant legal monitoring obligations from both national and International agreements are part of this. The real world situation is structured and formulated in a meaningful way from the systems point of view (Tsouvalis and Checkland 1996).

*Initiate* By discussing the result of the Exploration phase and a first analysis of information needs, all participants are brought at the same level of understanding. The participants will be asked to agree upon the results of the previous phase and to develop an initial model of the information system. This requires a mutual appreciation among the different participants (Customers (C) and Actors (A)) of their differences in Weltanschauung as part of the social learning process and leads to the necessary transparency and reduction of the subjectivity of the problem. A workshop is the preferred setting for this discussion, as it gives the opportunity to exchange ideas and intensify and consolidate mutual understanding.

*Elaborate* Essentially, in this phase the transition from the real world to the system world takes place (Tsouvalis and Checkland 1996); based on the scope of the study the actual problem structuring starts. The information need as roughly specified in the previous phase is further elaborated to enable development of an information network. The result of this phase in the methodology is what could be called the basic design of an information network. This phase consists of three elements:

1. *Concretise information needs*: The information needs as specified and structured in the previous phase are further elaborated into the structured breakdown schemes.
2. *Outline of the information programme*: Based on the structured and detailed information needs, an information programme is drafted.
3. *Determine present situation*: The existing information networks is studied and compared to the information programme.

*Conclude* The results of the process so far are discussed with the participants that have been involved in the process. The results are presented and the participants are invited to agree upon the draft information network as developed in the previous phases. As the level of detail in this phase can be rather high, information users may be reluctant to join in. The workshop therefore focuses on filling the remaining gaps and solving controversies that came up during the study.

*Complete* The results of the entire process and agreements of the Concluding workshop are documented in the form of a comprehensive overview, a blueprint for the new information network, or a programme of action.

The metaphor of the rugby-ball signifies that the rules of the game should be set, i.e. institutional support is needed, and that playing the rugby-ball requires practice, i.e. the process needs experienced facilitation. This representation of the framework as a rugby-ball proved to be a powerful tool in communicating the methodology within the Rijkswaterstaat organisation. It should be noted that the size of the elements in the figure do not reflect the amount of time or effort involved for the specific element but is merely designed in this way for a balanced figure.

## 4.5 The structured breakdown to organise the problem

The other element in the methodology is a structure to organise information related to the problem. The basic conceptual model for this breakdown is the integrating decision-model (figure 4.2). The participants reflect on the fundamental objectives within the scope of the study by thinking along three basic lines formed by the three elements of the model, which helps in developing an objectives hierarchy (Keeney 1992). The structured breakdown approach makes the transformation from the fundamental objectives into measurable (quantitative) or perceptible (qualitative) attributes. The selection of the attributes is an expression of the values or mindframes behind the fundamental objectives.

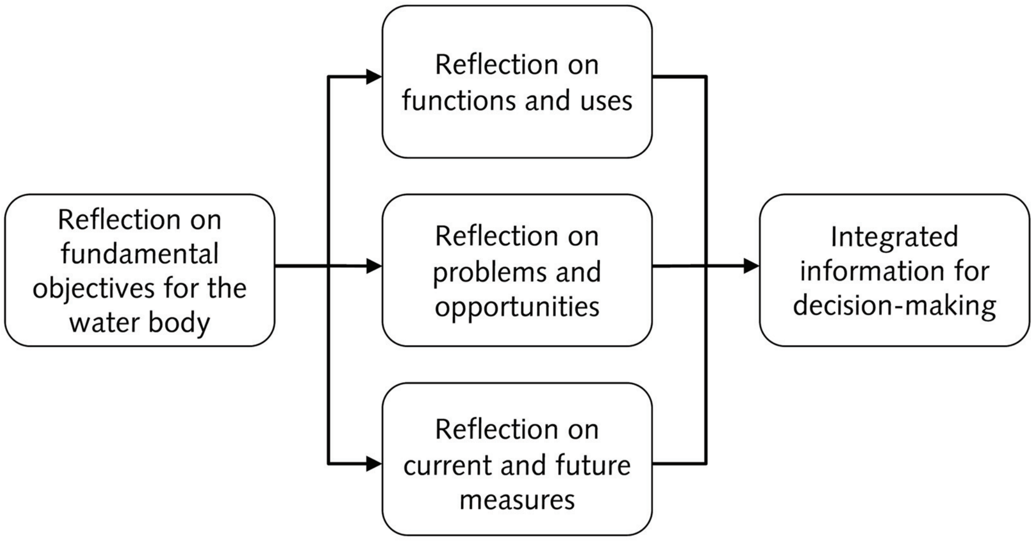



Figure 4.2. The integrating decision-model as a conceptual model for specification of information needs

### 4.5.1 Reflection on functions and uses

Elaboration of the integrating decision-model into the respective elements is done in the Elaboration phase and consecutively discussed in the Conclusion phase. The first element in the integrating decision model is to clarify what information is essential to verify if the objectives for the functioning and uses of the water system are achieved or approximated. The IWRM triangle of ecology, economy and society is the conceptual model where each element is an aspect of a water management objective. Each objective of a function/use is considered for its ecological, economic, and social aspects, subsequently translated into measurable or perceptible attributes for each aspect.

### 4.5.2 Reflection on problems and opportunities

The second element in the integrating decision-model is to develop understanding of how the natural environment and human uses of the water resources limit or enhance reaching the objectives. A different type of reasoning is required here compared to the first question, as it now deals with indicating causal relations. The DPSIR framework is selected here to focus on singular issues: for each problem / opportunity, the Driving forces, Pressures, Status, Impacts and Responses are listed and attributes are selected that describe these aspects.

### 4.5.3 Measures related to problems or functions/uses

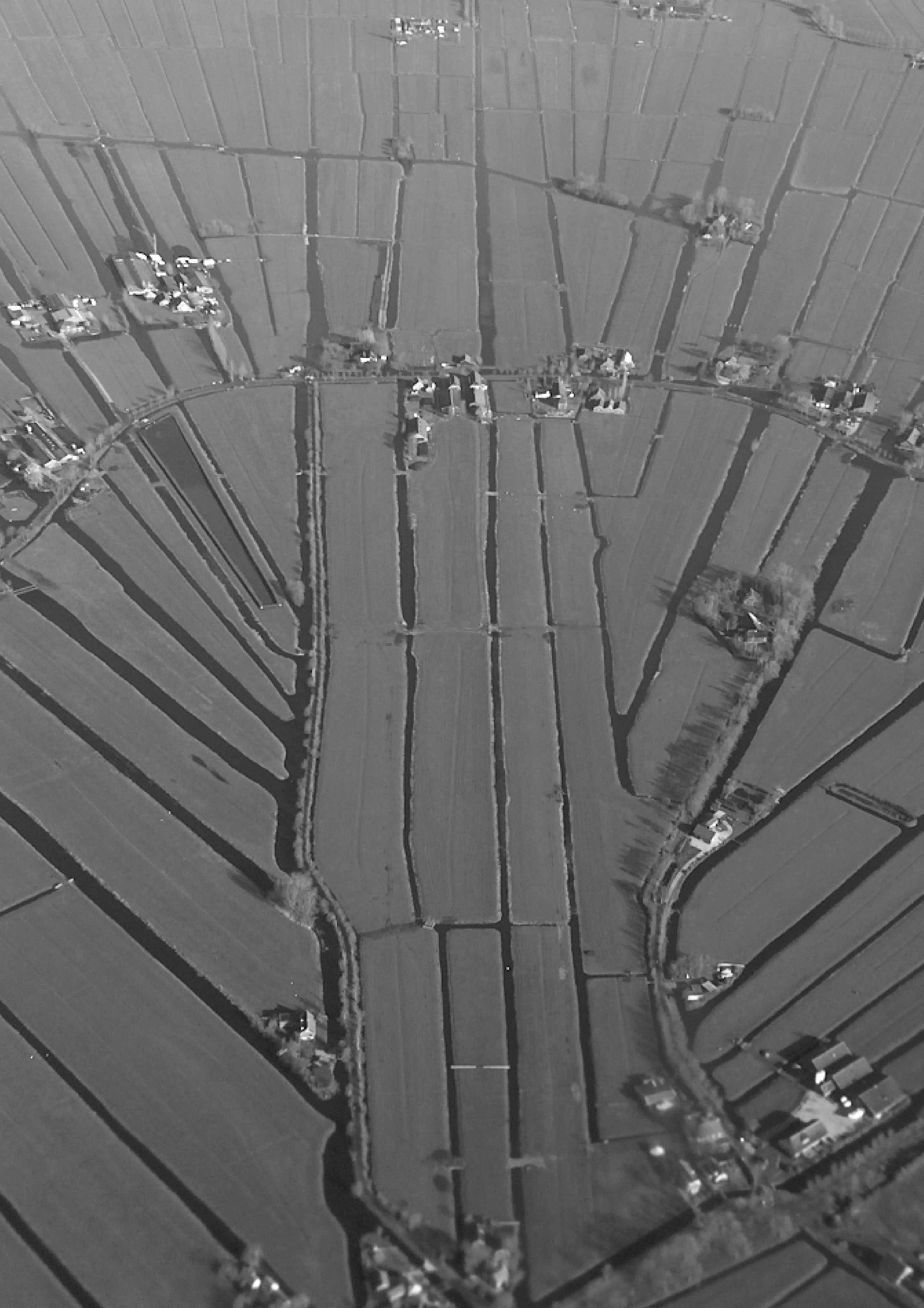
The third element in the integrating decision-model gives insight into what is already done and what can be done in future. This requires reasoning in terms of relationships between objectives and means. The information user must be able to make an analysis of reasons why the objective is not achieved and what actions can be taken to remedy the problems. The two aspects to be addressed here are 1) if measures are actually implemented and 2) if the measures have been effective in reaching the objectives. For each of these two aspects, relevant attributes are selected.

The frameworks used in the three lines of the integrating decision-model show overlap; information on the three elements of the IWRM framework in the first line are closely linked to the State information in the DPSIR framework in the second line, while the Response information is further defined in the structured breakdown of measures in the third line. As the perspective in each of the three frameworks is different it will add to a comprehensive set of information needs while any redundancy will be resolved at a later stage of the information producing process.

## 4.6 Conclusion

The methodology described in this paper is developed through a process of interaction between development of theory and practical implementation of this theory in real life called Reflection-in-Action (Schön 1991). Concepts for the methodology that were derived from literature were adapted on the basis of earlier experiences in daily work. Practical implementation of the concepts in several case studies helped to evaluate their applicability and subsequent improvement of the methodology. An important limitation in this process was that suitable case studies are scarce while the possibilities for implementing the methodologies depend on the willingness of the initiators of a study. The case studies mentioned in this paper were pivotal for the development of the methodology as described above. Evaluations of the case studies built confidence that the methodology was effective and revealed elements that needed improvement. The Reflection-in-Action approach is therefore necessary for this type of research.

The methodology was developed to bridge the water information gap. From the case studies it became clear that applying the methodology improves the communication between information users and information producers and enables mutual exchange of perceptions and expectations. Both groups consider working with the methodology an improvement compared to working without the methodology. Through the structured breakdown framework, the purpose of the different information needs becomes clear. The policy objectives are clarified in such a way that the connected information needs can be expressed. As a result, reporting from monitoring networks can be better tailored to specific uses as information needs through the structured breakdown can be linked to specific users. Through this approach, the interactions between the users and producers of information are guided and structured. The methodology thus addresses the problems that characterise the water information gap and is able to narrow this gap.



# CHAPTER 5

# SPECIFYING INFORMATION NEEDS FOR DUTCH NATIONAL POLICY EVALUATION


## *Abstract*

*There is mutual dissatisfaction among policymakers and monitoring specialists about producing what is considered useful information for policy development, implementation and evaluation. Insufficient or inappropriate communication between information users and producers is considered to be a main cause for this water information gap. This paper tests the rugby-ball methodology that has been designed to bridge the gap. The rugby ball methodology consist of a five step plan that helps policymakers and monitoring specialists to communicate in a proper way and to come to a joint process of defining information needs. The methodology is first tested in a study to assess the information needs for the 4th National Policy Document on Water Management in the Netherlands. From the study it is concluded that the rugby-ball methodology is an important step in bridging the water information gap by better defining what useful information is. The methodology is also improved on the basis of this study by including a structure to support the breakdown of policy objectives into information needs.*



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## 5.1 Introduction

Information collection in support of water management is under constant pressure. Annually, large amounts of information are collected by water management organisations to support the evaluation and development of water management and water policy. Scientists as information producers put a great deal of effort in developing and optimising monitoring networks to collect meaningful and scientifically sound information in a cost-effective way and in conveying this information to decision makers through well-documented reports, databases and presentations (Ning and Chang 2002). In the perception of the decision makers, however, the information provided often does not connect to the issues they are dealing with. This leads in turn to misunderstanding and dissatisfaction among the information producers because their efforts to produce meaningful information are not acknowledged. This mutual dissatisfaction in water monitoring is the so-called 'water information gap' (Giordano and others 2008; Timmerman and others 2010b) and is part of a wider problem of producing 'useful' environmental information (McNie 2007). Information is a fluent concept between data and information and is here defined as the general concept of something (knowledge or data) that adds to the knowledge of the receiver. What 'useful' information is cannot easily be determined. Monitoring programmes usually deal with the routine acquisition of chemical, biological and hydro metrological indicators required for operational water management and for policy implementation and evaluation. Such programmes invoke a long-term approach for issues which are important but in view of the position in the policy life cycle less urgent for decision makers. The attention of policymakers depends on societal developments and is highly dynamic. A need for clear, unambiguous information may arise for a range of issues on a short term. It is difficult to match the highly dynamic information need of policymakers with the long term perspective of providers of monitoring programmes in terms of the breadth of indicators and the desired degree of uncertainty in information. Following literature this study considers information to be useful when it is 1) salient and context-sensitive; responding to the specific information demands, 2) credible; perceived by the users to be accurate, valid and of high quality, and 3) legitimate; the production of information is perceived to be unbiased (Cash and others 2003; McNie 2007).

Analysis of the water information gap showed that the information is usually considered credible and legitimate but often does not respond to the users' need (salience) (Timmerman and others 2010b). It is therefore important that there is a clear understanding and agreement between information users and producers about the information required and about the way of processing and presenting information, including an understanding of how uncertainty is dealt with, to make the information salient. This is done in addition to the technical optimisation of information producing programs to ascertain the credibility and legitimacy of the information (Timmerman and others 2010b). To achieve such understanding, the rationale for collecting the different monitoring parameters needs to be established and shared. The essential question though is how to organise the process rendering useful information. Many scholars suggest that the process commences with a systematic effort considering the purpose of data collection through scientifically sound information needs assessment methodologies that involve the actual users of the information (Bernstein and others 1997; Boyle and others 2001; Meybeck and others 1996; Timmerman and Cofino 2004).

In 1998, the 4th National Policy Document on Water Management (NW4) was adopted by the Dutch parliament. The Dutch Directorate-General of Public Works and Water Management (Rijkswaterstaat), an agency within the Ministry of Transport, Public Works and Water Management (V&W) collects a baseline set of information of hydro-morphological, chemical and ecological characteristics for the national waters called 'basic information'. Adoption of NW4 was the trigger for Rijkswaterstaat (RWS) to reflect on the effects of this new policy on the information needed for management of the national waters, and consequently on the national monitoring networks. This study provided a good opportunity to test the rugby-ball methodology that had just been developed. The rugby-ball methodology is a process structure specifically designed for specification of information needs on the basis of available methodologies like SSM (Checkland 1981), the IRGC Risk Governance Framework (Bunting 2009), and Multiple criteria decision analysis (Belton and Stewart 2002) and on insights from the literature on policy- and decision-analysis, problem-structuring, and information management. This study is one step in developing and improving the methodology as described in Timmerman and others (Timmerman and others 2010a).

This paper shortly describes the rugby-ball methodology and how this methodology was applied to define the information needs from the National Policy Document. Then, the paper compares this study with an earlier, similar study that did not use the rugby-ball methodology and discusses the achievements from applying the methodology.

## 5.2 Short description of the rugby-ball methodology

The rugby-ball methodology has been developed on the basis of the analysis of the water information gap (Timmerman and others 2010b). It builds on a range of theories about strategic planning, information management, policy- and decision analysis, and indicators which were analysed and yielded procedures to support the development of the methodology. The methodology as developed is represented as a 'rugby ball' that symbolizes the initial diverging character of the process of specification of information needs that at a certain point should converge into a coherent plan (Figure 5.1) (Belton and Stewart 2002). This representation proved to be a powerful tool in communicating the method. The methodology is described in detail in Timmerman and others (Timmerman and others 2010a).

Five interrelated steps are discerned in the methodology: 1) Explore, to mark out the project; 2) Initiate, to communicate and verify the starting points; 3) Elaborate, to come to detail; 4) Conclude, to communicate and verify the results; and 5) Complete, to document the results and to plan subsequent steps.

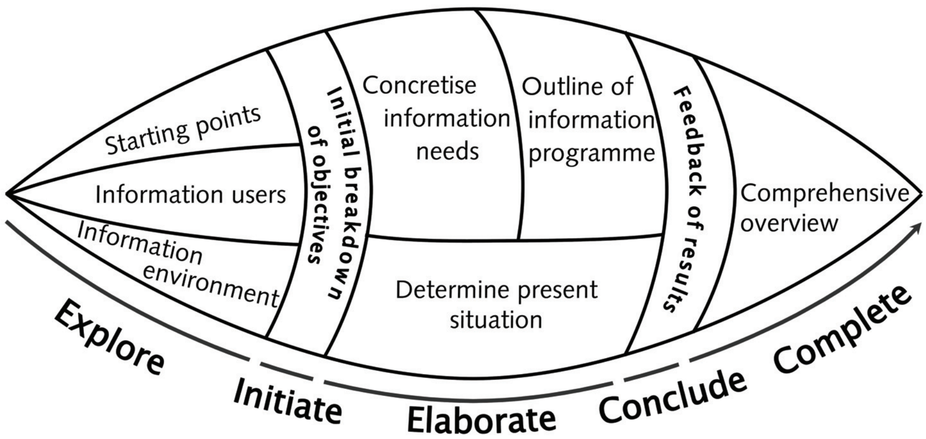


Figure 5.1 The rugby-ball framework for specification of information needs

The Exploration step entails in essence the CATWOE-analysis as used in Soft Systems Methodology (SSM). CATWOE stands for: (Basden and others 2004; Checkland 1981)

C: Customers: the victims or beneficiaries of the Transformation process (T). Here those who will be using the information; the information users.

A: Actors: those who would do the Transformation process (T). Here the organizations / departments / people involved in producing the information.

T: Transformation process: the conversion of input to output. Here the translation from policy objectives into meaningful information.

W: Weltanschauung: the worldview which makes the Transformation process (T) meaningful in its context. Here the role attached to information in the policy preparation, implementation, and evaluation process

O: Owner(s): those who could stop the Transformation process (T). Here the managers with a certain responsibility for information production.

E: Environmental constraints: elements outside the system which the system takes as given. Here issues like organisational policies, and financial, legal and ethical matters.

The CATWOE analysis helps in avoiding early conclusions by carefully working out a 'root definition' and expressing the domain of the problem. Note that Actors, Customers and Owners may overlap. The outcome of this first step, based on the CATWOE analysis, is an overview on the scope and goals of the information production. In addition, other approaches can be used if relevant. The International Risk Governance Framework, for instance, provides a well thought out approach when deciding on which Customers and Actors to involve depending on the issue at hand (Bunting 2009).

The goal of the Initiation step is to bring all the people involved on the same level of understanding and to agree upon the results of the Exploration phase. The step aims at developing a mutual appreciation among the different actors (information users and information producers) of each other's views and problems and leads to the necessary transparency and reduction of the subjectivity of the problem.

The actual specification of the information needs takes place in the Elaboration step. A translation is made of policy objectives into information needs through a hierarchy of objectives. Two types of objectives are distinguished here: the fundamental objective that characterises an essential reason for interest in the decision situation and the means objective that is of interest in the decision context because of its implications for the degree to which another (more fundamental) objective can be achieved (Keeney 1992).

In the Conclusion step, all actors in the process get feedback on the results and the draft information network as developed in the previous phases. In this way outcome of the Elaboration step is brought back into a discussion between information users and information producers.

Finally, the Completion step wraps up the results of the process and agreements of this workshop into a 'blueprint' for the information network to be developed upon the information needs. This result is also needed to evaluate if the information as specified is actually produced in the end.

## 5.3 Introduction of the case: The 4th National Policy Document on Water Management (NW4)

The 4th National Policy Document on Water Management (NW4) (Anonymous 1998b) sets and documents the Dutch policy in water management in 1998. The document lays down the state of the art on the different issues as valid for 1998 and provides a future outlook into the overall goals and aims of, and the reasoning behind the water management approaches. This is essentially the policy that is consolidated at the end of the policy formulation phase in the policy life-cycle (Pahl-Wostl 2007; Winsemius 1986) but the document covers many different water management issues that are each in a different phase of policy development, as will be discussed later.

The main water management aim as laid down in NW4 is "To have and maintain a safe and habitable country and to develop and maintain healthy and resilient water systems which will continue to guarantee sustained use" (Anonymous 1998b). This is the baseline direction, the fundamental objective of the water policy. NW4 is the result of a public consultation process which gave all those involved in Dutch water management the opportunity to express their views on the future water management. It advocates improved coordination between policies on water management, spatial planning and the environment.

Box 5.1 Text from NW4 on the major rivers, citation from English version (Anonymous 1998b).

**The major rivers**
With regard to the major rivers, the main challenge over the coming decades will be to maintain flood protection in the face of larger design discharges, while at the same time conserving landscape, ecological and historical features, promoting navigational use and creating new wildlife areas. In other words, integrated river management. Sustainable flood protection along the rivers will be achieved through a combination of measures: strengthening the dikes to the agreed levels, retaining the water, giving the rivers more room to expand and taking precautionary measures.

Integrated river management calls for an approach encompassing the entire river basin. Close cooperation with the other riparian states along the Rhine, Scheldt and Maas will be vital. Water management, spatial planning and habitat creation will go hand in hand.

**What are the aims?**

Over the coming decades, the winter beds of the major rivers will undergo dramatic changes. Fifteen years from now, the rivers should be flowing over beds designed to optimise the safe discharge of water and ice. Barges will be able to make their way easily between the seaports and the hinterland. The major rivers will form blue ribbons connecting the North Sea and areas upstream and the winter beds will be closely related in ecological and landscape terms to adjacent areas outside the dikes and beyond. A few polders and other areas will be reserved for temporary storage of water during times of exceptional peak discharges.

The achievement of this scenario will be associated with a radical reassignment of functions and large-scale engineering works. Rivers will be given room to expand as they did in the past, primarily by making their winter beds broader and deeper. Here and there, a main dike may be moved to landward, but landscape, ecological and historical features will be respected and integrated wherever possible. The river landscape will change, but will remain typically Dutch: small-scale landscapes will open out occasionally into sudden wide panoramas, and riverside towns and villages will not be allowed to expand at the expense of the river, but will retain their links with it. The area around the major rivers will be a splendid place for people to spend their leisure time.

**What are we going to do?**

- Allow the rivers more room to expand. Wherever possible, unnatural obstacles will be removed, side-channels will be restored and winter beds will be deepened (central government).
- Draft plans to expand the flow area and storage capacity of the Rhine and the Maas and to reduce peak water levels in these rivers. These plans are to be completed by the year 2001 and implemented by 2015 (central and local government). This will create many opportunities for enhancing the National Ecological Network of protected areas.
- Dike strengthening will become the flood protection measure of last resort.
- Increase coordination between water management, spatial planning and habitat creation. The long-term strategy for the major rivers will be rooted in national spatial planning policy.
- Encourage the rapid establishment of international action programmes for the protection and exploitation of the major rivers and the achievement of sustainable river flood protection. A high priority will be given to implementing these programmes.
- Promote efficient navigation by dealing with deficiencies in the inland waterway infrastructure.
- Give a high priority within regional and urban water management to more prolonged retention of water within river basins.

NW4 specifically targets the possible rising of the sea level as a result of the climate change as this is a major threat for the Netherlands as already half of the country lies below sea level only protected by dikes and coastal dunes. The decision stakes are consequently high as well as the systems uncertainties. This situation, together with the multiplicity of actors involved in the decision-making is described in literature as a complex and unstructured problem situation (Funtowicz and others

1999).(Rittel and Webber 1973; van der Brugge and others 2005) Structuring of the problem is needed to be able to handle the situation.

NW4 lays down the consensus on the norms and values attached to the problem situation for the Ministry of V&W by describing a series of policy objectives for different themes, that together help reaching the main aim. These objectives and sub-objectives were the basis for the breakdown into information needs. NW4 puts emphasis on implementing measures to achieve goals. This meant a shift in policy attention from compliance monitoring, which was the focus in the 3rd National Policy Document on Water Management (NW3), towards increasing the importance of evaluating if the measures are actually taken and if they lead to improvement. NW4 does not explicitly state what information is needed. There is consequently no agreement about the necessary knowledge and information. This problem situation where the norms and values are known but the necessary knowledge and information remains unclear is, according to Hisschemöller and Hoppe (1995), a moderately structured problem situation. Specifying the information needs as the first step in developing an information producing system as the study intends to do, will be the way to turn this moderately structured problem into a structured problem.

## 5.4 How the rugby-ball methodology was applied

The study was initiated and jointly carried out in 1998 by the Institute for Inland Water Management and Waste Water Treatment (RIZA) and the Institute for Coastal and Marine Management (RIKZ), two former institutes within RWS that were responsible for the inland and coastal water quality monitoring respectively. The first author of this paper was the project leader for RIZA. A steering group for the study was installed, comprising two representatives of the policy department of the Head office of RWS as the client of the study representing the information users and managers from RIZA and RIKZ representing the information producers.

The aim of the study was to specify the information needs based on NW4 on an abstract level. Full elaboration of the information needs was envisaged for a later stage through one or more projects that would further develop the information needs up to a level that was suitable for the design of a monitoring network. Shortly after this study was finalised the European Union Water Framework Directive came into force and attention within RWS changed towards implementing that Directive. Also RWS started to reconsider its organisational setup, which resulted in restructuring of the organisation. Because of these factors, the outcomes of this study were not further elaborated as was initially intended.

The study followed the phases in the rugby-ball framework. In the Exploration step, a series of semi-structured interviews were conducted with five high-level managers, all working in the field of water management and -policy within the Ministry of V&W and RWS, who were identified by the steering group as representing the Owners of the process. The interviews were reported and the reports were sent to the interviewees for comments and approval.

The Initiation step consisted of a one-day workshop that was conducted on 20 May 1998. An input document (Schobben and others 1998a) was developed in preparation for the workshop that presented an overview of the results of the Exploration step. Invitations were sent to the people identified as information users in the Exploration step, including an open invitation for other interested people. At the workshop, twenty-one participants from various RWS organisations (Specialist Departments, Regional Departments and the Head Office) were present as well as two participants from the Ministry of Agriculture, Nature and Food Quality (LNV) and the Information and Knowledge Centre (IKC) of LNV respectively. LNV has an important stake in water management both through the importance for the ecological situation as well as for agriculture. A representative of the IKC did the facilitation of the workshop. The workshop consisted of plenary sessions and breakout group sessions. Participants were mostly from middle management, others were experts. Most participants represented the information users. The outcomes of the workshop were reported and send to the participants for comments and approval.

In the Elaboration step, analysing the text of NW4 and constructing hierarchies of policy objectives structured the objectives. Box 5.1 provides the abridged (English) text from NW4 about the major rivers. The Dutch document in addition to this text provides an explanation and the Dutch text was used in the analysis. Figure 5.2 provides as an example a representation of the policy objectives hierarchy related to the major rivers based on the NW4 text.

The policy objectives hierarchies were used as input for discussions in 40 interviews with experts from the relevant policy fields. The interviews were semi-structured interviews in which the interviewees were asked to evaluate the analysis as presented in the policy objectives hierarchies. The steering committee and the project team were jointly responsible for the selection of experts to be interviewed by identifying those people that play a central role in the development and implementation of each of the policy issues and can be considered information users. The list of experts was also discussed with the interviewees in order to identify possible omissions in the selection. Reports of the interviews were sent to the interviewees for comments and approval.

- Major rivers (excluding safety)
  - Conserve landscape, ecological and historical features
    - The major rivers will form blue ribbons connecting the North Sea and areas upstream
      - Enhance the National Ecological Network of protected areas
      - Remove unnatural obstacles
      - Restore side-channels
  - Promote navigational use
    - Barges will be able to make their way easily between the seaports and the hinterland
      - Promote efficient navigation by dealing with deficiencies in the inland waterway infrastructure
  - Create large units of natural areas
    - The winter beds will be closely related in ecological and landscape terms to adjacent areas outside the dikes and beyond
      - Enhance the National Ecological Network of protected areas
      - Increase coordination between water management, physical planning, and habitat creation
      - The long-term strategy for the major rivers will be rooted in national physical planning policy

Figure 5.2 Policy objectives hierarchy as described in NW4 for the large national rivers, excluding the theme 'safety'

The report of the Elaboration step that was developed as input document to the second workshop (Schobben and others 1998b) carefully describes the steps in the process supported by the rugby-ball framework, the people involved in the process, and the results of the analysis, both in writing and in an overview table. The one-day Conclusion workshop was held on 25 November 1998. Invitations were sent to the people invited for the first workshop and others that had become involved during the process. There were 43 participants, 39 from RWS, 2 from the National Institute for Public Health and the Environment (RIVM) and 2 from LNV. The participants were middle managers and experts involved in policymaking and implementation, as well as in information production. A representative of the Ministry of V&W did the facilitation. The workshop consisted of plenary sessions and breakout group sessions. The outcomes of the workshop were reported and sent to the participants for comments and approval. Thirteen of the participants present at the Initiation workshop were also present at the Conclusion workshop. The increase in number of participants relative to the first workshop indicates that the study appealed to the people that had become involved in the process.

The Completion phase comprised developing the final report of the overall process and its outcomes, as well as the final conclusions (Schobben and others 2000). This report was to be used as the basis for the follow-up studies and consequent development of an information strategy. On the basis of the final report, also a management brochure was made summarising the conclusions and the major issues reported (Anonymous 2000) to disseminate the results of the study to a wider audience.

## 5.5 Results of the study

### 5.5.1 Results of the Exploration step

The initiators of the study had set out for an integrated approach and were of the opinion that the 'basic information' network was to be extended to include information about the sources of the problems as well as the implementation and evaluation of measures. Covering these aspects in their opinion would reduce the divide between information production and policy-making. The Owners (O) of the process however regarded collecting information on implementation and effectiveness of policies (do the implemented measures lead to the desired results?) as being part of the policy analysis process, which takes place outside of the information production process. This was the Weltanschauung (W) of the Owners for the study. The concept of 'basic information' was therewith limited to information on status and trends and for operational water management. Information on the wider context of water management was excluded.

The Owners acknowledged the need for close cooperation between information users and information producers on the issue of information production. They regarded the rugby-ball methodology as a logical framework that could add to the existing practice and adopted the methodology to guide the Transformation process (T) of going from policy objectives to information needs.

The Environmental constraints (E) as defined by the interviewees were that policies from ministries other than V&W were excluded from the study. Moreover, the information needs should have a national interest, which implied that information needs for the RWS regional departments and information collection for research purposes were excluded from the study.

To avoid a lengthy process of iterations in case of disagreements from these initial boundaries, the Owners mandated the participants of the Initiation workshop to deviate from these conclusions. This provided the initiators with sufficient support to enter the study. The Exploration step thus formalised the process and built support from the higher management.

### 5.5.2 Results of the Initiation step

The discussions in the Initiation workshop focused on the Weltanschauung and Environment constraints as defined in the Exploration phase. Especially the issue of how to define and delimit 'basic information' was extensively discussed. RWS was at the time responsible for both operational water management and water policy development. Collecting information solely for the first issue would go at the expense of a sound basis for water policy development. The outcome of the discussion was that an integrated approach was appropriate here, comprising information on hydrology, chemistry and ecology, as well as information on economy and society. Besides this, policy performance monitoring, comparing the effectiveness of policies to the level of implementation of the policy, was to be included to cover for the responsibilities of RWS. This result implied broadening of the Weltanschauung.

During the discussions the participants noted that arguments were based on different perceptions of how information is collected and aggregated. These different perceptions influenced the way the participants considered their contribution and they therefore decided to change the workshop agenda and discuss this topic in depth. It appeared that the differences emerged from two different models on how information from different water management levels is interlinked. It was realized that information was collected within different layers of the National Government (e.g. regional directorates of RWS) and by the water boards which are rather autonomously functioning regional water authorities. One model is a hierarchical model in which the information needs needed at a higher government level is collected at and aggregated from lower levels. The model stresses the primacy of policy over the administrative function of information collection with little communication between the two. The other model is based on the idea that each level collects its own information and consequently supports its own information needs. Part of the information needs however overlap and communication between the levels must prevent double work. This model builds on the cooperation between the different institutions each responsible for their own information collection with close communication. These two models emanate from different views on the governmental steering models and thus reveal differences in mindsets or mindframes.

The discussion on the two different models made the participants acknowledge that differences in perceptions hindered their discussion. Although no agreement was reached, mutual understanding of the different responses to the problem situation developed. The goal of the Initiation step to come to a common understanding of the study as well as a mutual appreciation of each other's viewpoints was thus achieved.

### 5.5.3 Results of the Elaboration step

The structured approach through the policy objectives hierarchies was positively received by many of the interviewees as it helped them structuring their thinking. On the other hand, some interviewees felt that the structure of the policy objectives hierarchy was limiting their line of reasoning. Various authors (Hopstaken and Kranendonk 1991) distinguish between ‘design’ and ‘development’ people. People having a ‘design’ style of thinking emphasise formal rules and will presumably easier adopt the structuring of the policy objectives hierarchies than people that have a ‘development’ style of thinking that are more inclined to observe in a sensing way and who may feel limited by the structure (Mintzberg and others 1998). The semi-structured interviews gave the interviewees sufficient room for elaboration along their own lines of reasoning. The policy objectives hierarchy, if used by an interviewee, served its purpose of clarification of the objectives to support identifying the relevant information. None of the interviewees however adopted the hierarchies as accurately describing the policy problem and they were therefore not used for the further analysis.

The policy life-cycle as described by Winsemius (1986) was a generally known and accepted structure in RWS and was adopted in the Initiation workshop to characterise the policy situation of the different policy issues. The cycle describes four phases in the process of policy making; Problem recognition, Policy formulation, Policy implementation, and Control. The cycle compares to other policy cycles like, for instance, the adaptive management cycle as described by Pahl-Wostl (Pahl-Wostl 2007) that includes the phases Policy assessment of the status, Goal setting, Policy formulation, Policy implementation, and Monitoring and evaluation. The policy issues discerned in the study were classified in one of the four phases during the interviews. Moreover, the interviewees were asked if the information need that was specified would be structural information needed for a longer term or was short term, temporarily needed information, and if the need for information was expected to increase, decrease, or remain at the same level.

Based on the interviews, a series of descriptions was made consisting of the changes in the policy that NW4 contains relative to NW3, the desired changes in information needs, and a short summary of the outcomes of the analysis and the interviews. The result of the analysis was also summarised in a table. Table 1 shows the part of the full table related to the major rivers.

Table 1 shows the transformation from policy objectives into information needs based on the input of information users, specified on an abstract level as was planned. In general, the information needs as specified are connected to means objectives (e.g. ‘increase spatial continuity’, ‘minimise costs’) and only few are connected to fundamental objectives (‘improve the ecological situation’). Also, few criteria or standards were defined to determine if these fundamental policy objectives were reached. Possibilities for policy evaluation are therefore limited if the information is produced on the basis of these information needs. An important reason for the focus of the information needs on means objectives is that NW4 is specifically deals with the measures to be taken and the outcome of this study reflects this point of departure.

### 5.5.4 Results of the Conclusion step

The overview of information needs was presented at the workshop and was readily accepted by the participants who generally expressed their appreciation of the work. Only few, minor changes were included. The participants appreciated the information needs as relevant and linked to the policy-context. The result of this step was consensus about the outcomes of the process. The steps in the process, the people involved and the results had all been explained and were approved by the participants of the workshop.

### 5.5.5 Results of the Completion step

This step comprised developing the full report of the study (Schobben and others 2000) as the basis for follow-up studies as well as a summary report (Anonymous 2000) to disseminate the results of the study to a wider audience. Completing these reports took a rather long time as it was given low priority. For this reason it is essential that this step is integral part of the methodology and a study cannot be finalised without this step being completed.

At the end of both workshops, a short oral round of experiences in the workshop was requested from the participants. In general, the participants were positive about the support provided by the methodology and considered being closely involved in assessing the information needs an improvement relative to the existing practice.

## 5.6 Discussion: Did the study lead to improving the information needs?

After adoption of the Third National Policy Document on Water Management (NW3), the changes in information needs on the basis of the changes in water policy and water management were assessed. That study comprised a desk study to assess the inland water quality information need from NW3 on the basis of a literature review and expert knowledge and was limited to physico-chemical parameters. The resulting list of parameters was presented to and discussed with selected information users and subsequently approved and was the basis for the improvement of the monitoring network (Breukel and Schäfer 1991).

The differences from the approach in the NW4 study are clear. The NW3 study is a good example of a thorough study to define information needs and putting this into a context. As such, it explicitly attempted to link to the information users, which was rare practice in the early 1990's. With the more advanced knowledge about the water information gap in the late 1990's this approach was no longer sufficient. Compared to the NW3 study, the NW4 study as described in this paper is much better equipped to bridge the water information gap. Firstly, the outcome of the NW4 study is a result of a joint effort of both information users and –producers whereas the outcomes of the NW3 study are the result of the effort of information producers, merely accorded by information users. Secondly, where the NW3 study took a bottom-up approach by providing a list of parameters and the reasons why they are linked to the policy objectives, the NW4 study started off from the policy objectives and then described the link between the policy objectives and the connected information needs, thus explicitly linking to the context of the information users. Thirdly, the NW3 study only concentrated on physico-chemical parameters and a few biological characteristics. The information needs from the NW4 study on the other hand include ecological as well as socio-economic determinands. The NW4 study consequently improved links to the information users as compared to the NW3 study.

In 1999, the Institute for Environmental Studies in Amsterdam conducted 8 semi-structured telephone interviews to determine how the rugby-ball methodology performed and what aspects were to be improved (de Boer and Hisschemöller 1999). Four of the interviewees had been involved in the NW4 case study as participants. Six of the interviewees had been responsible for applying the rugby-ball methodology in one or more projects, either as manager or as project leader. All interviewees mentioned that the rugby-ball had made people more aware of their relative position in the information production system, which was considered a positive improvement. This specifically related to the fact that the methodology had made people very much aware of the question what information is really needed. One interviewee voiced this as follows: “It led to new insights and a discussion about responsibilities”. Several interviewees mentioned that the methodology also led to improved communication between different departments and organisations, even after finalising the projects. As one of the interviewees said, the methodology “creates a connection between policy and science”. The resulting information needs were considered an improvement compared to the existing situation by all interviewees.

Table 1 Overview of information needs (selection from table, showing the objectives for the major rivers) (Schobben and others 2000).

| **Policy- or management objective** | **Specific objectives** | **Attribute used to quantify the achievement of the objective** | **Concrete example of determinands to be measured** | **Structural or temporary** | **Increase or decrease of interest** | **Principal information users [a]** | **Phase in policy life cycle** |
|---|---|---|---|---|---|---|---|
| | | | *Major rivers (excluding safety)* | | | | |
| Accomplish the water-related part of the National Ecological Network (NEN) | Increase spatial continuity (reduction of unnatural obstacles) | Number of areas isolated from each other by land use types other than … | Land use of the flood plains (for instance buildings, roads, etc.) | Structural | Neutral | RD | Policy implementation |
| | Improve soil quality | Soil quality in flood plains | Soil bio-chemical parameters evaluated against standards | Temporary | Increase | RD | Policy implementation |
| | Increase in ecological friendly areas | Surface area of ecological friendly areas (desired ecotopes) | Area of (desired) ecotopes (environmental friendly banks, fish passages, softwood floodplain forests, etc.) | Temporary | Neutral | HO, RD | Policy implementation |

| Policy- or management objective | Specific objectives | Attribute used to quantify the achievement of the objective | Concrete example of determinands to be measured | Structural or temporary | Increase or decrease of interest | Principal informa-tion users [a] | Phase in policy life cycle |
|---|---|---|---|---|---|---|---|
| | | | *Major rivers (excluding safety)* | | | | |
| | Minimise costs of measures and management in connection to nature restoration | Costs of nature restoration measures | Total costs and benefits of restoration | Temporary | Increase | HO, RD | Policy implementation |
| Adapt uses to new requirements resulting from NEN | Adapt the intensity and temporal and spatial spread of uses to the requirements of the NEN. | Temporal and spatial spread of land-use, recreation and navigation | Nature and recreation in flood plains | Structural | Increase | RD | Policy implementation |

[a] RD = Regional Department of RWS, HO = Head office of RWS, SD = Specialist Department of RWS

## 5.7 Reflection on the methodology

The approach of specifying information needs through an analysis of policy objectives taken in this case study was new to the RWS organisation. The idea and overall approach of the rugby-ball methodology was nevertheless welcomed by the RWS organisation and cooperation throughout the study was good. Within the RWS organisation many large projects are carried out based on extensive planning and employees are used to applying design approaches. Even people with a development style of thinking, who tend to feel limited by what they consider a rigid scheme, often recognise the added value of a structure. This mixed feeling towards design approaches is voiced in the study by de Boer and Hisschemöller (1999) where one of the interviewees, who had been project leader of an extensive project in which the rugby-ball framework was applied, signalled that he had somewhat contradictory wishes. On the one hand he needs a framework for reporting, not to overlook things and to come to the right level of detail. On the other hand, he does not want to be pushed into a rigid scheme. He was nevertheless positive about the use of the rugby-ball framework in his project because (1) the need for monitoring was made explicit on a very detailed level, (2) his project was divided into four parallel tracks that each worked on a separate theme and the rugby-ball framework enabled comparability between the four monitoring plans, and (3) the step by step elaborating of the information needs enabled the process to be slowed down at times when there was a danger of speeding. The hopscotch character of the rugby-ball framework in this way supports both design and development styles of working; the hopping possibility provides 'development' people with the possibility to step in and out of the process while they can identify how and where in the process their input will be used. The overall structure on the other hand appeals to 'design' people who can closely follow the process and identify their inputs.

The methodology is designed as a social learning process (Timmerman and others 2010a). Next to the process design this requires institutional support, facilitation and leadership while the participants must be willing to share their views (Woodhill 2004). The methodology provides both an analytical procedure in the Exploration and Elaboration steps as well as a deliberative approach in the Initiation and Conclusion steps to support this (Stern and Fineberg 1996). The Exploration step proved indispensable in the process as the institutional support for the process was established here by setting the scope of the study. The Owners established leadership by adopting the process and assigning the mandate for decisions to the steering group. The participants to the workshops showed their readiness to exchange views and to learn, which resulted in new insights and improved results. The methodology is consequently in practice able to support a social learning process.

In rather unstructured situations, the interviewees felt the need for more preparatory work, more support from experienced facilitators and a better grip on the process of specifying the information needs. One of the interviewees stated that "one should be forced or at least have handles to clearly describe the information needs". In some projects, frameworks were created to structure the information situation. According to Bardwell (Bardwell 1991), to frame a problem it is necessary to both manage the process as well as to organise the problem. From this study it is concluded that where the rugby-ball is suitable to manage the process, it fails in organising the problem. The methodology therefore needs improvement to include this latter aspect.

## 5.8 Information needs in different phases of the policy life-cycle

The NW4 study next to testing the rugby-ball methodology and providing an overview of the information needs yields another result. Winsemius (1986) described that the political attention increases in the first two phases of the policy life-cycle and decreases in the final two phases. Cofino (1995) noted that different types of information are needed in different phases of the policy life cycle and that higher political attention goes hand in hand with increased information needs and vice versa. As both the phase in the policy life-cycle as well as the increasing or decreasing of the information needs is included in this study, one specific outcome of this study is that these notions can be tested.

Table 2 provides an overview of the number of information needs in the overview table from the final report classified according to the phases of the policy life-cycle, the expectations of the interviewees of increasing, neutral, or decreasing interest, and a structural or temporary nature. Information needs are considered to increase or decrease along with the interests. To determine the number of information needs, each row in the overview table from the final report is counted as one information need.

Table 2 Number of information needs in the different phases of the policy life cycle that are attributed increasing, neutral or decreasing interest and structural or temporary nature (Schobben and others 2000) [a].

| | | Phase in policy life-cycle | | | | Total |
|---|---|---|---|---|---|---|
| | | Recognition | Policy formulation | Policy implementation | Control | |
| Increase | Temporary | 3 | 5 | 3 ½ | | 11 ½ |
| | Structural | 5 ½ | 3 ½ | 5 ½ | 4 | 18 ½ |
| Neutral | Temporary | | | 1 ½ | | 1 ½ |
| | Structural | ½ | 2 ½ | 6 ½ | 1 | 10 ½ |
| Decrease | Temporary | | | | | |
| | Structural | | | | 3 | 3 |
| Total | | 9 | 11 | 17 | 8 | 45 |

[a] The information needs that were labelled as Increase/Neutral are counted as ½ in both the rows Increase and Neutral.

The overall interest is increasing or neutral as shown in table 2. This is in accordance with the observation of Bemelmans (1989) that people tend to refer to the existing situations and tend to ask for additional information. The existing information is in such a situation not something that is easily discarded as obsolete. Next to this, legal obligations for monitoring will hinder any decrease in information needs.

Comparing the information needs in the different phases of the policy life cycle, it is clear that increasing interests exist in all phases (Table 2). In the Recognition phase, where usually only new information is needed, neutral interests are barely present while there are no decreasing information needs. In the Policy formulation phase the information base is built up. In this phase there is a similar increase as in the Recognition phase, but some of the information needs that are already in place will remain. In the Policy implementation phase there is still an increase in need for information as well as a continuation of an existing knowledge base. In the Control phase finally, the need for increasing the information still exists. Apparently, the available information that is already collected is not considered sufficient. Nevertheless, only in this phase some of the available information becomes obsolete. Temporary interests, related to research or inventories, are present in the first three phases. Structural interests, pre-eminently related to the monitoring type of information, are important in all phases, but increasingly with progress of the policy life cycle. All this confirms the notions of Cofino (1995) describing the relationship between policies and information.

## 5.9 Conclusions

This paper shows that the rugby-ball methodology improves both the translation from policy into science as well as the communication between information users and information producers. The steps in the rugby-ball framework proved to be instrumental for the process in the following way;

1. The Exploration step set the boundaries for the work and enabled to establish the necessary support for the process.
2. The Initiation step served its purpose of adopting the approach and the given boundaries, but also enabled adaptation of the boundaries.
3. The Elaboration step then certified that the policy objectives were clarified through the interviews. Structuring of the policy objectives with the use of policy objective hierarchies enabled clarification of the values of the participants.
4. The Conclusion step enabled the approval of the outcomes of the process.
5. The Completion step finally ensured proper documentation of the outcomes that can act as the fist step in following phases.

Also, the information needs link to the context of the information users through the explicit breakdown of policy objectives into information needs. Moreover, the information users perceive the information needs as improved relative to a situation where no methodology was used. The methodology is consequently able to improve the salience of the information thus narrowing the water information gap.

The methodology nevertheless has two shortcomings that need improvement. Firstly, the methodology lacks a structure to guide the breakdown of policy objectives into information needs. To deal with this, a conceptual model needs to be developed. Such a structure is meant to create an overview that contains a logic structure and can be used to prioritise. The structure that has been developed on the basis of this and other studies is described in Timmerman and others (Timmerman and others 2010a).

Secondly, more attention is needed for preparation of the workshops. The goals of the Initiation and Conclusion workshops have to be very clear and also the roles of the participants in this workshop must be clarified beforehand. Moreover, the actual discussion on the information needs as derived from the policy objectives needs to be discussed in specific, targeted workshops during the Elaboration step. All this supports the participants in contributing to the process and enables them to cooperate, despite differences in mindframes.

This paper also supports the notion that in different phases of the policy life-cycle different types of information are needed. The policy implementation phase for instance is evidently the phase where the need for information is highest. This conclusion stresses the importance of both a flexible process of specification of information needs as well as an iterative process of producing information through a cyclical approach as depicted in the information cycle (Timmerman and others 2000).

# CHAPTER 6

# SPECIFYING INFORMATION NEEDS: IMPROVING THE WORKING METHODOLOGY


## *Abstract*

*Specification of information needs is an important step in the design of monitoring networks. Within the framework of Monitoring Strategy 2000+, a programme of the Dutch Directorate General of Public Works and Water Management (Rijkswaterstaat) which seeks to provide innovation in the monitoring sector, a method has been developed to link water management policy to monitoring through specification of information needs. Over the past two years, this method has been applied in several projects within the Rijkswaterstaat organisation. Use of this method has led to improvements in the monitoring practice and was judged very positively by the people involved. Nevertheless, the main obstacle to employing the method was the actual translation of policy matters into information products. A special study is carried out, focusing on this aspect within the method, to provide the participants of a project with a mental framework that enables them to clearly specify their information needs. The major requirements for this mental framework are that all participants have a clear view of the process (system), and that they are able to relate their contribution to this process and to the contributions of others (transparency). The first step of the process is to focus the attention of stakeholders on the information they will actually need for decision-making. The next step is to confront the different expressed opinions through the method of the 'devil's advocate', which implies criticising the results of the first step by finding as many as possible arguments against these opinions. This should force the stakeholders to better specify their arguments. The method, its improvements and the results of one pilot project will be discussed in this paper.*



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## 6.1 Introduction

Policy-makers and water managers are overwhelmed with data and pieces of information that may or may not be of use to them. Ward and others (1986) have described this 'data-rich but information-poor syndrome' and more than a decade later, this 'syndrome' still exists. For instance, at the conference 'Bridging the Gap' at the end of the 1990s, a conference on new needs and perspectives for environmental information, it was concluded that at present some of the systems for monitoring and gathering information about the environment in European countries are inefficient and wasteful. They generate excessive amounts of data on subjects that do not need it; and they fail to provide timely and relevant information on other subjects where there is an urgent policy need for better focused and consistent environmental assessment and reporting (Pentreath 1998). Within the Dutch Directorate General of Public Works and Water Management (Rijkswaterstaat), part of the Ministry of Transport, Public Works and Water Management, this problem was recognised and action has been taken to solve it. The adoption of the information cycle (figure 6.1) as a framework to describe the process of information production was a first step. The next step was the development of a method for the specification of information needs. This method is represented as a 'rugby ball' (figure 6.2) symbolising the initial diverging character of the process that at a certain point should converge into a coherent plan. This representation proved to be a powerful tool in communicating the method. The method consists of a five-step plan, all steps being interrelated: 1) exploration, to mark out the project; 2) tuning, to communicate and verify the starting points; 3) elaboration, to come to detail; 4) conclusion, to communicate and verify the results; and 5) completion, to document the results and to plan subsequent steps. The method is further described in Timmerman and Mulder (1999).

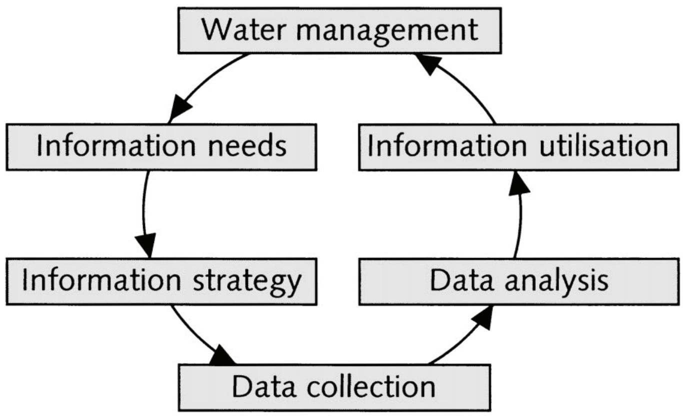


Figure 6.1 The information cycle (Adapted from Timmerman and Hendriksma 1997)

Although the method provided a good basis for linking policy to information production, experience in using the method showed that the major obstacle was to define the information needs in such a way that a monitoring network could be defined from it. A project was started to improve the method in this respect. Four phases were identified for the project: 1) diagnosis of the bottlenecks of the method as used; 2) adaptation of the method to obtain a better result; 3) testing of the adapted method in two pilot projects; and 4) evaluation of the method and reporting.

In this paper, the results of this project after the completion of a pilot exercise are presented and discussed.

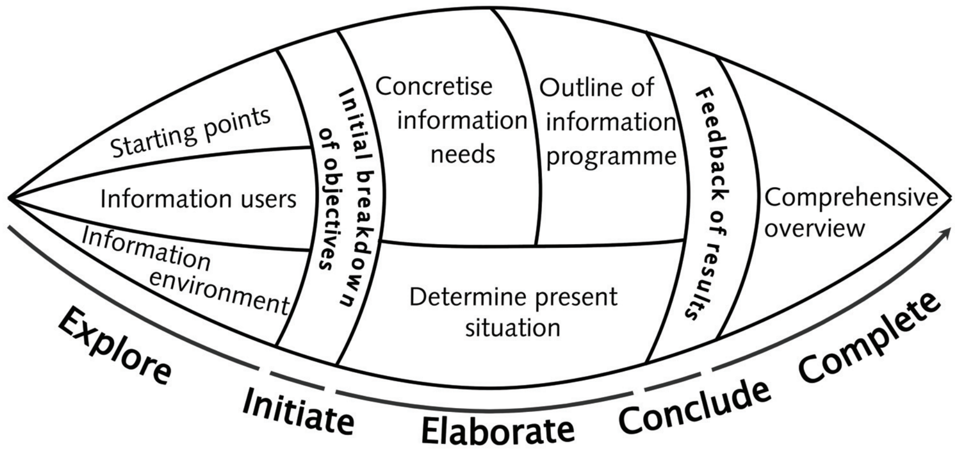


Figure 6.2 The five-step method for specification of information needs (Timmerman and Mulder 1999)

## 6.2 Diagnosis

To make a diagnosis of the weak points in the method, a number of people who had experience in applying the method were interviewed. From these interviews, three types of application situations were distinguished: relatively structured information problems, not very related to policy matters; relatively unstructured information problems in the context of ambitions to develop more integrated information systems; relatively unstructured information problems in the context of a pragmatic approach to information systems.

Application of the method in relatively structured information problems (with clear policy objectives and known relevant circumstances and useful parameters), such as information for operational water management, yielded little in the way of bottlenecks. In these cases, the method was focused on discussing the parameters. Information needs were not explicitly specified.

Application of the method in unstructured information problems revealed more shortcomings of the method. In these cases there was a need for more preliminary work, more assistance and a better perception of the start and end of the method. It appeared that in these cases the information has to serve several purposes, such as policy-evaluation, policy-analysis and related reports. The various objectives put different requirements on the information which hinders the adoption of an unambiguous perspective, like the question “What kind of decisions have to be taken on the basis of this information?“. Further, no clear distinction was made between specification of information needs and specification of information strategies. This blurs the outcome of the method and has led to diverging results. Also in the projects, information users and information producers were not intended to have their own role as it was considered enough to improve the contact between these groups, which normally do not run across each other. Consequently, the specific contribution of information users and information producers to answering the questions remained unused.

These observations may be seen against the background of the distinction between operational information and strategic information. Operational information is used for structured activities with a clear target while the relevant conditions and the actions to be performed are known. Information is needed to decide what action is necessary at what moment. An example of operational information is information that is needed to navigate, for instance signposts in a hospital or airport. Strategic information is needed when the tasks are not structured, like policy and management issues. Such issues have no clear structure because of the complexity of the targets, circumstances and possible actions. This is related to conflicting demands but also to different perceptions of the nature of the issue.

Strategic information should assist in structuring the issue and in clarifying what decisions should be taken. To deal with unstructured issues, strategic planning was developed in the 1970s. Strategic planning works systematically towards making the targets more explicit and exploring and predicting the circumstances that influence the achievement of these targets, followed by evaluation of possible strategies. In practice, this approach has some disadvantages in which the following factors play a role (Mintzberg and others 1998):

1. Formalised planning is based too much on abstracted and aggregated data;
2. Too little attention is paid to the strategic significance of concrete details and synthesis of findings;
3. Managers need alternative views on strategic possibilities, not uniform schemes;
4. ‘Hard’, factual data have limitations; on closer inspection they are not as ‘hard’ as they appear, they are often not available in time and do not cover all relevant aspects of the problem.

These disadvantages are partly in line with differences in styles of thinking (Hopstaken and Kranendonk 1991; Mintzberg and others 1998):

Design: Some people have a recording style of observation and are inclined to solve problems in an analytical way. They emphasise formal rules and explicit knowledge of the trouble-spot and formally record procedures in handbooks. Some characteristics are: a focus on quantifiable aspects; general design rules used to cope with change; the process of change is seen as a linear, finite and discontinuous process.

Development: Others are more inclined to observe in a sensing way, relying on intuition and implicit knowledge of the trouble-spot, which has more context than words can express. Emphasis is concentrated on developing ideas. Much attention is given to social and political, usually qualitative aspects; the specific situation is taken as the starting point for change; and change is viewed as a cyclic, open ended and continuous process.

Distinguishing between these styles of thinking is less important in operational matters, because the actions are known and it is only the information that determines the action to be taken. In strategic contexts, however, these styles can lead to quite different courses of action while it is not possible to determine which the better way is. When strategic issues are at stake, the use of a method such as a general design rule with a composite quantitative score will appeal to ‘design’ people, but will prove unacceptable to ‘development’ people.

The ‘rugby ball’ method contains many aspects of the ‘design’ approach. Yet it is not meant to be an established route but rather to provide handles with which the process can be implemented. The method should provide a framework for stakeholders to give them insight into the process. Within this framework individual ideas can develop further. The issues we are facing in specifying information needs are not strictly operational or strategic but represent an intermediate position. In most cases, there is knowledge about the targets, relevant circumstances and possible measures as laid down in policy documents. The policy takes the form of an integrating decision model, integrating social and economic aspects, like the use of a water body, with targets for water quality and quantity. Decisions are based on balancing measures that may be needed at a certain moment. This integrating decision model, which might result in some kind of multicriteria or multi-attribute evaluation (Keeney 1992; e.g. Von Winterfeldt and Edwards 1986), is here the starting point in specifying information needs. The policy-maker must reflect on the fundamental objectives that are relevant for a water body and then think along two lines (figure 6.3). One line is making criteria for objectives operational. The other line is making an inventory of problems and related measures that may influence the reaching of the objectives. Along these lines, the policy maker works towards specification of information that is needed to balance between future measures.

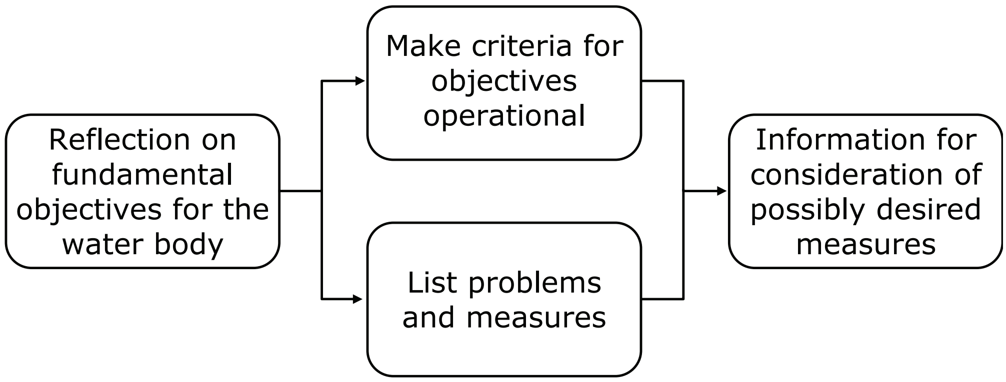


Figure 6.3 The integrating decision-model as a basic concept for specification of information needs.

A number of items have to be accounted for when this integrating decision-model is used for specifying information needs (Keeney 1992; Von Winterfeldt and Edwards 1986):

1. It is essential that all people involved are familiar with the terminology, as for instance, for some a target may be just a direction and not something to actually reach;
2. Special attention is needed to specify the borders of the system in space and time;
3. When using the integrating decision model, the unruly reality must be described in an understandable and consistent way. This implies looking for compromises between different ways of partitioning and describing reality;
4. Usually, it is not possible to come to a complete elaboration of the decision-model. Therefore, an iterative approach is needed to view the relation between the fundamental objectives en criteria both top-down (from abstract to concrete) as bottom-up (from concrete to abstract).

The pilot exercise interviews also highlighted some other relevant points:

1. The available knowledge about the various parts of the integrating decision-model is spread over different organisational units;
2. The organisational units are not constructed along the lines of fundamental policy objectives;
3. Little experience exists with the process of linking fundamental objectives to concrete criteria;
4. More knowledge is available on the physical, chemical and ecological aspects of the subjects than on the societal aspects;
5. The emphasis is not on decisions as such but on the design of a monitoring programme to support decisions.

Some of these points must be considered as part of the continuous problem of organisational decision-making. However, at other points improvement is possible to support policy-makers in specifying their information needs:

- Make the underlying decision-model more explicit;
- Explain the most important concept and steps in the process of thinking;
- Use working schemes that clarify the in-between steps of the process;
- Aim at a result that is understandable and transferable

From this diagnosis it was concluded that specification of information needs is best done by anticipating the decisions that have to be taken based on the information. The 'rugby ball' method as described is based on this assumption but the relation to the decisions is rather implicit and is not worked out systematically. To support the method, working schemes are developed that can be used to clarify and direct the thinking process. A further distinction is made between operational and strategic information. In specifying information needs for operational use, the working schemes will easily be detailed. In specifying information needs for strategic purposes, the structure of objectives, aspects and criteria will require much elaboration.

## 6.3 Adaptation of the method

In adapting the method, the keywords are *system* and *transparency*. All participants in a project must work according to the set plan (system) and must be able to relate their own contribution to the contributions of the other participants at any moment in the project (transparency). The proposed method comprises four steps, which will be discussed in this section: (1) preparation by initiators; (2) interviews for the preparation of a workshop; (3) the workshop; and (4) feedback to participants, aiming at initiating the next step: specification of the information strategy.

### 6.3.1 Preparation by initiators

The attention of stakeholders should be focused to the decisions they have to take sooner or later, based on available information. Normally, everybody anticipates on having to make decisions; however, usually not very systematically. By working systematically, with the use a few simple questions and schemes, a person can give an almost complete view of his/her information needs. The mind-steps to be followed are presented in figure 6.4.

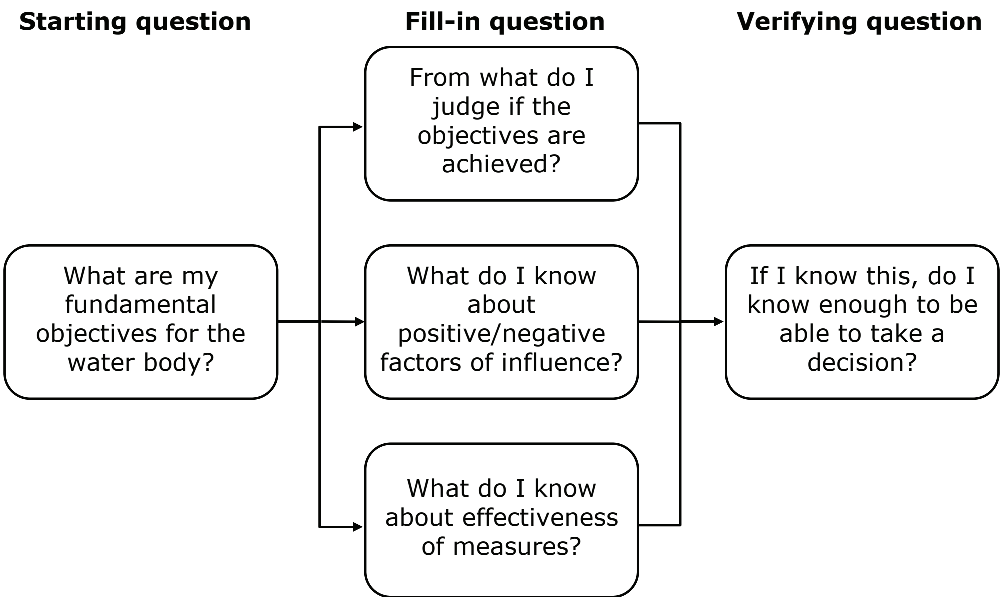


Figure 6.4 Essential questions in the mind-model for the specification of information needs.

The first question that the stakeholder should pose is: 'What are my fundamental objectives for the water body?'. Objectives should not be interpreted as assignments. The objective indicates what is considered to be important and this is generally matters that should be maximised (safety) or minimised (costs). After the starting question, three 'fill-in' questions are formulated. First, the stakeholder should speculate on: 'On what basis do I judge if the objectives are achieved?'. To find these criteria, it is useful to separate the important aspects from a general objective and then work out what measurable or easy perceptible criteria can be derived from this. This can be done on the basis of the scheme in figure 6.5. It should be noted that criteria should not be confused with means to reach a target. In fact, criteria are part of the fundamental objective. If a criterion changes towards the desired direction or reaches a desired level, part of the fundamental objective has been achieved. Keeney (1992) distinguishes between fundamental objectives and means objectives. The fundamental objective characterises an essential reason for interest in the decision situation. The means objectives are important because they are means to the achievement of the fundamental objective. As an example, an objective in water management may be to achieve high transparency of the water. This is a means objective, because it is of interest only because of its implications for the quality of the ecosystem. In figure 6.5, criteria are derived from fundamental objectives in a 'top-down' way. There is also the possibility to do this in reversed order. This implies that the stakeholder starts summing up the criteria he/she uses in daily practice and then asks himself/herself why; for what fundamental objective is this criterion important.

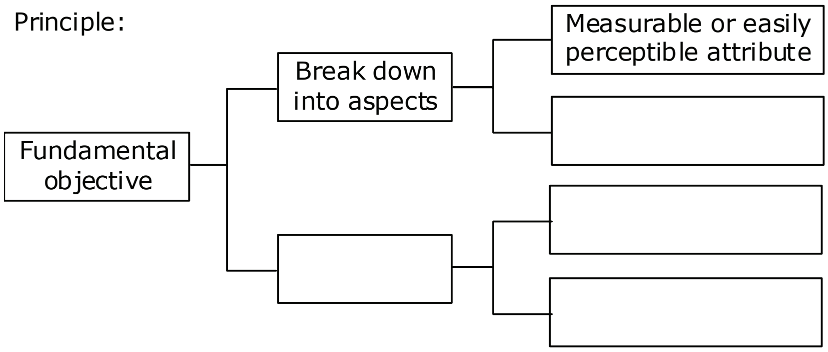


Figure 6.5 Systematic break down of objectives; principle.

At the second fill-in question, the stakeholder wonders: 'What do I know about positive and negative factors that promote or hinder achieving the objective?'. This requires a different type of reasoning compared to the first question, as it now deals with indicating causal relations, making a distinction between cause and effect. There is the possibility that the stakeholder will put a fully developed causal diagram to paper, indicating how the objective is achieved. In practice it is more likely that he/she draws up a list of factors without all causal relations fully elaborated. On the basis of that list, he/she can indicate what he/she should know about the factors of influence to be able to account for them. Following from this, the third fill-in question is: 'What do I know about the effectiveness of measures that have to be taken if a negative influence occurs?'. This also requires reasoning in terms of relationships between targets and means (see the scheme in figure 6.6).

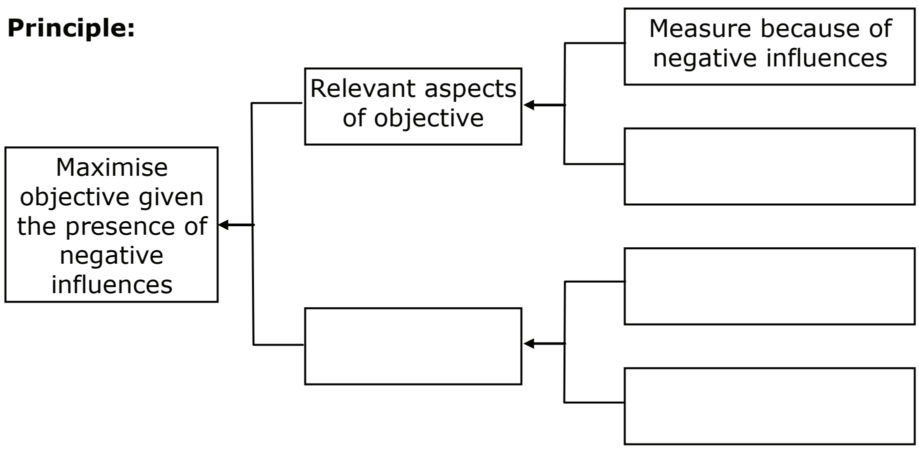


Figure 6.6. Systematic break down of target and means, principle.

Based on the three fill-in questions, for each objective a working scheme can be produced in which the information needs are reported. Table 1 gives an example of such a working scheme. The information covers criteria, positive and negative factors of influence and the effectiveness of measures. The logical question that follows from this scheme is: 'If I have this information, do I know enough to be able to take a decision?'. Initially, a first draft of the working scheme in table 6.1 is made up, based on general knowledge of the policy field. In the next steps, the scheme will be improved and expanded by the stakeholders.

Table 6.1 Working scheme for information needs; principle

**Matrix of information needs per objective**

| **Criteria for the objective** | **Required data** | **Required processing** | **Further details** |
|---|---|---|---|
| | | | |
| | | | |
| **Positive/negative factors of influence** | | | |
| | | | |
| | | | |
| **Effectiveness of measures** | | | |
| | | | |
| | | | |

### 6.3.2 Identification and selection of stakeholders

Stakeholders are selected to participate in the interviews and in the workshop. They can be identified through the next questions: (1) Who are (potential) users of information inside and outside the organisation? (2) Who are (potential) producers of information inside and outside the organisation? (3) To what extend are users and producers involved in policy-making?

Identification of stakeholders is followed by selection, based on the roles that the different actors play in the process. The final list of invitees for interviews and the workshop should balance (potential) users and producers together with other interest groups/individuals. It is important that the identification and selection of stakeholders is done in a systematic way and that how this is done is recorded, because (1) it clarifies the relationship between the content of the project and the process, and (2) it clarifies the opinions of the initiators about the various roles that the actors play in the process (for example user, producer, mediator).

### 6.3.3 Interviews for the preparation of a workshop

Interviews are a good means to complete the working scheme (Table 1) and to indicate the gaps. The synthesis of the individual interviews, containing an overview of information needs and gaps, is input to the workshop. When all interviewees have identified the same gaps, it is obvious that there is a common information need. When the same boxes in the working scheme are filled in differently by different interviewees, there is a need to further discuss the information needs or policy objectives.

### 6.3.4 Workshop

In the workshop, the working scheme, as drawn on the basis of the interviews, should be discussed. Next, attempts should be made to fill the gaps and make the information needs concrete for those boxes in the scheme where this is felt to be needed. It is very important that representatives of all the various sections are present in the process. In addition, a premature end of the process should be avoided, as there might be a tendency among the participants of the workshop to come to a quick agreement to be able to 'get back to work again' rapidly. This tendency is not necessarily advantageous because a full specification on information needs requires critical reflection. A dialogue sparked by conflicting opinions can be very productive to the achievement of a common goal. If consensus is reached at an early stage, this could be because differences of opinion are concealed instead of resolved. Therefore, the participants of the workshop should be stimulated to engage in constructive confrontation. One method to facilitate such a constructive confrontation is the 'devil's advocate' method.

*The Devil's Advocate*

This method is used to support strategic decision-making. The goal of the method is to test if the line of reasoning on which specific policies or strategic plans are founded contains inaccurate assumptions or inconsistencies. In practice, the method aims at making opinions as concrete as possible. Schwenk (1984) describes the approach as inviting some employees to voice strong criticism of the plan, by casting reasonable doubt on as many assumptions as possible. The authors of the plan can react on this, which then opens the discussion.

### 6.3.5 Feedback to participants

It is important that the workshop participants get feedback. So the outcomes of the workshop and a proposal for the next steps to implement the outcomes need to be communicated to them. Generally, the next step will be the translation of the information needs into an information strategy. This provides the participants with the opportunity to make corrections if needed.

## 6.4 Pilot

The pilot at hand involved the setting up of a monitoring plan for the evaluation of restoration of saline gradients in estuaries. The Dutch water management policy is aiming at restoring such transition zones, which should then lead to ecological benefits (Anonymous 1999). The policy goal is formulated as: 'Gradual transition zones between water and land and between salt water and fresh water will be restored'.

The first step in this project was to make an inventory of the existing policy and measures that were formulated. From this step it was concluded that the policy lacked detail. The above-mentioned policy goal was chosen as input for the workshop. A provisional working scheme was set up. However, preparations for the workshop did not include interviews and completion of the working scheme. Workshop participants were stakeholders from different water management organisations and experts in the ecology field. In the workshop, each participant was asked to list the major aspects related to this goal. The resulting overall list could be clustered into three major groups: aspects of the ecosystem (changes in the ecological situation), aspects of the surrounding area (influence on agriculture, recreation, safety, etc.), and aspects for specific measures (specific restoration projects may aim at a particular goal). These clusters were discussed in three working groups to derive measurable criteria for each of them. It appeared that it is not easy to fit the results from the working groups into the proposed working scheme. This is partly due to the fact that the working scheme was not used as input to the workshop and that the participants were not familiar with the method. The organisers of the workshop were reluctant to apply the scheme in this case, due to the sensitivity of the issue of nature restoration in the Netherlands.

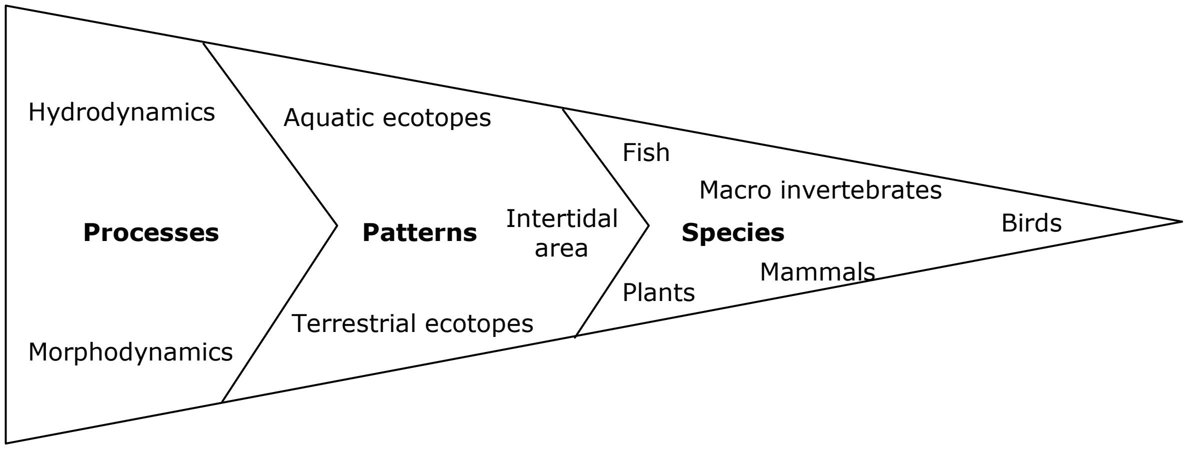


Figure 6.7. Hierarchic connection between hydrological and morphological processes, patterns in ecotopes, and occurrence of species.

For this paper, an attempt is made to turn the outcome of the workshop into the working scheme of Table 6.1. One conclusion from this exercise was that the three discerned aspects - aspects of the ecosystem, aspects of the surrounding area and aspects for specific measures – can be seen as the fundamental objective, factors of influence and effectiveness of measures, respectively.

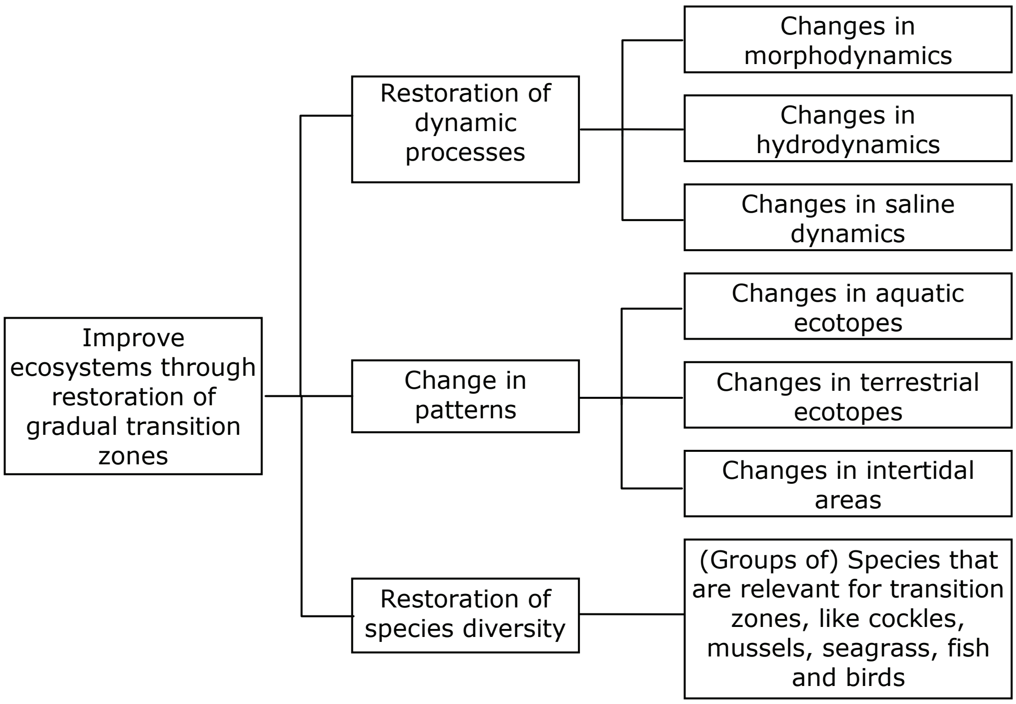


Figure 6.8 Systematic break down of objectives; example.

Breakdown of the fundamental objective leads to the scheme shown in figure 6.7. This scheme represents the hierarchic connection between the various aspects discerned from the information about the ecosystem. Systematic breakdown of this fundamental objective in the proposed method leads to the next scheme (figure 6.8).

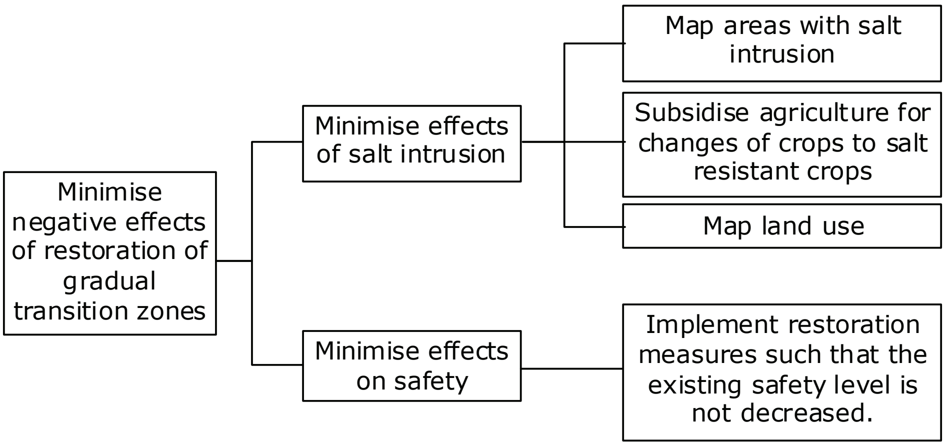


Figure 6.9 Systematic break down of targets and means; example.

Deriving measurable criteria for the causal factors has led to a summation of various criteria. Figure 6.9 represents a systematic breakdown of targets and means for some of the criteria mentioned in the workshop.

Table 6.2. Working scheme for information needs; example

| **Matrix of information needs per objective** | | | |
|---|---|---|---|
| **Criteria for the objective** | **Required data** | **Required processing** | **Further details** |
| Changes in morphodynamics | Areas of sedimentation and erosion per year<br>Tidal volume | Use as input for dynamics model | Areas on a map |
| Changes in hydrodynamics<br>Changes in saline dynamics | Chloride concentrations in surface water<br>Ecotope mapping | | |
| Changes in aquatic ecotopes | | | |
| Positive/negative factors of influence | | | |
| Area with salt intrusion | Chloride concentrations in groundwater | | Salt intrusion map |
| Implement restoration measures such that the existing safety level is not decreased | Data on high water levels, storms, etc. | Model calculations of flood risks | |
| Effectiveness of measures | | | |
| Increase in fish migration | Diadromic fish species like eel and stickleback | | |

For information on the effectiveness of measures, a series of possible measures was listed. For each measure, specific effects have been described. An example of a measure is the construction of fish passes. The expected effect would be an increase in fish migration. In Table 6.2, an example is provided of how the working scheme is constructed based on the objectives, effects and measures.

The importance of including aspects of the surrounding area came as a new result for the initiators of the project. The other outcomes of the workshop provided confirmation for the initiators that they were on the right track.

## 6.5 Conclusions and recommendations

From the experiences in the pilot project and previous projects in specification on information needs the following conclusions can be drawn:

1. The terminology used is important for the understanding of the initiators and participants. Use of the word ‘aspects’ in the context of ‘the most important aspects for this objective’ was confusing to many people. The question: ‘What do you think of when thinking about this objective?’ provided more grip on the issue at hand. The same goes for the term ‘measurable criterion’; when replaced with the question ‘What do you need to know about this?’, adequate answers were provided.
2. The systematic breakdown of objectives, targets and means provided much difficulty for the initiators. In a way, the scheme is limiting lines of thought. However, experiences in other projects show that in the end, schemes can provide much insight, once formulated and accepted.
3. The method has been helpful to make the decision model more explicit. The importance of socio-economic aspects was initially underestimated by the initiators. The workshop brought this fact into the spotlights.
4. It is important for the facilitator of the workshop to be acquainted with the subject, to be able to direct the discussion.
5. The devil’s advocate method was not used in this pilot. Experiences from earlier projects, where this method was used in an incidental way by breaking down arguments in discussions to very basic assumptions, proved useful in forcing stakeholders to be more precise in their statements.

The adapted method clarifies the process to the participants. Nevertheless, application of the method is still difficult. To improve this, it is recommended that further adjustments to terminology are necessary. Further, it is recommended that the project is guided by a person who has experience in using the method. Finally, the method is not a template that only needs filling in, it is a framework that needs to be adapted to the situation at hand, thus emphasising the need to balance between the ‘design’ and ‘development’ lines of thought.

# CHAPTER 7

# DEVELOPING TRANSBOUNDARY RIVER BASIN MONITORING PROGRAMMES USING THE DPSIR INDICATOR FRAMEWORK


## *Abstract*

*Policymakers are often dissatisfied by the lack of what they consider useful information to support water management. Analysis of this 'water information gap' shows that this is caused by a lack of proper communication between information users and information producers. To improve the communication the process of specification of information needs has been structured. Earlier experiences showed that this entailed not only a developing a structure to manage the process, but also a structure to guide the breakdown of policy objectives into information needs. A structure to organise the problem supports policymakers and monitoring specialists in their communication. This paper describes three pilot projects where the DPSIR indicator framework was used to organise the problem. It is concluded that the DPSIR framework is useful for improving the communication between information users and information producers and helpful in breaking down policy objectives into information needs in a structured way. The structured approach in this way assists in narrowing the water information gap. Use of the DPSIR framework however leads to a bias towards water management problems and does not provide for all the relevant information needs.*



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## 7.1 Introduction

Information on relevant environmental characteristics helps policy makers and others to determine the best ways to proceed and is the basic source to evaluate the effects of specific environmental policies (Haklay 2003). For this purpose, nowadays vast effort is put into the collection and dissemination of environmental information. Policy makers however are, in general, not satisfied with the information that is produced as they do not perceive this information as useful (McNie 2007; Vaes and others 2009; Wesselink and others 2009). Useful information is defined as information that is 1) salient and context-sensitive; responding to the specific information demands, 2) credible; perceived by the users to be accurate, valid and of high quality, and 3) legitimate; the production of information is perceived to be unbiased (Cash and others 2003; McNie 2007). I call the dissatisfaction about the produced information in water management, i.e. the divide between users and producers of information (McNie 2007), the 'water information gap'. Analysis of the water information gap showed that water information is usually considered credible and legitimate but often does not respond to the users' need; it is not salient (Timmerman and others 2010b).

Many scholars suggest that bridging the water information gap requires a process of determining about the water management problems and the information needs related to them. A systematic effort to consider the purpose of data collection ahead of designing/executing a monitoring program – supported by a scientifically sound information needs assessment methodology and involving the actual users of the information – is considered as a way to produce useful information (Bernstein and others 1997; Brett 2000; Giordano and others 2008; Gooch and Stålnacke 2006a; MacDonald 1994; Meybeck and others 1996; Strobl and Robillard 2008). Such a methodology enables managing the gap through close interaction between users and producers of information (Sarewitz and Pielke 2007) and a participatory process based on the concept of social learning literature is promoted to reach close communication (McDaniels and Gregory 2004; Mostert 2004; Pahl-Wostl and others 2007a; Woodhill 2004). Structuring the communication process requires both a structure to *manage the process* and a structure to *organise the problem* (Bardwell 1991). Following this approach, the methodology for specification of information needs was structured (Timmerman and others 2010a) and tested in several case studies (Timmerman and others 2001; Timmerman and others 2010c). The case studies showed that the structure to *manage the process* was successful in guiding the process but still lacked a framework to *organise the problem* and to guide the structured breakdown from policy objectives into information needs.

This paper responds to these findings by focusing on organising the problem. It discusses the results of three pilot projects that used the DPSIR indicator framework as a structured breakdown to organise the problem. The DPSIR indicator framework is developed for assessing environmental problems in general but also links closely to the IWRM principles as adopted at the World Summit on Sustainable Development (WSSD 2002) and was e.g. adopted by the UN World Water Assessment Programme for their selection of indicators (WWAP 2006). It was therefore considered a valid framework for developing a monitoring programme.

From the analysis of the water information gap (Timmerman and others 2010b) it was concluded that the information needs need to respond to the policy problem environment, thereby linking to policy objectives. The structure used has to enable an unequivocal translation from policy statements into information needs. This would improve the communication and consequently produce more salient information to narrow the water information gap. The structure also has to enable an analysis of the policy problem from multiple perspectives and at least support balancing between uses, problems and measures. In this way, the policy statements can be clarified. Moreover, the structure must be able to deal with connecting different types of information like social, economic, and ecological information, information about the implementation of measures, and information about the degree to which the policy objectives are reached to enable recognition of change. Finally, the resulting information needs should include information about progress in, and futures of the policy problem.

This paper discusses the pilot projects; their background and the way they were put into practice. It provides a short description of the breakdown structure and presents and discusses the results from the pilot projects. The paper concludes that the DPSIR framework is a useful structure for organising the problem that however leads to a bias in the information needs towards water management problems.

## 7.2 Pilot projects on transboundary monitoring

To develop transboundary monitoring networks in support of water management, pilot projects were conducted under the supervision of the Working Group on Monitoring and Assessment under the UNECE Convention of the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) (UNECE 1992). The pilot project programme was initiated in 1997 to test the Guidelines on Monitoring and Assessment of Transboundary Rivers (Timmerman and others 1997), a document developed under the UNECE Water Convention. The Guidelines describe the respective steps in designing and executing monitoring networks, and the subsequent data storage, data handling and reporting on the basis of the information cycle (Timmerman and others 2000). The first and determining step in this cycle is specification of information needs. The Guidelines describe how specification of information needs is based on an analysis of the water management situation.

The goal of the pilot projects was to test the UNECE monitoring guidelines and to demonstrate their applicability, to assist countries in their implementation, and to identify gaps and indistinctness in order to propose improvements for the guidelines (Adriaanse 2003). The latter objective was among others realised through the revision of the guidelines in the year 2000 (UNECE TFMA 2000b). The pilot projects focused on this first step in the information cycle and provided important experience in the development of the methodology for specification of information needs that was not included in the Guidelines. Wider objectives of the pilot project programme were to initiate bilateral and multilateral co-operation and to realise effective and efficient (tailor-made) monitoring and assessment that is sustainable in the specific economic context of countries concerned.

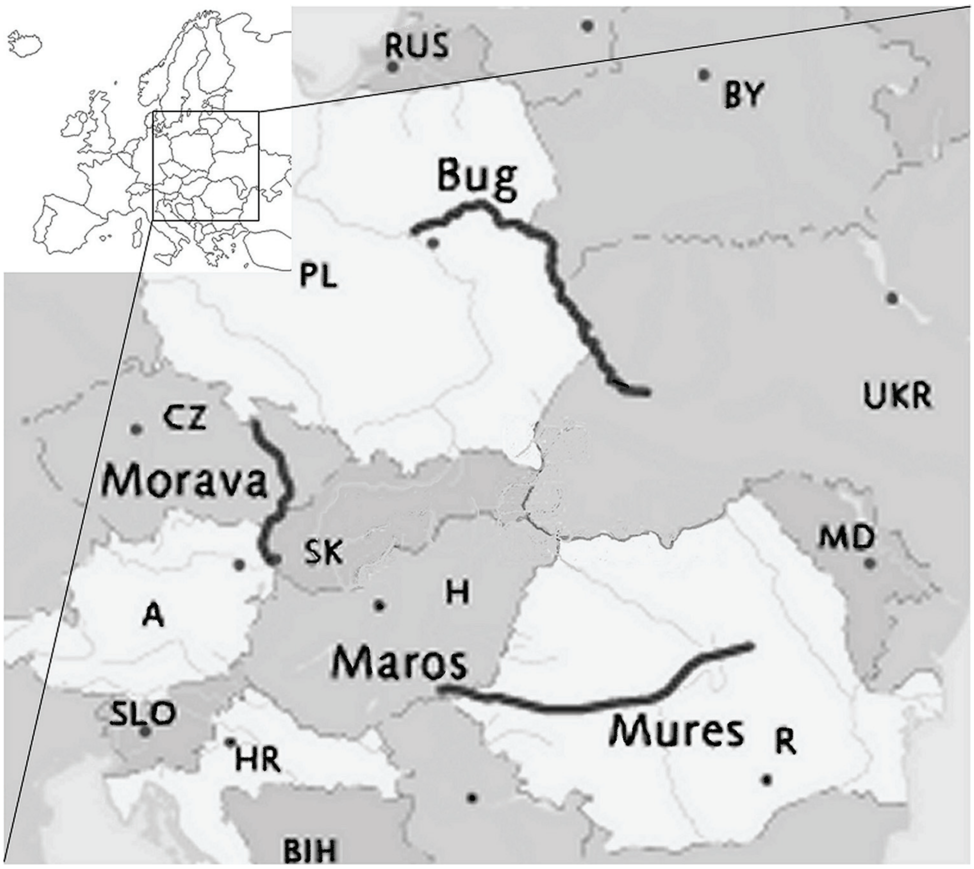

Figure 7.1 Location of the three pilot rivers (UNECE TFMA 1999)

The pilot project programme comprised eight pilot projects that each took a different approach and had a different time-line. This paper deals with the Central-European pilot projects in the (Western) Bug (Ukraine/Belarus/Poland), Morava (Czech Republic/Slovak Republic) and Mures/Maros (Romania/Hungary) rivers (Table 7.1) that were performed with close involvement of the first author, and that used the DPSIR framework as the basis for the structured breakdown of policy objectives.

Belarus, Poland and Ukraine share the Bug River basin. The river has its source in the northern edge of the Podolia uplands in the L'viv region (Ukraine) at an altitude of 310 m. The river forms part of the border between Ukraine and Poland, passes along the Polish-Belarusian border, flows within Poland, and empties into the man-made Lake Zegrzynskie, a reservoir built as Warsaw's main source of drinking water. The river Bug itself is not regulated, but its tributaries are heavily regulated, especially in the Ukraine (over 218 dams) and Poland (over 400 dams). The reservoirs are mainly used for irrigation. Significant variations in the flow of the river, caused by melting snow in spring and low discharges in autumn, affect the quality of water. Agriculture and waste water, both untreated and from treatment plants with insufficient treatment, are the main sources of pollution and the subsequent risks for eutrophication and drinking water supply in Ukraine and Poland (Landsberg-Uczciwek 2002). The Bug pilot project was performed by representatives of the Polish Regional Water Management Board in Warsaw, the organisation responsible for water management, the Inspection of Environmental Protection in Poland, the Institute of Environmental Protection in Warsaw and the Institute of Water Management and Meteorology in Wroclaw as institutions responsible for coordinating and implementing monitoring, the Ministry of Natural Resources and Environmental

Protection of the Republic of Belarus and the Central Institute of Complex Use of Water Resources, the Belarusian organisations responsible for water management and monitoring, and the Ministry of Environment and Natural Resources of Ukraine and the Ukrainian Ministry of Ecology, responsible for water management and coordination of monitoring.

Box 1 The UNECE Water Convention (UNECE TFMA 2000b)

The Water Convention provides a common legal basis for countries to cooperate and offers a range of guidelines for practical implementation as well as good practices. The Water Convention covers such items as monitoring and assessment of transboundary waters; the assessment of the effectiveness of measures taken to prevent, control and reduce transboundary impact; the exchange of information between riparian countries and public information on the results of water and effluent sampling. The Convention states that riparian parties should harmonise their rules for setting up and operating monitoring programmes, including measurement systems and devices, analytical techniques, data processing and evaluation procedures.
The Guidelines on Monitoring and Assessment of Transboundary Rivers consider the process of monitoring and assessment as a sequence of related activities that starts with the definition of information needs, and ends with the use of the information product (figure 7.2). Successive activities in this monitoring cycle are specified and designed based on the required information product as well as the preceding part of the chain. In drawing up programmes for the monitoring and assessment of river basins, riparian countries jointly consider all stages of the monitoring process. The evaluation of the obtained information may lead to new or redefined information needs, thus starting a new sequence of activities. In this way, the monitoring process will be improved. The monitoring cycle is a framework that needs tailoring to each specific river basin.

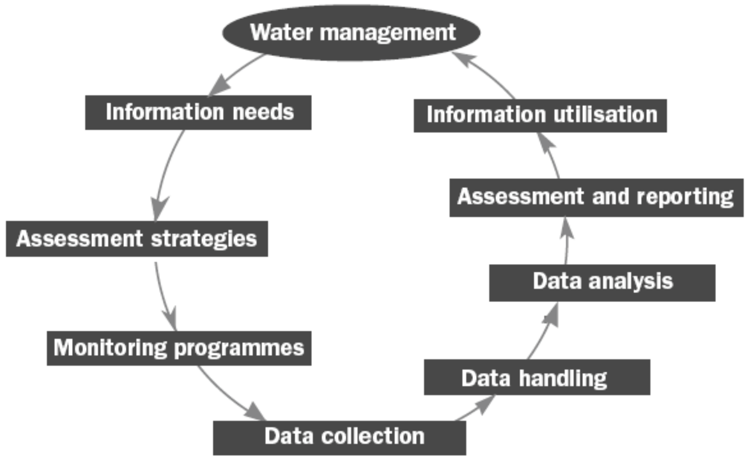


**Figure 7.2 The monitoring cycle as a sequence of related activities**

The river Mures/Maros is a tributary of the Tisza River, the main tributary of the Danube. It has its source in Romania, where the major part of the catchment lies. In Romania, the river water is mainly abstracted for drinking water supply and irrigation. In the Hungarian part of the watershed, water abstraction is mainly from groundwater resources. Agriculture and waste water from municipalities and industries are the main sources of pollutants (Ognean and others 1998). The pilot project for the Mures River basin was carried out by representatives of the central public authority for water management in Romania, the National Administration "Apele Române" with representatives from both the national branch (Bucharest) and the regional branch (Mures River branch), the Hungarian Ministry of Environment and Water as responsible central government, the Lower Tisza Environmental Inspectorate as responsible organization for water pollution control, and the organization responsible for monitoring (VITUKI).

Table 7.1 Some characteristics of the pilot river basins (Adamková and others 1998; Landsberg-Uczciwek 2002; Ognean and others 1998; UNECE 2007).

| **River** | **Area ($km^2$)** | **Average discharge at mouth ($m^3/s$)** | **Total length (km)** | **Country** | **Country's share ($km^2$)** | **Percentage** |
|---|---|---|---|---|---|---|
| Bug | 39,400 | 157 | 772 | Belarus | 9,200 | 23.35% |
| | | | | Poland | 19,400 | 49.24% |
| | | | | Ukraine | 10,800 | 27.41% |
| Mures/Maros | 30,195 | 110 | 789 | Hungary | 1,885 | 6.2% |
| | | | | Romania | 28,310 | 93.8% |
| Morava | 26,580 | 119 | 352 | Czech Republic | 20,732 | 78% |
| | | | | Slovak Republic | 2,126 | 8% |
| | | | | Austria | 3,721 | 14% |

The source of the Morava River, one of the most important tributaries of the upper Danube, is in the northern part of the Czech Republic. The downstream reach of the Morava forms the border between the Czech Republic and Slovakia and from thereon between Austria and Slovakia. A major part (ca. 60%) of the river basin is agricultural land. Forests, mainly in the mountains and upland parts of the basin, cover approximately 30%. There are over thirty important water-storage reservoirs constructed in the river basin. Surface water is used for drinking water supply, industry, agriculture recreation and fishing. Large amounts of water are used by power stations for cooling purposes. Waste water from municipalities and agricultural activity are the main sources of surface water pollution. The most significant industries from the pollution point of view are food processing, textile, rubber, tannery, paper and chemical manufacturing (Adamková and others 1998). The pilot project for the Morava River basin was carried out in close cooperation between representatives of the Slovak Ministry of Environment as responsible for water management, the Slovak Hydro- meteorological Institute (SHMU) and the Czech T.G. Masaryk Water Research Institute Brno branch as institutes responsible for monitoring. Also regional water boards were involved.

## 7.3 Short description of the process of the structured breakdown approach

The process of specification of information needs is structured through two frameworks: a framework to manage the process and a framework to structure the breakdown of policy objectives into information needs. The overall methodology is described in Timmerman *et al.* (2010a). The framework to manage the process of specifying information needs was only loosely applied in the pilot projects and will not be discussed here.

The framework to structure the breakdown consists of conceptual models of the information problem situation. To make a water management analysis as a first step in defining information needs, the basic structure used in the pilot projects is the triangle of core elements in water management: uses/functions, problems/issues, and measures (Figure 7.3). The Driving force – Pressure – State – Impact – Response (DPSIR) indicator framework is used as the conceptual model for further elaboration of the information needs. The DPSIR framework provides information on the cause-effect relationship between sources of problems and the way this affects the use of the water system. This framework describes the chain originating from a Driving force (any human or human-related activity) that causes a Pressure (e.g. through emissions) on a water body, in turn changing the State of the water body. This changing state has an Impact on the functioning of the water ecosystem and/or on the human uses of the water. This results in a societal Response directed at any of the four elements mentioned to minimise the negative impacts (EEA 1998; Timmerman 2004).

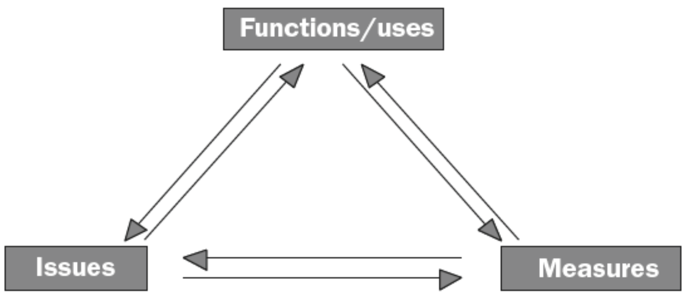


Figure 7.3 Core elements in water management (UNECE TFMA 2000b)

Examples of Driving forces are the sources of a policy problem, like households or agriculture. The Pressures are the way they produce the problem, like wastewater or wash-off of fertilisers. The State of the surface water is then depicted by concentrations of nutrients or organic matter. The Impact can be seen in changes of biodiversity or changes in use, like a drinking water company that has to apply extra treatment. The societal Response is the policies and measures taken. Aiming at Driving forces the Response is, for instance, promotion of best agricultural practices. Aiming at Pressures, applying improved wastewater treatment can be an appropriate measure. An example of a measure to change the Status is liming to fight acidification of lakes. Remediation of Impacts is done by, for instance, active fishing of specific fish species that maintain turbidity of the water by stirring up sediments (de Jong and others 1994). Structuring the breakdown for each water management problem is done by specifying indicators that are considered relevant for that problem to each of the five elements of the DPSIR-framework. Examples will be provided later in this paper.

The participants in the process of specification of information needs are requested to reflect on the policy objectives and to elaborate on each element of the conceptual model to make the translation into information needs for that objective. A full overview of the information needs including the relationship between the various information needs is obtained by filling in all elements.

The structured approach enables to repeat the information needs specification after some time, as described in the information cycle [27], to check if still the right information is produced and the proper priorities are targeted. The structure enables to change only those parts where modifications are needed while leaving the unchanged parts untouched.

## 7.4 How the pilot projects were conducted

Each pilot project basically consisted of two phases. First phase was the analysis of the water management issues along the lines of the triangle of core elements (figure 7.3). This entailed identification of the uses and functions of the river, the criteria and targets linked to these functions and uses, relevant water management policies, action plans and measures, an inventory of the water legislation and existing legal obligations for monitoring, an inventory of the available information about the water management situation including monitoring data, the impacts of the river water quality on the receiving water body, and a series of surveys for those aspects on which information was missing. Also field visits were conducted to make the participants more aware of the actual situation. Priorities were assigned to the functions and uses, depending on the mutually agreed importance of that use in the river basin.

Information users were identified during the first workshops. A division was made between information users that were involved in the process and others that would be interested to use the information. The first group was administrations directly involved in water management like Ministries of Environment or Public Works, research institutes like Hydro Meteorological Institutes and Water Research Institutes, Inspectorates, and Water Supply Companies. These were the information users that were actually involved in the pilot projects in the first stage of developing the monitoring network. Other parties that were identified as information users were a wide range of other ministries and agencies with a relation to water management, international organisations, non-governmental organisations, and the public at large. The extensive overview of information users that the pilot projects drew up reflects the importance of information but it is in practice impossible to actively involve all these users in the process. When a more advanced monitoring network is in place, additional information users can be involved to improve the usefulness of the information.

For each of the river basins, a function/issue table was developed. The function/issue table is an important tool for linking the functions or uses of the water body to issues and problems (UNECE TFMA 2000b). In the table, the uses and functions are put on the horizontal axis and the problems and issues on the vertical axis. The tables were developed through discussions between participants in various meetings, based on some examples. Check-lists of uses and problems were not provided in order to avoid a mere fill-in exercise and to make the tables tailor-made and in the wording of the participants. Table 7.2 provides an example of this table for the River Bug. The overview that is thus constructed offers a view on the decision context and the information environment to be dealt with. Developing the table is also an important means for the countries to discuss their issues. The function/issue table in this way summarises the issues at hand and in this way forms the basis for the breakdown needed. The individually documented function/issue combinations are discussed between the countries relative to their importance for the transboundary situation to identify shared concerns (Timmerman 2004). A description of the situation in each of the different rivers is added to each cross in the table, detailing how the specific use is affected by that particular problem (Table 7.3). In this way, the most important management objectives are listed in the water management analysis, based on the uses, and linked to problems that hinder reaching these objectives.

Table 7.2 Relations between the functions of the River Bug basin, the utilisation of the water and the problems occurring in the basin (adapted from Landsberg-Uczciwek 2002)

| | **Uses/functions** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Problems** | **Ecological function** | **Supply of drinking water** | **Agriculture** | **Fish-farms** | **Recreation and angling** | **Supplies for the industry** | **Transport medium including sewage** | **Impact on lake** |
| Pollution by nutrients and eutrophication | +++ | +++ | | + | +++ | + | + | +++ |
| Microbiological pollution | + | ++ | + | + | +++ | | + | +++ |
| Organic pollution | +++ | ++ | | + | + | | + | +++ |
| Accidental pollution | + | + | + | + | + | | + | + |
| High variability of flows | + | | | | + | | + | |
| Flood hazard | + | + | | + | + | + | + | + |
| River regulation, damming and draining | ++ | | | | + | | + | |
| Pollution by toxic substances | + | + | + | | + | | + | + |

Highly important — Moderately important — Not important as common concern

+++ High stress — ++ Medium stress — + Moderate stress

Table 7.3 Overview of management objectives for the Morava River and the most important constraints related to it (adapted from (Adamková and Bernardová 2002; Adamková and Bernardová 2003)).

| Management objectives | Constraints / Factors of influence |
|---|---|
| Secure drinking water supply for the future, both in quality and in quantity | Organic pollution can cause problems for drinking water supply |
| | Increased N or P concentrations cause eutrophication of some water sources and it requires higher water treatment costs for drinking water production |
| | Flooding occasionally threaten quality of water resources |
| | Occurrence of accidental pollution threatens quality of water resources |
| | Bacteriological pollution threatens quality of water resources |
| | Water scarcity in low water flow periods |
| | Low water levels may lead to increased concentration of pollutants |
| Ensure water supply for industrial purposes | If conditions for the river water quality are in compliance with raw water for drinking water production, then industrial purposes are also possible |
| Secure water supply for (agricultural) irrigation | Water deficits may occur during low water levels |
| | The retention capacity (reservoirs) is not sufficient |
| | The water quality is not adequate for irrigation. If conditions of the river water quality are in compliance with requirements for raw water for drinking water production, then irrigation purposes are also possible |
| Secure water for fishing and recreation | Risk of accumulation of dangerous substances in sediments and biota |
| | Increased N/P concentrations cause eutrophication of some stretches of watercourses, making the water unattractive for bathing due to algal bloom |
| | Morphological conditions of the river should constitute suitable habitat for commercial fish species life and reproduction as well as for recreation |
| | Bacteriological parameters are not in compliance with water quality criteria for bathing |
| | Organic pollution affects fish populations |
| | Fish kills caused by accidental pollution |
| Ensure good quality of the river ecosystem | Structure of river communities does not meet requirements for good ecological state |
| | River water and sediment quality are inappropriate |
| | The morphological conditions of some river reaches are in such a state that development of aquatic communities is limited |
| | Water-flows lower than critical may occur during droughts |
| | River regulation hinder migration and affects river communities |
| Limit effects of flooding | Too little volumes of flood-control storages |
| | The technical condition and the length of flood banks is insufficient |
| Minimise impact on receiving water body | Occurrence of accidental pollution |
| | Concentrations of polluting substances in downstream region are too high |

In the second phase, the assessment of information needs and development of the strategy to collect the data took place. Indicators were identified along the lines of the DPSIR framework on the basis of the function/issue table. The indicators were complemented with strategies on how to collect the necessary information (Chilton and others 2004; Timmerman and Frintrop 2000). A set of indicators was derived for each cross in the function/issue table for the elements Driving force, Pressure, State, Impact and Response. The analysis led to recommendations for improvement of the monitoring network.

The overview of the water management situation, the transformation process and the subsequent elaboration of the information needs and identification of indicators was developed in an iterative manner with the use of desktop analyses and discussions in bilateral or trilateral workshops. The progress in the pilot projects as well as the results of the individual projects were discussed during several meetings of the UNECE Working Group on Monitoring and Assessment. Final results of discussions between representatives of the respective countries took place during a synthesis workshop in Budapest in winter 2002 and a recommendations workshop in Helsinki in fall 2002. The resulting recommendations were finalised within the countries and were reported (Adamková and Bernardová 2003; Landsberg-Uczciwek 2003; László and others 2003). A workshop to evaluate the pilot projects and the experience gained in them took place in May 2003 (Landsberg-Uczciwek and Zan 2004; Roncák and Vasenko 2003).

## 7.5 Results of the study

### 7.5.1 Overview

Generally the water quality in most of the rivers did not yet comply with all standards. Important issues for the Morava River were the implementation of EU legislation like the European Water Framework Directive (WFD) (European Commission 2000) and the EU Urban Wastewater Directive (European Commission 1991) as well as implementation of the objectives and provisions of the Convention on Cooperation for the Protection and Sustainable Use of the Danube river (Botterweg and Rodda 1999). Like in the Morava River basin, for the Mures River water management objectives are related to EU legislation and the Danube Convention. For the Bug River, restoration of aquatic ecosystems is found in national policies and strategies for environmental protection of all three riparian countries. One important water management issue is to minimise the impact from pollution on Lake Zegrzynskie, which is an important source of drinking water for the city of Warsaw (Landsberg-Uczciwek 2003).

Box 2 The EU Water Framework Directive (European Commission 2003; Quevauviller 2008)

The WFD establishes a framework for the protection of all waters (including inland surface waters, transitional waters, coastal waters and groundwater) which prevents further deterioration of, and protects and enhances the status of water resources, promotes sustainable water use based on long-term protection of water resources, aims at enhancing protection and improvement of the aquatic environment through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances, ensures the progressive reduction of pollution of groundwater and prevents its further pollution, and contributes to mitigating the effects of floods and droughts. It prescribes how member states should perform their monitoring.

Article 8 of the WFD states that member states shall ensure programmes for monitoring in order to establish coherent and comprehensive overview of the water status. Monitoring should provide for the evidence that environmental objectives as identified by the member states will be achieved (art. 11, 15) or evidence for environmental contamination (art 16). Annex V of the directive sets out the monitoring programme essentials (Chave 2001; Lise and others 2004). The WFD still leaves a high level of freedom for the member states to implement their monitoring despite all the detail provided.

For the implementation of the WFD, a series of guidance documents is produced amongst which the guidance document on monitoring under the WFD. The document provides the means to achieve a common understanding of the monitoring and reporting requirements of the WFD. It proposes an overall methodological approach to monitoring for the implementation of the WFD, within which Member States can either use/modify their existing methods, or where no appropriate monitoring and assessment systems exists, develop new systems that will incorporate all the requirements of the WFD. The monitoring has to be tailored to the specific situation in a body of water. The information cycle supports tailoring the information network and is part of the guidance document.

Tables 7.4 and 7.5 present a selection of indicators as described in the various information needs reports for the aspects of ecological functioning and use of the river water as a source for drinking water in view of the problems of eutrophication and organic pollution. The chains from Driving forces like number of households or agricultural land use area to Pressures in the form of nutrient loads to nutrient Status of the water systems to Impacts in the form of changes in biodiversity to Responses like investments into good agricultural practices and waste water treatment facilities clearly show in the tables. There is a distinction between Table 7.4 that shows several different ways of looking at implementation of measures like the number of systems built, improvements in percentage removal, costs of specific removal methods, and overall investment costs, and Table 7.5 that concentrates on investment costs. A possible explanation for this difference is that the Impacts in drinking water abstractions are described in the form of costs of removal, which sets the mindframe to economic considerations.

Table 7.4 Overview of indicators for the aspect of ecological functioning of the water body for the Morava River (adapted from (Adamková and Bernardová 2003))

| Ecological functioning | | | | | |
|---|---|---|---|---|---|
| | **Driving force** | **Pressure** | **State** | **Impact** | **Response** |
| Eutrophication | Number of individual households<br>Amount of water consumption for municipal purposes | The load of P and N from WWTP´s discharged into the river and its tributaries from point sources | Concentrations of P and N<br>Concentration of chlorophyll<br>Water consumption index per capita | Changes in diversity, abundance and distribution of species, number of species of flora and fauna<br>Number and area of algae blooming (blue-green algae, diatoms, green algae), including the algae toxic for the water fauna, for cattle and people | Number of sewage systems<br>Number of new sewage treatment plants constructed<br>Costs of removing N and P from the sewage |
| | Agricultural land use area and distribution in the basin<br>Amount of artificial and natural fertilisers used in agriculture | Amount of nutrients washed off into the river | N and P concentrations, $O_2$ concentration | Turbidity, changes in diversity and abundance in fish populations, timing and number of fish kills, timing and number water bloom | Investment into good agriculture practices in € per year |
| Organic pollution | Number of households not connected to sewage systems<br>Percentage of inhabitants connected to sewerage system<br>Amount of rainwater in built-up areas that does not undergo the purification | Total organic load from municipal WWTP´s<br>Load of organic pollution in area run-off<br>Load of organic pollution | Concentration of oxygen and organic substances<br>Water consumption index per capita | Oxygen concentration, timing and duration of anaerobic processes in the waters<br>Abundance and diversity changes in the species composition of macro | Improvements in percentage and loads of removal of N and P of municipal sewage treatment plants<br>Construction of new municipal treatment |

| Ecological functioning | | | | | |
|---|---|---|---|---|---|
| | **Driving force** | **Pressure** | **State** | **Impact** | **Response** |
| | process | from built-up areas discharge d without treatment | | invertebrates Timing and number of fish kills | plants in percentage and loads of removal of N and P Investments for connection of households to WWTP´s in € per year Effectiveness of sewage treatment by municipal treatment plants in percentage of removal of P and N |
| | Total amount of wastewater discharged from food industry | Load of pollutants discharge d from industrial treatment plants | Water consumption index per production unit Oxygen and organic substances concentrations | Oxygen concentration, timing and duration of anaerobic processes in the waters Abundance and diversity changes in the species composition of macro invertebrates Timing and number of fish kills | Improvements in percentage and loads of removal of N and P of industrial sewage treatment plants Costs of removing organic substances and re-aeration in € per year |

Table 7.5 Overview of indicators for the aspect of drinking water use for the Morava River (adapted from (Adamková and Bernardová 2003))

| **Water abstraction for drinking water supply** | | | | | |
|---|---|---|---|---|---|
| | **Driving force** | **Pressure** | **State** | **Impact** | **Response** |
| Eutrophication | Amount of artificial and natural fertilisers used in agriculture | Amount of nutrients washed off into the river | N and P concentrations | Costs for removal of nutrients in € per year | Investment into good agriculture practices in € per year |
| | Number of households | Load of nutrients from WWTP´s | N and P concentrations | Costs for removal of nutrients in € per year | Investment in treatment capacity of WWTP´s in € per year<br>Investments for upgrading WWTP´s in € per year |
| Organic pollution | Percentage of inhabitants connected to sewerage system | Load of untreated domestic waste water | COD, BOD and nitrate concentrations | Costs for removal of organic substances in € per year | Investments for connection to WWTP´s in € per year |
| | Amount of waste water discharged from food industry | Organic load from industries | Oxygen and organic substances concentrations | Costs for removal of organic substances in € per year | Investment in treatment of industrial waste water in € per year<br>Investments for upgrading WWTP´s in € per year |

### 7.5.2 The Morava pilot project

A total of 120 indicators were identified for the Morava River. Data was already collected for almost half of the identified indicators (58) in at least one of the two countries. For almost 16% of the indicators (19) no data was available at all. A selection of monitoring sites, parameters and frequencies was derived from the overview of information needs to form joint monitoring programmes. Next to the elaboration of these joint monitoring programmes, several recommendations were made to improve cooperation between the countries. This entailed ensuring exchange of information and data characterising pressures that are relevant from the transboundary point of view, as well as collecting, compiling and evaluating at national levels of data dealing with transboundary pollution sources. The recommendations also included the preparation of inventories related to transboundary pollution sources and transboundary effects of effluents, and assessment of the effectiveness of control programmes or measures connected with transboundary waters. The overall conclusion for the Morava pilot project was that there is a need to enlarge the scope of information in current monitoring and assessment on pollution caused by hazardous substances and pathogenic organisms, on ecotoxicology, and on ecological monitoring and assessment (Adamková and Bernardová 2003).

### 7.5.3 The Mures pilot project

For the Mures, 28 indicators in total were identified. These were however not directly linked to the DPSIR-framework. The framework nevertheless influenced the selection of indicators. Connected to the indicators, 42 (groups of) parameters were identified. In surface waters, 40 individual chemical and physico-chemical parameters were identified to be included in the proposed monitoring programme, two of which had not yet been included in the Romanian monitoring programme. Several biological elements were identified that were not included in either monitoring programme. In sediment, which was not in the monitoring of either country, 13 individual chemical and physico-chemical parameters were identified to be included. Surveys were planned to identify specific organic compounds, pesticides and other organic micropollutants to be included in the monitoring programme for both surface water and sediment. Effluent monitoring still had to be developed (László and others 2003).

The new recommended information needs were extensions of the existing monitoring programme with the addition of new parameters (for instance micropollutants and biological parameters) or new media (sediments or effluents). Important is also the identified need for new assessment methods (for instance ecological and hydromorphological quality, and diffuse pollution assessment) that lead to new information needs. The recommendations focused on State and Impact parameters and some Pressure parameters (pollution loads). No recommendations relate to assessing Driving forces and Responses. One important recommendation was made to set up two automatic water quality monitoring stations in the Mures River, one near the Romanian – Hungarian border and one approximately 170 km upstream. This last location was chosen because this was the point where most of the pollution sources are located upstream therewith having a good chance of detecting any pollution spills while there will be enough time for warning the downstream country. This is a clear shift from merely monitoring at the border to monitoring transboundary effects.

### 7.5.4 The Bug pilot project

The information needs for the Bug River were divided into three groups; 1) General indicators for management targets and identified issues; 2) Indicators related to specific issues and management targets; and 3) Economic indicators. A total of 50 indicators were identified, 17 general indicators, 26 specific indicators, and 7 economic indicators. It was apparent that the project participants felt most at ease with the familiar chemical and hydrological elements. A selection of parameters and media for the monitoring programme was made in accordance with the main problems identified and the results of the surveys done in 1999 and 2000. This general set of parameters was modified at designated sampling points in the detailed monitoring programme. For surface waters and effluent monitoring, 27 (groups of) chemical and physico-chemical parameters were identified to be included in the proposed monitoring programme, 4 (groups of) hydrobiological parameters, and 5 hydromorphological parameters. For sediment monitoring, 12 (groups of) parameters were identified. The focus in the report is on the chemical status of the river and the pollution sources for this status as is for instance clear from the identification of missing information in the recommendations report (Landsberg-Uczciwek 2003).

There is a difference between the existing monitoring network and the new one as specified through the water management analysis and further elaboration of information needs. From the pilot project it was concluded that the location of sampling points and the range of measured parameters are not in line with the water uses, problems and issues identified in the basin and should be altered. A reduction in the existing sampling points is identified as desirable from a cost-efficiency point of view. New assessment tools and improved information exchange are recommended next to that (Landsberg-Uczciwek 2003).

## 7.6 Discussion and conclusions

The pilot projects, although in principle only preparatory to the implementation of a monitoring programme, took a long time to finalise; the proposed three-year schedule extended to five or six years. One important reason for this was that raising strong formal commitment took far more time than anticipated. This is partly attributed to the low priority given to extensive evaluation of the existing monitoring programme and possibly also to the transboundary character of the pilots, where priority would preferably be given to national issues especially during a time of transition and change in central and eastern Europe.

A major disturbance in protracted linear design projects in general is that over time the process-environment changes. During the lifetime of the pilot projects the EU Water Framework Directive became a dominant factor in monitoring and assessment and many members of the various project teams have become closely involved in work in their own countries in preparation for adopting the WFD. The WFD monitoring guidance was found to be complementary to the UNECE guidelines. Where the WFD prescribes what has to be monitored in what way, the UNECE guidelines provide strategies how to design and implement this. In comparing the work of the UNECE pilot project with the requirements of the EU-WFD, Adamková and Bernardová (2003) conclude that: "*The current state in the process of implementation of the UN/ECE Guidelines for Monitoring and Assessment has already resulted in an appreciable amount of information, skills and experience that are necessary for the implementation of the EC - Water Framework Directive. In the next steps of this process towards the design of an adequate monitoring system, it is possible to incorporate the more specific requirements of the EC - WFD and its underlying directives*". The pilot projects therefore not only delivered new insights into the development of a transboundary monitoring system but also provided important input for the implementation of the WFD in the countries involved.

Expectations about the process and outcome differed greatly at the beginning of the pilot projects. The participants took a long time to realise the extent of the scope and the analytical character of the projects. Although the guidelines were available and known to the participants, the broader process of water quality assessment as described in the guidelines was initially not well understood. For instance, at the start there was general agreement that the analysis was limited to monitoring at the national borders. Over time realisation grew that the information needs had the wider perspective of monitoring transboundary issues.

The three pilot projects show differences in implementing the methodology. The Morava River pilot project is the most advanced in implementing a water management analysis and subsequent specification of information needs. The two countries in the Morava basin, Czech Republic and Slovak Republic, were only recently separated and still have a very similar legal and political system and little language problems. Both countries are also closely involved in the development of the TransNational Monitoring Network (TNMN) of the International Commission for the Protection of the Danube River (ICPDR) that concerns the ecological status of the Danube River and its tributaries. These similarities enabled the countries to communicate well and to come to agreement quite soon. Their focus in the process could consequently be more on the concepts and principles of the methodology and they were able to implement these almost entirely. The Mures River pilot project did not establish such a clear link between the water management analysis and the information needs, and there is a focus on ecological information. The two countries in the Mures basin, Hungary and Romania, are countries with different languages and different legal and political systems. These differences complicated cooperation and coming to agreement between the countries and much of their effort went into this alignment. Both countries concentrated on implementing EU legislation. The two countries are also closely involved in the development of the TNMN, the design of which closely relates to the monitoring network of the pilot project. The design of the network, including the selection of monitoring locations, shows a clear reconsideration of the existing network on the basis of the water management analysis. The link between water management objectives and information needs was also not unambiguous in the Bug River pilot project. Nevertheless, significant changes in the monitoring network were recommended and missing socio-economic information identified. The three countries in the Bug basin, Poland, Ukraine and Belarus, are countries with different languages and different legal and political systems. EU regulations were only relevant for Poland. Socio-economic information is much less available in Belarus and Ukraine than in the other countries involved in the pilot projects. The water management analysis as a result was for this pilot project more laborious than for the others. This made the pilot project focus on clarifying the situation more than elaborating all details according to the methodology. The process nevertheless revealed the imperfections in the water management situation and recommendations for improvement could be developed.

The evaluation workshop revealed that the overall opinion of the participants about the pilot projects was very positive and the usefulness of the structured breakdown through the DPSIR framework was acknowledged. Moreover, the function/issue table proved a good basis for discussing the common ground in water management for the countries sharing a water body. The connection that was established between water management and monitoring was highly appreciated. It was noted that in the past generally the transboundary monitoring programme was prepared to produce information on the state of the water without adequate background information like knowledge of the impact of pressures on the ecosystem. The ensuing assessments did not relate to the causes of the results. Application of the DPSIR approach in the pilot projects enabled explaining of the cause-effect relations and distinguishing between the different aspects of issues. New elements that were included in the monitoring programmes as a result of the structured approach were effluent monitoring systems, regular inventories of potential accidental risk sources, and monitoring of biological quality elements like flora, benthic invertebrate fauna and fish (see Chilton and others 2004).

Looking at the question if the structure to organise the problem is able to narrow the water information gap it becomes clear that the DPSIR structure supports the translation from policy statements into information needs. The information needs as assessed respond to the policy problem environment and the policy objectives. The structured breakdown approach accommodates broadening of the scope as the analysis of functions, uses and issues within water management required the project teams to consider the whole basin and to assess the spatial distribution of functions and issues in relation to the main river and its tributaries. The structure thus enhances an analysis of the policy problem from multiple perspectives. In two of the three pilot projects, social, economic, and ecological information needs were identified. Nevertheless, in one of the pilot projects the information needs concentrated merely on the S and I indicators and socio-economic and institutional needs were not assessed (Nilsson 2006; Scheltinga and others 2010). Overall, the resulting information needs would enable recognition of progress in the policy problem over time. From these arguments it is concluded that the structured breakdown supports narrowing the gap. The information needs in general however provided only limited information to support balancing between uses, problems and measures. The attention of the participants had concentrated on the problems and their causes, which was further focussed through the DPSIR framework. In the end little information would be provided on the level to which the water management objectives would be achieved, neither on the effectiveness of measures. This focus on problems has led to the understanding that the structured approach needed additional elaboration on the aspects of functions/uses and measures within the structured breakdown.

# CHAPTER 8

# SYNTHESIS AND CONCLUSIONS

## 8.1 Introduction

A substantial part of the information needed for water management is collected on a regular basis through monitoring. While information producers devote much effort into making information production effective and efficient, decision-makers in general consider the information they receive as only partly salient. This situation is what I call the water information gap. The goal of this study is to bridge the water information gap by improving the salience of water information. The research focused on structuring the process of determining the information needs related to the water management situation. This chapter summarizes the main findings of the thesis and elaborates on the results of the empirical application of the methodology developed in this research.

## 8.2 The nature of the water information gap

The Dutch national inland water quality monitoring network was used to analyse if the information as currently produced is useful, i.e. salient, credible and legitimate. The analysis showed that the information resulting from the network is perceived to be credible; ample efforts through quality assurance programs and regular evaluations are undertaken to produce high quality data. These efforts are generally acknowledged where information users state that the information is of high quality and the information producers are considered to have adequate expertise. Also, the legitimacy of the information is not disputed; the information from the Dutch network is not perceived as biased or providing only part of the relevant information. The information users however experience the applicability of this information for their work as limited; the information is not salient. Other studies showed that the Dutch situation is not unique but that in other countries as well, little attention is given to ensure that the information collection is linked to the actual priorities and needs of the decision-makers.

This study focused on improving the salience of the information. The issue of information not being salient was addressed by looking at two distinct questions:

- Is the information that is produced actually used?
- Are the needs of information users met or otherwise?

The analysis showed that information coming from the monitoring networks is used, among others in a range of reports and other communications. The notion that too much information is produced was consequently not substantiated. The widespread use of the information even suggests that this information has much more value for water management than generally acknowledged. But information users are interested in only part of the information that is produced and are not always aware of other users with other needs. Moreover, they are not always aware of the origin of the information they get and as the use is rather diffuse, information users do not always acknowledge the work, which explains for part of the depreciation.

The analysis also showed that evaluations of the network and considerations of information needs as well as balancing the various needs against the available resources are done with little or no involvement of information users. A special study comparing policy statements with information production confirmed the idea that only part of all information needs as derived from the policy statements was produced. Information users may also have needs that are not identified as they are not involved in the specification of the information needs. As a result, certain information needs are not answered through the monitoring network.

The analysis of the water information gap thus showed that information producers have limited insight in the work and needs of information users and vice versa which also leads to reluctance when it comes to investing efforts in communicating. To improve the salience, better communication between the groups is needed. Better communication entails respectful interactions in which both groups are willing to learn from and deal with their different interpretations. Structuring the process of specification of information needs, guiding and supporting communication between the groups, enables both parties to become aware of the fact that their opinion is limited by their respective mindframe. Understanding of the other party's mindframe is considered to be capable of lowering the mutual reluctance to cooperate (Brooks 2003). The structure in that way supports joint (both information users and information producers) description of the exact information to be produced to make the information more salient. Such a structured process will also explain the various uses of the information and the fact that certain information is not produced due to limited resources. A structured, transparent process can in this way improve the information user's satisfaction.

## 8.3 How does the process of information production link to the water management process?

Regular production of information or monitoring is a lengthy process involving planning, sampling, analysing, processing, storing and disseminating. The information cycle is a conceptual framework developed to describe this process in an appealing and understandable way. It supports improving the quality of the process and the information resulting from it and assists in communicating the process to information users to inform them on their role in the process. The cycle is explicitly linked to water management as the essential driving force for information production. Specification of information needs is the first logical element in the information cycle and that links water management to the information production process. Other steps in the cycle describe how the information is collected and processed. The final step in the cycle is the information utilisation. This is the step that links the information production process back to the water management process. These two steps, specification of information needs and information utilisation, are the elements that connect between the information production process and the water management process. Specification of information needs as the first step is the determining factor for the rest of the process and is therefore essential for improving the salience of the information. The information cycle in practice has proven to be a powerful tool. This is for instance shown in the fact that Rijkswaterstaat has modelled the information production process on the basis of the cycle (Rijkswaterstaat 2010).

## 8.4 How is the process of specification of information needs structured?

The process of specification of information needs is constructed as a problem structuring or problem framing process that enables deliberating over the complex problem situation and making a translation from often ambiguous policy statements into unambiguous information needs. On the basis of a literature analysis and a process of Reflection-in-Action, the problem framing process is developed, divided into a structure to manage the process and a structure to organise the problem.

To manage the process of specifying information needs a structure is developed that supports communication between the information users and producers in such a way that interaction and collaboration between the multiple actors can take place. This involves developing understanding of the policy process among information producers and understanding of the information production process among information users. The interactions involve exchange about mutual needs and interests to develop a common view on the issue at hand. The structure is a participatory process that engages the participants in a process of social learning (McDaniels and Gregory 2004; Mostert 2004). The structure, called the rugby-ball methodology, aims at making the actors confident that they embark in a useful process and encounter the proper actors while the topics they will be dealing with are provided to them in a way that enables them to discuss and contemplate. Feedback of the users of the methodology revealed the importance of having a structure at hand that was comprehensible. The rugby-ball provided for this. An important element in the structure is the use of workshops, where the majority of the interactions take place. Experiences with applying the methodology showed that thorough elaboration of the problem structure prior to the workshops is needed to make them effective.

To organise the problem, a conceptual model of the problem is developed that enables breakdown of the problem into manageable parts (Lindenmayer and Likens 2009). The three case studies described in this thesis used different models for structuring the problem. In the case study on the 4$^{th}$ national policy document (Chapter 5), various structures were built on the basis of the policy document. This approach was helpful in structuring the translation from policy objectives into information needs, but it remained uncertain if the full scope of the information needs was covered. The need for a comprehensive conceptual model of the water management situation independent of the policy structure became apparent. The integrating decision-model, the triangle of functions/uses, problems and measures, was used in the gradients case study (Chapter 6) as the conceptual model. From this study it was concluded that this model improved the analysis but did not provide sufficient conceptual support to reach sufficient detail. To account for the necessary detail, the Driving force – Pressure – State – Impact – Response (DPSIR) framework was used in the transboundary pilot projects (Chapter 7). The framework provided a clear conceptual structure with manageable pieces and their linkages which provided confidence that the breakdown was balanced and comprehensive. The DPSIR framework nevertheless focused too much on the problems and provided little information about attaining the water management goals or information about implementation of measures. Additional frameworks to develop information needs form functions/uses and measures were selected to account for this and are described in Chapter 4. Each case study in this way added to the understanding of how to organise the problem.

## 8.5 Does the structuring help to narrow the water information gap?

### 8.5.1 Does managing the process narrow the gap?

The process structure was tested in two of the three case studies. The case studies showed that the process structure was suitable to meet the design criteria to narrow the water information gap. Involvement and inputs from a wide group of actors with different stakes and from different management levels was effectuated in the case studies. The participants were able to influence the process by, for instance, changing the contents of the workshop they were in. Also, a specific group of participants with a certain stake was able to widen the problem definition. The inputs thus led to other results then would have been realised without the methodology. Furthermore, evaluations among the participants showed that the process structure supported interaction and collaboration, ensuring the exchange of values and building of common understanding. Participants to the three case studies became aware of their own role as well as of the roles of the other actors as they reported to have obtained a better appreciation of the information producing process and the importance of investing into the specification of information needs to obtain improved information. This is among others shown through the common adoption of the results of the process. The participants were also happy with the transparency of the process, the people that were involved and the translation of the policy into information needs. The essential elements to manage the process were a combination of 1) special attention to the specification of information needs; 2) a clear and logical process structure; and 3) willingness of information users and producers to embark in the process.

### 8.5.2 Does organising the problem narrow the gap?

The three case studies showed that the structured breakdown approach is able to meet the design criteria that will help narrowing the gap. From the onset, the policy statements as put down in policy documents were taken as the starting point.

The structured breakdown takes care of unravelling the policy situation into manageable parts for which information needs are developed and a clear response to the policy problem environment is developed in this way. The policy objectives are clarified while insight is provided into the process that causes the problem. A well-developed model is better capable of supporting the breakdown as became clear from the case studies. Structures on the basis of the individual policy problems are helpful for discussing the respective problems but give insufficient overview over the full extent of information needs for water management. The integrating decision-model supports considering information needs on uses, problems and measures accounts for this but provided too little detail. Detailed structured breakdown frameworks are therefore needed to help clarifying the policy statements and enhance looking at the problem from multiple perspectives. The DPSIR framework showed the necessary improvement on the element of problems and provides information about progress and futures of the policy problem. The IWRM framework is a complementing framework to determine the degree to which the policy objectives for the functions/uses are reached and puts the emphasis on social, economic, and ecological aspects. The third framework provides information about the implementation and effectiveness of measures. The latter two frameworks are not tested. The essential elements for organising the problem through a conceptual model are a combination of 1) understanding among the participants of the model used; 2) a model structure that links the individual elements; and 3) the model elements need to be sufficiently detailed to provide for manageable pieces.

## 8.6 Conclusions and considerations

Structuring the process by managing the process and organising the problem is able to improve the salience of the information and to narrow the water information gap. The information users generally perceived the information needs as improved relative to the classical situation where no structured approach was available. The breakdown structures provided confidence among the participants that the relevant issues were discussed. Further research and practical experience is needed to determine if the salience can be sufficiently improved to actually bridge the gap. This includes looking at the final step in the information cycle; information utilisation, that deals with conveying the information to water management. It should be noted that the case studies took place in an environment where there was willingness to collaborate and learn (Raadgever 2009). Next to that, the credibility and legitimacy of the information were not disputed. The approach may therefore not be applicable in all types of situations.

The structure for the process of information needs assessment was developed and tested through a process called Reflection-in-Action; by interaction between ideas and practice, experiences develop that help to improve both. This approach proved to be necessary and successful in structuring the process. Suitable case studies were few while the possibilities for implementing the methodologies depended on the willingness of the owners of a study. Nevertheless, the case studies as described in this thesis were pivotal for the development of the methodology. Evaluations of the case studies built confidence that the approach was effective and revealed elements that needed improvement. The Reflection-in-Action approach is therefore necessary for this type of research where experimentation possibilities are limited.

There is an inclination among implementers of the methodology to carry out the structured breakdown during the two workshops. Translation of the policy objectives into information needs however requires a level of detail that is not easily dealt with in a workshop setting. Much more attention is therefore needed in performing interviews and analysis of documents prior to the workshops. The resulting analysis then feeds into the workshops that preferably focus on 1) explanation of the work done; 2) controversies that have been encountered in the analysis; 3) identification of gaps in the analysis; and 4) agreement among the participants about the results and further actions. As the process is essentially participatory, balancing is needed here to ensure that participants can influence the outcomes.

In analysing the water information gap it appeared that changes in monitoring programmes are usually poorly documented. This is undesirable from a viewpoint of accountability, quality control and quality assurance. Meta-information about the network as presented in the analysis in Chapter 2 is helpful to obtain an overview of the developments. By better documenting why parameters, locations, etc. are chosen, changed or deleted, evaluation of monitoring networks can be improved. A fully developed structured breakdown set of information needs that is regularly updated will be helpful in this respect.

From Chapter 5 it follows that in different phases of the policy life-cycle different types of information are needed. This conclusion stresses the importance of both a flexible process of specification of information needs as well as an iterative process of producing information through a cyclical approach as depicted in the information cycle. Such an approach will enable a more critical evaluation of the monitoring and its results. It also implies that where legislation often prescribes monitoring efforts, to become salient legislation should focus more on the relevant outcomes. This tendency is already visible in the EU Water Framework Directive and even more in the EU Marine Strategy Framework Directive. The downside of such an approach is that parties may be tempted to collect only that information that is favourable for their purposes. Balancing is consequently needed.

Specification of information needs is still a step in the information production process that receives little attention and the mere existence of a methodology does not imply that it will be used. The reasons for this lack of attention may vary from ignorance to the fear of identifying obvious omissions, both in information production and in policy development. The need for proper information needs assessment is however still growing. This can be illustrated with the provisions of the EU Water Framework Directive (WFD). The WFD in its annex V prescribes in much detail the information requirements for water management. There is a tendency to consider these requirements as stand-alone tasks where the goal is to provide information to support the river basin management. The methodology described in this thesis provides a structure for linking the information requirements with various information elements like the review of the environmental impact of human activity and economic analysis of water use (Article 5), and the programme of measures (Article 11) to develop, for instance, the surveillance-monitoring programme (Annex V) in detail. The resulting framework can be used to further develop the river basin management plans (Article 13) and to provide coherent reporting to the Commission (Article 15). The methodology also has a great potential for developing the programmes for operational and investigative monitoring (Annex V) as well as identification of the information needs of the public (Article 14).

Information producers are the ones that currently initiate the process of specification of information needs. Input from information users is however essential to certify that the information needs as specified reflect the actual information needs. Active ownership of the process from information users is therefore imperative.

## 8.7 Suggestions for further research

The conceptual model for the structured breakdown is only partly tested. The integrating decision model together with the DPSIR indicator framework proved to be very helpful in structuring the policy issues and connecting information needs. The additionally added IWRM framework and the measures framework were however not tested. The breakdown structure therefore needs to be tested in full. Moreover, alternative models may provide better results. It is therefore recommended to further test the methodology and the used frameworks.

The tasks of water management and water policy in a situation of changing economic and demographic trends and changing climate stretch out over a much wider range of issues than currently put down in legislation. It is therefore recommended to invest into determining the need for and use of information in the overall water management process. This requires readiness to invest time and efforts into communicating and learning, both from information users and producers, but will yield substantial results as the case-studies showed. Especially in view of climate change, the social learning through the structured process will assist in building the necessary adaptiveness (Lebel and others 2010; Timmerman and others 2008).

Specification of information needs is essential to produce salient information. But, as the information cycle depicts, the way the information is reported and communicated is equally important to make the information salient. Research is needed to improve the way information is brought to decision makers (Denisov and others 2004).

The methodology developed helps to improve the production of information. It is however not clear which information is actually used in the decision-making and policy development processes and to what extent. More research into the use of environmental information in decision-making processes can provide improved insights into what type of information is used in what kind of situations. This enables to better conclude about the salience of the information and its ability to support the decision-making process, and to tune the methodology to this use. It will also help to conclude about the range of uses of the information and therewith the societal value the information has.

Monitoring is under continuous pressure to change; the long-term, inflexible time-series approach has to change towards more flexible, more targeted approaches. Also, more attention is needed for socio-economic information and policy process information. It is generally acknowledged that this can be realised based on information needs that have been specified through a participatory process (Allen and others 2001; Gouveia and others 2004; Pahl-Wostl and others 2007b). Research is needed to determine the reasons why this realisation is sparsely put into practice.

With improved computing power, modelling has become more powerful. The link between monitoring and modelling is however weak. For instance, there is a need for improved predictions, among others in view of climate change. Models may provide for this. Monitoring on the other hand is needed to feed the models. Also, improved models may to a certain extent be able to complement monitoring (Silberstein 2006). Further research in the link between monitoring and modelling is recommended to determine the possibilities of and constraints for mutual enrichment.

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# LIST OF ACRONYMS

| | |
|---|---|
| CATWOE | Customers, Actors, Transformation process, Weltanschauung, Owners, Environmental constraints |
| HO | Head office of RWS |
| IKC | Information and Knowledge Centre of LNV |
| IRC/ICPR | International Rhine Commission/International Commission for the Protection of the Rhine |
| LNV | Ministry of Agriculture, Nature and Food Quality |
| MWTL | Dutch National Monitoring System |
| NEN | National Ecological Network |
| NW3 | 3rd National Policy Document on Water Management |
| NW4 | 4th National Policy Document on Water Management |
| RD | Regional Department of RWS |
| RIKZ | Institute for Marine and Coastal Research |
| RIVM | National Institute for Public Health and the Environment |
| RIZA | Institute for Inland Water Management and Waste Water Treatment |
| RWS | Rijkswaterstaat (Directorate-General for Public Works and Water Management) |
| SD | Specialist Department of RWS |
| SSM | Soft Systems Methodology |
| V&W | Dutch Ministry of Transport, Public Works and Water Management |
| WFD | European Union Water framework Directive |

# SUMMARY

# NARROWING THE GAP BETWEEN INFORMATION USERS AND INFORMATION PRODUCERS

## Introduction

Water is an essential but scarce natural resource and is crucial for human well-being. Sound decision-making in water management is needed to manage this resource in a sustainable way and needs support from information. Information enables to evaluate the situation, be knowledgeable about the processes and the implementation of measures in the water system, and have insight into the effects of these measures. A substantial part of this information is collected on a regular basis through monitoring. Water monitoring over time developed from measuring a few simple parameters to a complex process where many different parameters in various frequencies on various locations are measured. The information resulting from monitoring however does not always satisfy the decision maker's needs. This is what I call the water information gap.

Policy makers from around the world are calling for more 'useful' information; information that is salient and context-sensitive, credible, and legitimate (McNie 2007). Many scholars today call for a process of determining the water management problem and the information needs related to it to overcome the water information gap. The goal of this study is to improve the salience and suitability of water information by structuring the process of specification of information needs. To reach this goal, the following research questions were defined:

1. What is the exact nature of the water information gap?
2. How does the process of information production link to the water management process?
3. How can specification of information needs be structured; how can the process be structured and the problem situation be organised?
4. Can the water information gap be narrowed by structuring the specification of information needs?

A desk study and a literature study after the Dutch national monitoring network were done to analyse the water information gap and comparison was made to the situation in other parts of the world. On the basis of the findings of that study, a literature study was done to determine the link between information production and water management. Then, through a process of Reflection-in-Action findings from literature were combined with practical experiences from case studies to develop a structure for the process of specifying information needs.

## Analysis of the water information gap

From the analysis of the Dutch national monitoring network it is concluded that information producers put ample effort into producing useful information. Quality assurance programs together with regular evaluation studies ensure the credibility of the information. Legitimacy of the information is, among others, ensured by making the production process transparent. The analysis of the water information gap therefore concentrated on the salience of the information.

Salience is related to the question if information that is produced is actually used and to the question if information users have information needs that are not met. The study showed that information coming from monitoring is used in various ways and it is concluded that the bulk of the produced information is used. The study also showed that decision makers have unmet information needs. Although information producers put ample effort in specifying information needs, this is done with little or no involvement of information users. An essential reason for this is that information producers have a limited insight in the work and needs of information users and vice versa. As both groups have a task to fulfil, this unawareness leads to reluctance when it comes to investing efforts in communicating about mutual needs and interests.

To bridge the water information gap, better communication between information users and information producers is needed. Better communication entails respectful interactions between the groups in which they are willing to learn from and deal with their different interpretations that are rooted in different mindframes. It entails identifying users' information needs prior to producing information. To manage such improved communication, a methodology is needed to guide and structure the interactions.

## Linking information production to the water management process

To facilitate the dialogue between information users and information producers, a common framework to describe the information production process is developed to ensure that all parties involved share the same notion of the process. The information cycle is a general framework that describes the essential steps in the process of information collection. The cycle is inextricably bound up with water management. In going from information required to information obtained, the following steps can be distinguished: (1) Information users, as part of the information cycle, should, in cooperation with information producers, decide upon the characteristics of the information that is needed. (2) Information producers will, in cooperation with information users, decide upon the best way (i.e., strategy) to collect information. (3) The actual collection of data is the next step in the information cycle. (4) The collected data are analyzed and the results interpreted relative to the information sought; information statements are made. (5) The resulting information is presented and transferred to the information users in a proactive manner. Each step in the information cycle puts requirements on the previous step of the cycle. The cyclic character comprises regular evaluation of the gathered information, thus quantitatively connecting the monitoring system design and operations with the information expectations and/or products required by management.

The essential steps that link the information production to the water management process are the first step in which the information needs are specified and the last step in which the produced information is brought to the decision makers. This thesis focuses on the first step of defining the information needs. This will also improve the last step as the purpose of the information has been clarified in the first step.

## A structured process

The methodology to specify information needs entails design of a structure to manage the process and a structure to organise the problem. The structure to manage the process is given the form of a rugby-ball with five phases. The process starts by exploring the scope of the study (Explore), using the CATWOE (Customers, Actors, Transformation, Weltanschauung, Owners and Environment constraints) -analysis. This scope is discussed with the stakeholders in a workshop setting to bring all participants at the same level of understanding; the initiation phase (Initiate). Then, the problem structuring takes place in the third phase (Elaborate). The information need as roughly specified in the previous phase is further elaborated to enable development of an information network. The results of the problem structuring are discussed with the stakeholders, again in a workshop setting (Conclude). Finally the process is described and a comprehensive overview of the problem structuring is developed that enables building an information network (Complete).

The other element in the methodology is a structure to organise the information related to the problem. The basic conceptual model for this breakdown is the integrating decision-model, essentially the water management triangle of uses/functions, problems and measures. The participants reflect on the fundamental objectives within the scope of the study by thinking along three basic lines formed by the three elements of the model, which helps in developing an objectives hierarchy. The first element in the integrating decision model is to clarify what information is essential to verify if the objectives for the functioning and uses of the water system are achieved or approximated. The IWRM triangle of ecology, economy and society is the conceptual model where each element is an aspect of a water management objective. The second element is to develop understanding of how the natural environment and human uses of the water resources limit or enhance reaching the objectives. The DPSIR framework is selected here to focus on singular issues: for each problem / opportunity, the Driving forces, Pressures, Status, Impacts and Responses are listed and attributes are selected that describe these aspects. The third element gives insight into what is already done and what can be done in future. The two aspects to be addressed here are 1) if measures are actually implemented and 2) if the measures have been effective in reaching the objectives. The structured breakdown approach makes the transformation from the fundamental objectives into measurable (quantitative) or perceptible (qualitative) attributes. The selection of the attributes is an expression of the values or mindframes that are behind the fundamental objectives.

## 4th National Policy Document on Water Management

Adoption of the 4th National Policy Document on Water Management (NW4) by the Dutch parliament in 1998 was the trigger for Rijkswaterstaat to reflect on the effects of this new policy on the information needed for management of the national waters, and consequently on the national monitoring networks. The document lays down water management policies as valid for 1998 and provides a future outlook into the overall goals and aims of, and the reasoning behind the water management approaches. This reflection provided a good opportunity to test the rugby-ball methodology that had just been developed. The methodology at that time only comprised the structure to manage the process. The results of the study were compared to a study that was done to specify the information needs in the basis of the Third National Policy Document on Water Management (NW3).

Compared to the NW3 study, the NW4 study was much better equipped to bridge the water information gap as the outcome of the latter was a result of a joint effort of both information users and –producers, it explicitly linked to the policy objectives and therefore the context of the information users, and the results included ecological as well as socio-economic determinands. Moreover, interviews with people that had been involved in the NW4 case study or that had been responsible for applying the rugby-ball methodology in other projects showed that the rugby-ball process structure had made people more aware of their relative position in the information production system, more aware of the question what information is really needed and that the methodology led to improved communication between different departments and organisations, even after finalising the projects. The resulting information needs were considered an improvement compared to the existing situation by all interviewees. However, from the study it appeared that where the rugby-ball is suitable to manage the process, it lacks a structure to guide the breakdown of policy objectives into information needs. The methodology therefore needed improvement by including a structure to organise the problem.

## Gradients

Dutch water management policy aims at restoring transition zones; so-called gradients. A case study was developed to define the information needs, focusing on the ecological aspects of the policy objective. One complicating factor was that the policy was not yet detailed; this elaboration was part of a study that was done in parallel. On the basis of the integrating decision-model, the major aspects related to the policy were inventoried in a workshop setting. The outcome of the workshop deviated from the expectations of the initiators of the study as socio-economic aspects were included, like agriculture and safety. Further breakdown of the mentioned aspects into information needs was done in a second workshop. For this purpose, the integrating decision model was complemented with an existing ecological model which proved very helpful in further detailing the information needs on the ecological aspects. As the policy was not fully elaborated, detailing of the policy objectives into information needs could only be done roughly.

The participants reported that the outcome of the case study was substantially improved relative to the common practice. Especially the interdisciplinary character was welcomed. From this study it was concluded that the ruby ball process structure and the structured breakdown framework were successful in improving the specification of information needs. The study also showed that additional conceptual models are helpful in further detailing the information needs.

## Transboundary pilot projects

Under the supervision of the Working Group on Monitoring and Assessment under the UNECE Water Convention (UNECE 1992), three pilot projects were conducted to develop transboundary monitoring networks in support of water management. These pilot projects used the DPSIR indicator framework as the basis for the structured breakdown. Elaboration of the information needs and identification of indicators was done by the countries involved and was discussed in bilateral or trilateral workshops. For each river basin the uses and functions were specified for the situation in the respective countries like for instance the overall abstraction of water for a specific use. Priorities were assigned to the functions and uses. The most important management objectives were listed in the water management analysis, based on the uses, and linked to problems that hinder reaching these objectives. An overview of the water management situation and the transformation process was developed in an iterative manner with the use of workshops. Indicators were derived for each cross in the function/issue table for the elements Driving force, Pressure, State, Impact and Response.

It took the participants a long time to realise the extent of the scope and the analytical character of the projects. Nevertheless, the overall opinion of the participants about the pilot projects was very positive and the usefulness of the structured breakdown through the DPSIR framework was acknowledged. The connection that was established between water management and monitoring was highly appreciated. Application of the DPSIR approach enabled explaining of the cause-effect relations and distinguishing between different aspects of problems. However, the integrating decision model was narrowed down to the problems is the river basin through the DPSIR framework. The attention of the participants therefore concentrated on the problems and their causes and gave little or no attention to achieving water management goals. This bias towards problems led to the understanding that the methodology needed additional elaboration on the water management objectives coupled to the functions/uses of the water system and the implementation of measures. The structured breakdown framework should provide for this.

## Conclusions

The process of specification of information needs is through the methodology constructed as a problem structuring or problem framing process that enables deliberating over a complex problem situation and making a translation from often ambiguous policy statements into unambiguous information needs. On the basis of literature analysis and a process of Reflection-in-Action, the methodology was developed, divided into a structure to manage the process and a structure to organise the problem.

The structure to manage the process enables developing understanding of the policy process among information producers and understanding of the information production process among information users. The workshops that are part of the methodology are imperative to achieve this as involvement and inputs from a wide group of actors with different stakes and from different management levels were effectuated. The structure makes the actors confident that they embark in a useful process and encounter the proper actors while the topics they will be dealing with are provided to them in a way that enables them to discuss and contemplate. Evaluations among the participants showed that the process structure supported interaction and collaboration, and ensured the exchange of values and building of common understanding.

The structure to organise the problem enables breakdown of the problem into manageable parts. In the first case study, no breakdown framework was available which rendered uncertainty if the full scope of the information needs was covered. The integrating decision-model that was developed on the basis of that experience improved the analysis but did not provide sufficient conceptual support to reach adequate detail. The DPSIR framework provided a clear conceptual structure with manageable pieces and their linkages. This provided confidence that the breakdown was balanced and comprehensive. It nevertheless caused a bias towards problems and provided too little information about attaining the water management goals or information about implementation of measures. The IWRM framework and the implementation and effectiveness of measures were added to account for this omission. In this way, the Reflection-in-Action process helped improving the methodology.

Structuring the process by managing the process and organising the problem is able to improve the salience of the information and to narrow the water information gap. The information users generally perceived the information needs as improved relative to the classical situation where no structured approach was available. The breakdown structures provided confidence among the participants that the relevant issues were discussed. The credibility and legitimacy of the information were not disputed. The approach may therefore not be applicable in all types of situations.

# SAMENVATTING

# HET DICHTEN VAN DE KLOOF TUSSEN INFORMATIEGEBRUIKERS EN INFORMATIEPRODUCENTEN

## Introductie

Water is een essentiële maar schaarse natuurlijke hulpbron en is cruciaal voor de samenleving. Goede besluitvorming is in het watermanagement nodig om deze hulpbron op een duurzame wijze te beheren en informatie is nodig om deze besluitvorming te ondersteunen. Informatie maakt het mogelijk om de situatie te evalueren, kennis te vergaren van de processen, kennis te verkrijgen van de mate van implementatie van maatregelen in het watersysteem en om inzicht te verkrijgen in de effecten van maatregelen. Een belangrijk deel van deze informatie wordt op reguliere wijze verzameld door middel van monitoring. Watermonitoring heeft zich in de loop van de tijd ontwikkeld van het meten van een paar eenvoudige parameters tot een complex proces waarin een groot aantal verschillende parameters in verschillende frequenties en op verschillende locaties gemeten worden. De informatie die door monitoring wordt verzameld voldoet helaas niet altijd aan de behoeften van beleidsmakers. Dit is wat ik de water-informatiekloof noem.

Beleidsmakers over de hele wereld hebben behoefte aan meer 'nuttige' informatie; informatie die relevant and contextgevoelig is, geloofwaardig en legitiem. Vanuit de wetenschap wordt daarom opgeroepen tot het ontwikkelen van een proces om het waterbeheerprobleem en de daaraan gerelateerde informatiebehoefte vast te stellen teneinde de water-informatiekloof te dichten. Het doel van deze studie is om de relevantie en geschiktheid van waterinformatie te verbeteren door het structureren van het proces van vaststellen van informatiebehoeften. Om dit doel te bereiken zijn de volgende onderzoeksvragen gedefinieerd:

1. Wat is precies de water-informatiekloof?
2. Hoe is het proces van informatieproductie verbonden met het watermanagementproces?

3. Hoe kan de specificatie van informatiebehoeften worden gestructureerd; hoe kan het proces worden gestructureerd en hoe kan het probleem georganiseerd worden?
4. Kan de water-informatiekloof verengd worden door de specificatie van informatiebehoeften te structureren?

De water-informatiekloof is geanalyseerd aan de hand van een bureaustudie en een literatuurstudie naar het Nederlandse nationale monitoringnetwerk en een vergelijking is gemaakt van deze situatie met die in andere delen van de wereld. Op basis van de uitkomsten is een literatuurstudie gedaan om het verband tussen informatieproductie en watermanagement te bepalen. Daarna zijn door middel van een proces van Reflection-in-Action de bevindingen vanuit de literatuur gecombineerd met praktische ervaringen vanuit casestudies om een structuur te ontwikkelen voor het proces van specificeren van informatiebehoeften.

## Analyse van de water-informatiekloof

Uit de analyse van het Nederlandse nationale monitoringnetwerk is geconcludeerd dat informatieproducenten zich grote inspanningen getroosten om nuttige informatie te produceren. Programma's om de kwaliteit te beheersen zorgen er samen met regelmatige evaluatiestudies voor dat de informatie geloofwaardig is. Legitimiteit van de informatie wordt onder meer gerealiseerd door het productieproces transparant te maken. De verdere analyse van de water-informatiekloof heeft zich daarom geconcentreerd op de relevantie van de informatie.

Relevantie is gerelateerd aan de vraag of de geproduceerde informatie daadwerkelijk gebruikt wordt en aan de vraag of de informatiegebruikers informatiebehoeften hebben, die niet vervuld worden. De literatuurstudie toonde aan dat de informatie vanuit het monitoring netwerk op veel verschillende manieren gebruikt wordt en er werd geconcludeerd dat het grootste deel van de geproduceerde informatie daadwerkelijk wordt gebruikt. De studie toonde ook aan dat beleidsmakers informatiebehoeften hebben die niet vervuld worden. Hoewel informatieproducenten veel moeite doen om de informatiebehoeften vast te stellen, gebeurt dit met weinig of geen bemoeienis van informatiegebruikers. Een belangrijke reden hiervoor is dat informatieproducenten maar een beperkt inzicht hebben in het werk en de behoeften van beleidsmakers en vice versa. Omdat beide groepen hun eigen taken hebben leidt deze onbekendheid met elkaars werk tot tegenzin als het gaat om het investeren in inspanningen om over wederzijdse behoeften en belangen te communiceren.

Om de water-infomatiekloof te overbruggen is betere communicatie nodig tussen informatiegebruikers en informatieproducenten. Betere communicatie behelst respectvolle interacties tussen de groepen, waarin de groepen bereid zijn om te leren van elkaar en leren om te gaan met verschillende interpretaties, die geworteld zijn in verschillende denkramen. De communicatie omvat het identificeren van de informatiebehoeften van gebruikers voorafgaand aan het produceren van informatie. Om zulke verbeterde communicatie te beheersen is een methodologie nodig om de interacties te begeleiden en te structureren.

## Het verbinden van informatieproductie met het watermanagementproces

Om de dialoog tussen informatiegebruikers en informatieproducenten te faciliteren is een gemeenschappelijk raamwerk ontwikkeld dat het informatieproductieproces beschrijft. Dit raamwerk zorgt ervoor dat alle betrokken partijen een gezamenlijk beeld van het proces hebben. De informatiecyclus is een generiek raamwerk dat de essentiële stappen in het proces van informatieproductie beschrijft. De cyclus is onverbrekelijk verbonden met watermanagement. Gaande van benodigde informatie naar verkregen informatie kunnen de volgende stappen worden onderscheiden: (1) Informatiegebruikers, als onderdeel van de informatiecyclus moeten in samenwerking met informatieproducenten beslissen over de karakteristieken van de informatie, die nodig is. (2) Informatieproducenten besluiten in overleg met de informatiegebruikers over de beste manier (de beste strategie), waarop de informatie wordt verzameld. (3) Het daadwerkelijke verzamelen van de gegevens is de volgende stap in de informatiecyclus. (4) De verzamelde gegevens worden geanalyseerd en de resultaten geïnterpreteerd in relatie tot de gezochte informatie; er worden informatie uitspraken gedaan. (5) De resulterende informatie wordt gepresenteerd en overgedragen aan de informatiegebruikers op een proactieve manier. Elke stap in de informatiecyclus stelt eisen aan de voorgaande stap in de cyclus. Het cyclische karakter omvat tevens een regelmatige evaluatie van de verzamelde informatie, waarmee een kwantitatieve connectie wordt gelegd tussen het ontwerp van het monitoringsysteem en de uitvoering ervan met de informatiebehoeften en/of de informatieproducten, die nodig worden gevonden voor het watermanagement.

De essentiële stappen, die de informatieproductie verbinden met het watermanagement proces, zijn de eerste stap waarin de informatiebehoeften worden gespecificeerd en de laatste stap waarin de geproduceerde informatie wordt overgedragen aan de beleidsmakers. Deze studie richt zich op de eerste stap van specificeren van informatiebehoeften. Hiermee wordt ook een verbetering van de laatste stap gerealiseerd, omdat het doel van de informatieproductie duidelijk is gemaakt in de eerste stap.

## Een gestructureerd proces

De methodologie om de informatiebehoeften vast te stellen omvat het ontwerp van een structuur om het proces te beheersen en een structuur om het probleem te organiseren. De structuur voor de procesbeheersing heeft de vorm van een rugbybal met vijf fasen gekregen. Het proces begint met het verkennen van de reikwijdte van de studie (Verkenning), gebruikmakend van de CATWOE (Customers (klanten), Actors (actoren), Transformation (de transformatie), Weltanschauung (visie op het proces), Owners (eigenaren) and Environment constraints (beperkingen opgelegd door de omgeving)) -analyse. De uitkomsten van deze fase worden bediscussieerd met de stakeholders in een workshop, waarmee alle deelnemers op hetzelfde begripsniveau worden gebracht (Initiatie). Vervolgens wordt het probleem gestructureerd in de derde fase (Uitwerken). De informatiebehoeften, zoals deze grofweg zijn vastgelegd in de voorgaande fase, worden hier verder uitgewerkt om de ontwikkeling van een informatieproductie netwerk mogelijk te maken. De resultaten van deze uitwerking worden bediscussieerd met de stakeholders, wederom in een workshop (Concluderen). Ten slotte wordt het doorlopen proces beschreven en wordt een bondig overzicht gegeven van de uitwerking van het probleem waarmee een informatienetwerk ontwikkeld kan worden (Completeren).

Het andere element van de methodologie is een structuur waarmee de informatie gerelateerd aan het probleem georganiseerd kan worden. Het conceptuele model voor deze uitsplitsing is het integrerend beslismodel, in essentie de water-managementdriehoek van gebruik/functies, problemen en maatregelen. De deelnemers reflecteren op de fundamentele doelen van de studie langs de drie basale lijnen, die gevormd worden door de drie elementen van het model. Hiermee wordt een doelenhiërarchie ontwikkeld. Het eerste element van het integrerende beslismodel is het verduidelijken welke informatie essentieel is om te verifiëren of de doelstellingen voor de functies en gebruik van het water systeem worden bereikt of benaderd. De driehoek ecologie, economie en samenleving van integraal waterbeheer is hiervoor het conceptuele model, waarin elke component een aspect is van een water-managementdoel. Het tweede element is het ontwikkelen van begrip van hoe het natuurlijk milieu en het humane gebruik van het water het behalen van de doelen beperkt of versterkt. Hiervoor is het DPSIR raamwerk gekozen, waarmee concentratie op enkelvoudige kwesties mogelijk wordt: voor elk probleem of mogelijkheid worden de Driving forces, Pressures, Status, Impacts en Responses geïnventariseerd en worden attributen geselecteerd die deze aspecten beschrijven. Het derde element geeft inzicht in wat al is gedaan en wat gedaan kan worden in de toekomst. De twee aspecten die hier aan de orde komen zijn 1) of de maatregelen daadwerkelijk geïmplementeerd zijn en 2) of de maatregelen effectief zijn gebleken in het behalen van de doelen. Deze gestructureerde aanpak verzorgt de transformatie van fundamentele doelen naar meetbare (kwantitatieve) of waarneembare (kwalitatieve) attributen. De selectie van attributen is vervolgens een uitdrukking van de waarden of denkramen, die achter de fundamentele doelen verborgen zitten.

## Vierde Nota Waterhuishouding

Het aannemen van de Vierde Nota Waterhuishouding (NW4) door het Nederlandse parlement in 1998 was de aanleiding voor Rijkswaterstaat om te reflecteren op de effecten van het nieuwe beleid op de informatie die nodig is voor het beheer van de Rijkswateren, en daarmee de consequenties voor het landelijke monitoring netwerk. NW4 legt het waterbeleid, zoals dat in 1998 gold, vast en geeft een vooruitblik op de doelstellingen en de gedachtegang rondom watermanagement, die daaraan ten grondslag ligt. Deze overwegingen boden een goede gelegenheid om de rugbybal methodologie, welke juist ontwikkeld was, te testen. De methodologie bestond op dat moment uitsluitend uit een structuur om het proces te beheersen.

De resultaten van de studie naar de informatiebehoeften van NW4 aan de hand van de rugbybal is vergeleken met een studie, die is uitgevoerd om de informatiebehoeften op basis van de derde Nota Waterhuishouding (NW3) te bepalen. Vergeleken met de NW3 studie was de NW4 studie veel beter uitgerust om de water-informatiekloof te dichten. Dit omdat de uitkomst van de laatste het resultaat was van een gezamenlijke inspanning van informatiegebruikers en –producenten, omdat er een expliciete link gelegd werd met de beleidsdoelstellingen en omdat de resultaten betrekking hadden op zowel ecologische als sociaaleconomische informatie. Daarnaast toonden interviews met enkele personen, die betrokken waren bij de NW4-studie of die verantwoordelijk waren geweest voor het toepassen van de rugbybal methodologie in andere projecten, aan, dat de rugbybal processtructuur de mensen bewuster had gemaakt van hun relatieve positie in het informatieproductiesysteem, bewuster had gemaakt van de vraag welke informatie werkelijk nodig is en dat de methodologie tot een betere communicatie geleid heeft tussen verschillende afdelingen, zelfs na afloop van de projecten. De hieruit voortvloeiende informatiebehoeften werden beschouwd als een belangrijke verbetering ten opzichte van de bestaande situatie door al de geïnterviewden. Desalniettemin bleek uit de studie, dat waar de rugbybal in staat is om het proces beter beheersbaar te maken, een structuur om de vertaling te maken van beleidsdoelstellingen naar informatiebehoeften nog ontbrak. De methodologie heeft daarom een aanvullende structuur nodig, om het probleem te organiseren.

## Gradiënten

Een van de doelen van het Nederlandse waterbeleid is het herstellen van overgangszones; zogenoemde gradiënten. Een studie werd ontwikkeld om de informatiebehoeften te bepalen, met de nadruk op de ecologische aspecten van deze beleidsdoelstelling. Een complicerende factor daarbij was, dat het beleid zelf nog niet ontwikkeld was; het uitwerken van het beleid werd parallel aan deze studie gedaan. Op basis van het integrerende beslissingsmodel werden in een workshop de belangrijkste aspecten van het beleid geïnventariseerd. De uitkomst van de workshop week af van de verwachtingen van de initiators van de studie, omdat ook sterk gekeken werd naar de socio-economische aspecten van gradiënten, zoals landbouw en veiligheid. Een verdere omzetting van de in de workshop geïnventariseerde aspecten naar informatiebehoeften werd gedaan in een tweede workshop. Voor dit doel werd het integrerende beslissingsmodel aangevuld met een bestaand ecologisch model, wat erg behulpzaam bleek bij het verder detailleren van de informatiebehoeften voor de ecologische aspecten. Omdat het beleid nog niet was uitgekristalliseerd, was de detaillering van de informatiebehoeften tamelijk globaal.

De deelnemers aan de workshop rapporteerden, dat de uitkomsten van de studie een belangrijke verbetering inhielden in vergelijking met de gebruikelijke aanpak. Vooral het interdisciplinaire karakter van de studie werd verwelkomd. Uit deze studie is geconcludeerd, dat de rugbybal als processtructuur samen met het gestructureerde uitwerkingsmodel succesvol waren in het verbeteren van het specificeren van informatiebehoeften. De studie toonde ook aan dat additionele conceptuele modellen bovenop het integrerend beslissingsmodel een goed hulpmiddel zijn voor het verder detailleren van de informatiebehoeften.

## Grensoverschrijdende pilotprojecten

Onder de supervisie van de 'Working Group on Monitoring and Assessment' onder de Water Conventie van de Economische Commissie voor Europa van de Verenigde Naties (UNECE 1992), zijn drie pilotprojecten voor het ontwikkelen van grens-overschrijdende monitoring netwerken ten behoeve van het watermanagement uitgevoerd. Deze pilotprojecten gebruikten het DPSIR indicatoren model als basis voor het gestructureerd uitwerken van de informatiebehoeften. Het uitwerken van de informatiebehoeften en identificatie van indicatoren werd door de respectievelijke landen gedaan en werd bediscussieerd in bilaterale of trilaterale workshops. Voor elk stroomgebied zijn het locale gebruik en de functies beschreven, zoals de abstractie van water voor een specifieke toepassing. Aan de functies en het gebruik zijn prioriteiten toegewezen. De belangrijkste beleidsdoelstellingen zijn opgesomd voor de watermanagement analyse, gebaseerd op het gebruik en de functies en gekoppeld aan de problemen, die het behalen van de doelstellingen verhinderen. Een overzicht van de watermanagement situatie en het transformatieproces werd op een iteratieve wijze ontwikkeld in verschillende workshops. Indicatoren werden afgeleid voor elk kruis in de functie/probleem tabel voor elk van de elementen Driving force, Pressure, State, Impact en Response.

De deelnemers aan de studie werden zich pas na geruime tijd bewust van de reikwijdte en het analytische karakter van de projecten. Toch was het algemene idee van de deelnemers over de pilotprojecten zeer positief en werd de gestructureerde uitwerking met behulp van het DPSIR raamwerk als nuttig beschouwd. Het verband dat kon worden gelegd tussen watermanagement en monitoring werd zeer gewaardeerd. Toepassen van het DPSIR raamwerk maakte het mogelijk om de oorzaak-gevolg relaties uit te werken en om onderscheid te maken in de verschillende aspecten van problemen. Het integrerend beslissingsmodel werd door het DPSIR raamwerk echter wel gereduceerd tot uitsluitend de problemen in het stroomgebied. De aandacht van de deelnemers werd daardoor gericht op de problemen en hun oorzaken, en er werd weinig aandacht besteed aan het behalen van watermanagementdoelen. Deze focus op problemen leidde tot het inzicht dat de methodologie additionele uitwerking van watermanagementdoelen behoefde, gekoppeld aan de functies en het gebruik van het watersysteem, en dat informatie over de implementatie van maatregelen nodig was. Dit moest worden opgenomen in de gestructureerde uitwerkingsmethodiek.

## Conclusies

Het proces van specificeren van informatiebehoeften is met behulp van de methodologie geconstrueerd als een probleemstructurering of ‘problem framing’ proces, dat het delibereren over een complexe probleemsituatie en de vertaling van ambigue beleidsuitspraken naar eenduidige informatiebehoeften mogelijk maakt. Op basis van een literatuuranalyse en het proces van Reflection-in-Action is de methodologie ontwikkeld, bestaande uit een structuur om het proces te beheersen en een structuur om het probleem te organiseren.

De structuur om het proces te beheersen maakt het voor de informatieproducenten mogelijk een beter begrip van het beleidsproces te ontwikkelen en voor de informatiegebruikers om een beter begrip van het informatieproductie proces te ontwikkelen. De workshops, die deel zijn van de methodologie, zijn onontbeerlijk om betrokkenheid en invoer vanuit een brede groep van actoren met verschillende belangen en verschillende managementniveaus te bewerkstelligen. De structuur geeft de actoren vertrouwen, dat zij zich bezig zullen houden met een nuttig proces en daarin de juiste actoren tegen zullen komen, terwijl de onderwerpen waar zij zich mee zullen bezighouden worden aangereikt op een wijze, waarop zij in staat worden gesteld deze te overdenken en daarover te discussiëren. Evaluaties onder de deelnemers toonden aan, dat de processtructuur uitwisseling en samenwerking ondersteunde en dat deze het uitwisselen van waarden en het bouwen aan een gezamenlijke grondslag verzekeren.

De structuur om het probleem te organiseren maakt een uiteenrafeling van het probleem in beheersbare brokken mogelijk. In de eerste case studie was er geen raamwerk voor deze gestructureerde uitsplitsing aanwezig, waardoor er onzekerheid ontstond over de mate waarin het volledige spectrum van de informatiebehoeften afgedekt was. Het integrerende beslissingsmodel dat op basis van deze ervaring was ontwikkeld hielp om de analyse te verbeteren, maar gaf onvoldoende conceptuele ondersteuning om een geschikt detailniveau te bereiken. Het DPSIR raamwerk voorziet in een heldere conceptuele structuur met beheersbare delen en hun onderlinge samenhang. Dit gaf vertrouwen dat de uitsplitsing gebalanceerd en omvattend was. Het veroorzaakte desalniettemin een eenzijdige vertekening in de richting van de problemen en gaf te weinig informatie over het bereiken van de watermanagementlendoelen, noch gaf het informatie over de implementatie van maatregelen. Het IWRM raamwerk en de implementatie en effectiviteit van maatregelen zijn toegevoegd als conceptuele uitsplitsingmodellen om in deze omissie te voorzien. Op deze wijze heeft het Reflection-in-Action proces geholpen bij het verbeteren van de methodologie.

Structureren van het proces door het beheersen van het proces en het organiseren van het probleem is in staat gebleken om de relevantie van de informatie te verbeteren en daarmee de water-informatiekloof te versmallen. De informatiegebruikers beschouwden de informatiebehoeften algemeen als verbeterd ten opzichte van de klassieke situatie waarin geen gestructureerde aanpak beschikbaar was. De uitsplitsingstructuren gaven vertrouwen onder de deelnemers dat de relevante onderwerpen bediscussieerd zouden worden. De geloofwaardigheid en legitimiteit van de informatie stond niet ter discussie De geschetste aanpak is daardoor mogelijk niet in alle situaties bruikbaar.

**Netherlands Research School for the**
**Socio-Economic and Natural Sciences of the Environment**

# C E R T I F I C A T E

The Netherlands Research School for the
Socio-Economic and Natural Sciences of the Environment (SENSE),
declares that

## *Jan Goos Timmerman*

born on 1 November 1959 in Leersum, The Netherlands

has successfully fulfilled all requirements of the
Educational Programme of SENSE.

Wageningen, 30 November 2011

| the Chairman of the SENSE board | the SENSE Director of Education |
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The SENSE Research School declares that **Mr. Jan Goos Timmerman** has successfully fulfilled all requirements of the Educational PhD Programme of SENSE with a work load of far more than 30 ECTS, including the following activities:

**SENSE PhD courses**

- Research Context Activity: Co-organizing conferences 'Monitoring Tailor-Made III' (2000) and 'Monitoring Tailor-Made IV' (2003), as well as contributing to SENSE Wetenschapsmarktdag (2012).

**Didactic Skills Training**

- Co-lecturer Senior Management Staff course Water Quality Monitoring, Kaduna, Nigeria
- Supervision MSc minor thesis Chantal Simons: "Differences in status of water management and climate adaptation in SEE and EECCA"
- Guest lecturer: Information needs in water management, Management of European River Basins, Wageningen University and Research Centre, Wageningen, Netherlands
- Guest lecturer: Information for management and decision-making: Frameworks and mindframes, Natural Resources Management, Royal Technological University, Stockholm, Sweden

**Oral Presentations**

- Monitoring programmes and chemical risk assessment, OECD workshop on improving the use of monitoring data in the exposure assessment of industrial chemicals, 13 - 15 May 1998, Berlin, Germany
- Information needs: linking water quality information to water management, 11th Stockholm Water Symposium "building bridges through dialogue, 13-16 August 2001, Stockholm, Sweden
- The use and valuing of environmental information in the decision making process: an experimental study, International Conference on Sustainable Management of Transboundary Waters in Europe, 21 - 24 April 2002, Szczecin, Poland
- Water information: what is it good for. On the use of information in transboundary water management, Monitoring Tailor-Made IV; Information to support sustainable water management: from local to global levels, 15 - 18 September 2003, St. Michielsgestel, The Netherlands
- The use of information in transboundary water management, 10th Scientific and Technical review Euraqua, 22 – 23 October 2003, Wallingford, UK
- On the use of environmental information in IRBM, Harmoni-CA conference, 18 – 19 Februari 2004, Brussels Belgium
- Information for internationally shared surface waters, UNESCO-IHP workshop: Development of an inventory of internationally shared surface waters in South-Eastern Europe, 18 - 20 October 2004, Thessaloniki, Greece
- Essentials of specification of information needs, Fifth National Water Quality Monitoring Conference, 7 - 11 May 2006, San Jose, California ,USA

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