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Knowledge and Perceptions in Participatory Policy Processes: Lessons from the Delta-Region in the Netherlands

Saskia Hommes · Joanne Vinke-de Kruijf · Henriëtte S. Otter · Geiske Bouma

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Abstract Water resources management issues tend to affect a variety of uses and users. Therefore, they often exhibit complex and unstructured problems. The complex, unstructured nature of these problems originates from uncertain knowledge and from the existence of divergent perceptions among various actors. Consequently, dealing with these problems is not just a knowledge problem; it is a problem of ambiguity too. This paper focuses on a complex, unstructured water resources management issue, the sustainable development—for ecology, economy and society—of the Delta-region of the Netherlands. In several areas in this region the ecological quality decreased due to hydraulic constructions for storm water safety, the Delta Works. To improve the ecological quality, the Dutch government regards the re-establishment of estuarine dynamics in the area as the most important solution. However, re-establishment of estuarine dynamics will affect other uses and other users. Among the affected users are farmers in the surrounding areas, who use freshwater from a lake for agricultural purposes. This problem has been addressed in a participatory decision-making process, which is used as a case study in this paper. We investigate how the dynamics in actors' perceptions and the knowledge base contribute to the development of agreed upon and valid knowledge about the problem–solution combination, using our conceptual framework for problem structuring. We found that different knowledge sources—expert and practical knowledge—should

S. Hommes (✉) · J. Vinke-de Kruijf
Water Engineering & Management, University of Twente,
P.O. Box 217, 7500 AE, Enschede, The Netherlands
e-mail: s.hommes@utwente.nl

H. S. Otter
Deltares, P.O. Box 85467, 3508 AL, Utrecht, The Netherlands

G. Bouma
Innovation and Environment,
The Netherlands Organization for Applied Scientific Research (TNO),
P.O. Box 49, 2600 AA, Delft, The Netherlands

be integrated to create a context-specific knowledge base, which is scientifically valid and socially robust. Furthermore, we conclude that for the convergence of actors' perceptions, it is essential that actors learn about the content of the process (cognitive learning) and about the network in which they are involved (strategic learning). Our findings form a plea for practitioners in water resources management to adopt a problem structuring approach in order to deal explicitly with uncertainty and ambiguity.

Keywords Participation · Perceptions · Knowledge base · Problem structuring · Learning · Decision-making · Case study

1 Introduction

In 1953, a destructive flood inundated large parts of the Delta-region in the southwest of the Netherlands. Following this disaster the government decided to construct the Delta Works. The Delta Works closed off and compartmentalized the sea-inlets, making the Delta-region safer and more accessible. Moreover, the Delta Works created several freshwater lakes, which provided opportunities for drinking water supply and agriculture. However, in the recent years it appeared that the Delta Works also have drawbacks, such as the degradation of the ecological quality, due to the disappearance of the characteristic freshwater–saltwater transitions and the disappearance of estuarine dynamics. Therefore, the Dutch government regards the re-establishment of estuarine dynamics in the Delta as "*...an important solution for a sustainable restoration of the ecological quality, for the preservation of safety against flooding* [with respect to higher river discharges as a result of climate change]*, and for navigation...* (Ministeries van VROM et al. 2004, in Dutch, translation by: S. Hommes)" However, the potential re-establishment of estuarine dynamics will also affect other uses and other users of the freshwater lakes, for example the farmers who use freshwater for agricultural purposes. This example illustrates that water resources management issues arise in a complex social and natural system. Consequently, they are examples of complex, unstructured problems that are characterized by complexity, uncertainty and disagreement (Kolkman et al. 2005).

This paper builds on the idea that it is not possible to deal with complex, unstructured problems through a purely content-directed or analytical approach. In Hommes et al. (2008), it was shown that such an approach, which mainly focuses on reducing uncertainties, creates knowledge that is not relevant to the policy debate as it does not match the interests of the actors involved. It is now widely accepted that a more process-oriented approach should be adopted. This is an approach which pays attention to participation, communication, collaboration, learning and divergent perceptions (e.g.: De Bruijn et al. 2002; Edelenbos et al. 2003; Koppenjan and Klijn 2004; Orr et al. 2007; Pahl-Wostl 2007). Many authors support this point of view. However, very few of their papers (e.g.: Denters et al. 2003; Edelenbos and Klijn 2005; Grin and Hoppe 1999; Van Bueren et al. 2003; Wiering and Driessen 2001) are based on empiricism. In this paper we aim for empiricism to provide a more applicable theoretical basis for management practice in complex water resources management issues. More specifically, we show that solving water management problems benefits from a problem structuring approach. This is done by presenting

the results of an in-depth case study 'Fundamental discussion on freshwater supply for agriculture in the Delta-region in the southwest of the Netherlands'. This case study addresses the problem sketched at the beginning of this section. The case study analysis focuses on how the creation of a knowledge base and the development of actor's perceptions contribute to the formulation of an agreed upon and valid problem–solution combination.

This paper is organized as follows. In Section 2, the theoretical framework and our conceptual model are presented, focusing on the following aspects: problem structuring, actors' perceptions and knowledge in participatory policy processes. Section 3 presents the methodology that is used to analyze the case study on sustainable development of the Delta-region in the southwest of the Netherlands. In Section 4, this case study is described. In Section 5, the case study is analyzed on the core variables from the conceptual model. Finally, the results are discussed in Section 6 and conclusions on actors' perceptions and knowledge in participatory processes are drawn in Section 7.

2 Theoretical Framework

2.1 Complex, Unstructured Problems

A problem occurs when a factual situation is in discrepancy with a desired situation. This implies that problems are not objective givens, but highly subjective social constructs (Dery 1984; Hisschemöller 1993; Van de Graaf and Hoppe 1996). Taking this subjectivity into account, two dimensions can be used to distinguish different policy problems. These dimensions are: consensus about values and norms (normative standards) and the certainty of the knowledge base or content. Using these two dimensions, four types of policy problems can be distinguished (Fig. 1). Well structured problems (type 1) are problems for which a certain knowledge base and consensus about values and norms (normative standards) exists. Some problems are moderately structured because knowledge is uncertain (type 2) or because disagreement exists about values and norms standards (type 3). When knowledge is

Knowledge base → / Values and norms ↓	Certain	Uncertain
Consensus	1. Well structured	2. Moderately structured
Disagreement	3. Moderately structured	4. Unstructured

Fig. 1 Classification of policy problems (adapted after: Hisschemöller 1993; Van de Graaf and Hoppe 1996)

uncertain and actors disagree on values and norms, a problem is unstructured (type 4) (Douglas and Wildavsky 1982; Hisschemöller 1993; Van de Graaf and Hoppe 1996).

Water resources management problems are often examples of (partly) unstructured problems, i.e. type 2, 3 or 4. Such problems are not 'solved' or stopped through standardized procedures or techniques but 'finish' once resources such as time and money have finished (Rittel and Webber 1973; Van de Graaf and Hoppe 1996). Within interactive processes, actors' problem formulations "…*have a tendency to change over the course of time as a result of new information, interactions between actors, and external developments*…(Edelenbos and Klijn 2005)" Another characteristic of unstructured problems, is that its formulation cannot be separated from its solutions. In fact, discussions are often not driven by a problem that has to be solved; they are dominated by solutions which appear to be attractive and to be in reach for a number of actors (De Bruijn and Ten Heuvelhof 1999). Instead of an exact formulation of the problem, a choice for solutions is made. This choice involves an implicit choice which problems are considered and which not. The fact that it is not possible to define a closed pair of an unambiguous problem and its solution does not mean that such a problem never ends. As a result of negotiation, a formulation of a problem and/or solutions can become authoritative (De Bruijn et al. 2002). What is needed to solve (partly) unstructured problems is a problem structuring approach which also pays attention to communication and interaction (Hisschemöller 1993; Van de Graaf and Hoppe 1996). In this paper, we focus on this process of problem structuring in a complex water management issue, using the conceptual model presented in the rest of this section.

2.2 Conceptual Model for Problem Structuring

We define problem structuring as one or multiple rounds of interaction in which actors actively participate in the formulation of a problem and its solutions. Problem structuring should not be understood as a linear process through which an unstructured problem becomes structured. Problem structuring rather aims to identify, confront and (if possible) integrate divergent views with respect to a given problem situation (Hisschemöller and Hoppe 2001; Hisschemöller 1993). Problem structuring thus requires a participative or interactive decision-making process. Figure 2 shows

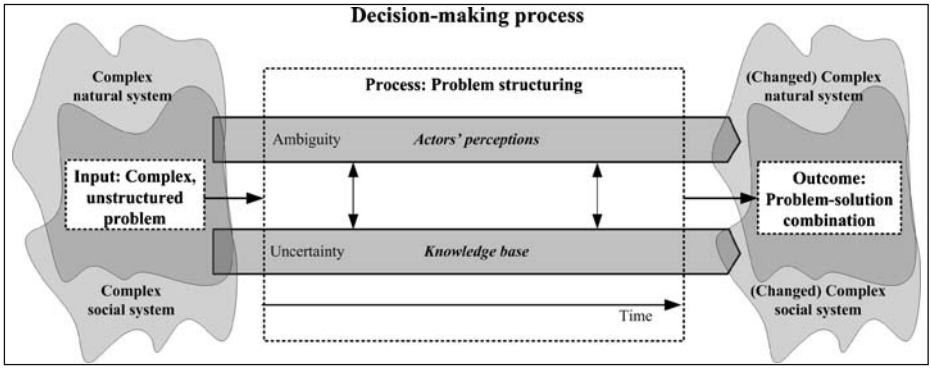

Fig. 2 Conceptual model on the input, process and outcome of problem structuring

how the input, process and outcome of problem structuring are related. The input of problem structuring is a complex, unstructured problem. We conceptualize the process of problem structuring along two tracks: the development of *actors' perceptions* and the creation of a *knowledge base*. Furthermore, we investigate the connection between these tracks in relation to the process of problem structuring. The outcome of the process of problem structuring, i.e. a *problem–solution combination*, will also be investigated. In the remainder of this section, we further introduce the main elements of our analysis: knowledge base, actors' perceptions and problem–solution combination. Although we also investigated the participatory process itself, we will not elaborate on this in the present paper. For more information on participatory processes see e.g.: Glicken (2000), Mostert (2003), Orr et al. (2007), Sultana et al. (2008), Van Ast and Boot (2003).

2.3 Knowledge Base

In this paper, a knowledge base is defined as a collection of knowledge sources (i.e. research reports, models, data, practical experiences, etc.) that have been made explicit and are related to a specific problem situation. Unstructured problems are characterized by an uncertain knowledge base. At first sight, uncertainty about the problem situation can be reduced by providing more and more relevant or adequate information (Koppenjan and Klijn 2004; Van Buuren and Edelenbos 2005). However, new information might also increase uncertainty, because it reveals the presence of uncertainties that were unknown or understated until then. A strategy of reducing and controlling uncertainties may even be counterproductive when uncertainties cannot be reduced. This is the case for ontological uncertainty, which is uncertainty due to inherent variability of the system. Epistemic uncertainty, on the other hand, is uncertainty due to imperfect knowledge of the system and can in principle be reduced when having the necessary time and means. The possible means to reduce the epistemic uncertainty depend on its type and source (van der Keur et al. 2008; Walker et al. 2003). The reduction of uncertainty by means of knowledge production is therefore only possible if there are facts that can be measured objectively. However, for unstructured problems basically any type of information is ambiguous or contested, since underlying facts and normative standards are controversial (De Bruijn and Leijten 2007).

Various actors hold, produce and value knowledge that differs in both content and orientation; this contributes to their perception of a problem situation. By allowing actors to contribute to the knowledge base, the process of problem structuring creates a link between the knowledge base and actors' perceptions (see Fig. 2). We distinguish between two types of knowledge sources: expert (or scientific) knowledge; and practical (lay or non-scientific) knowledge (Eshuis and Stuiver 2005; Pahl-Wostl 2002; Rinaudo and Garin 2005). The first type of knowledge is mainly developed by experts, like scientists or consultants, and based on education and professionalism (Van Buuren and Edelenbos 2005). The validity of this type of knowledge is based on scientific models, statistics and sophisticated models based on (scientific) research. Practical knowledge is often grounded in experiences of people. They can provide context-related knowledge about the environment and the specific case (Eshuis and Stuiver 2005). Involving actors in decision-making processes offers several substantive benefits and opportunities. The mobilization of non-scientific

knowledge, values and preferences can improve the quality of the identification of issues at stake, the formulation of complex, unstructured problems and the identification of alternative solutions. The contribution of practical knowledge can be very significant, as people at the local level have a better understanding of the real potential and limitation of their local environment (Rinaudo and Garin 2005). To speak with the words of Mitroff (1983) "*…an expert is not a special kind of person, however each person is a special kind of expert, especially with respect to his of her own problems…*". Furthermore, knowledge that fits to the local situation often needs to be constructed as it is not readily available. Meaning and interpretation have to be given to existing knowledge stemming from different sources (Eshuis and Stuiver 2005).

2.4 Actors' Perceptions

Actors' perceptions are based on frames (or frames of reference). These frames function as filters through which information or a problematic situation is interpreted. They encompass ideas of actors about facts, interests, norms and values regarding their environment and the problems and opportunities within it (Koppenjan and Klijn 2004; Rein and Schön 1993; Sabatier 1988; Schön and Rein 1994; Van Buuren 2006; Van de Riet 2003). Actors' perceptions possess certain stability, since they are formed gradually through experiences. Actors' basic assumptions about reality (deep core beliefs) rarely change. Assumptions related to the specific content of a problem which is relevant to an actor (policy core beliefs) also rarely change, although they are less resistant to change. What changes quite easily are secondary aspects, these are the more interchangeable aspects of a problem e.g. instrumental decisions or information searches (Sabatier 1988). Among these secondary aspects are actors' concrete objectives and strategies to realize these objectives. A strategy is a goal-mean combination which aims to influence the (chosen) content of the problem–solution combination, the course of the interactive process or the strategy of other parties. A strategy is not fully rational. It is shaped by limited information and non-rational elements such as sympathy. Behaviour of other actors, dissatisfaction with results or changed goals or perceptions might cause a quick adaptation of an actors' strategy (Koppenjan and Klijn 2004).

Water resources management problems involve many different actors. The involvement of various actors results in ambiguity since actors have diverging and sometimes conflicting perceptions of the problem. On the basis of these perceptions, they will judge knowledge and information differently. Ambiguity implies that a problem situation can be approached and interpreted in many ways, i.e. the existence of two or more equally plausible interpretation possibilities, and no clear criteria exist to distinguish between valid and less valid interpretations. Possible sources of ambiguity are an overload of information, confusion and knowledge conflicts (Dewulf et al. 2005; Koppenjan and Klijn 2004; Van Buuren and Edelenbos 2005).

The strategic and cognitive dimensions of actors' perceptions are closely related. Actors continuously influence each other through their cognitions and interactions, which are based on their strategies. Their interaction depends on their cognitions and vice versa. A snapshot of a shared cognition within a social process is called a social–cognitive configuration. If actors are not confronted with other cognitions, they have no incentive to adjust their cognitions. Therefore, the configuration approach

states that adjustment of cognitions is only possible if actors are confronted with other cognitions (Termeer 1993).[1] Thus, although each individual has its unique perception, there will also be similarities among individuals in the same social group. Interaction may result in the development of patterns of perceptions (Koppenjan and Klijn 2004; White 1992). Within certain sectors actors often hold similar perceptions about the importance of a certain sector or share professional norms and convictions (Klijn 2005).

Perceptions develop and change as a consequence of learning processes. Much has been written on theories of learning and knowing. There are too many contributors to mention them all here, for an overview of categories of learning theories we refer to Blackmore (2007). After Koppenjan and Klijn (2004) we distinguish between two types of learning processes: *cognitive* and *strategic* learning. Both types of learning processes contribute to the development of actor's perceptions. Cognitive learning relates to the content of a process. We interpret it as actors' increased knowledge and insight about the nature, causes and effects of the problem, possible problem–solution combinations, and their consequences. This interpretation is slightly different from Koppenjan and Klijn (2004), who describe cognitive learning as a general increase in knowledge and insight. Besides cognitive learning, actors can learn about the involvement of other parties and mutual dependencies. This learning about social aspects is called strategic learning. Learning processes are necessary to create a common ground to enable mutual adjustment of strategies and joint action. The creation of a common ground is also called 'joint image building'. Actors become aware of the divergence of perceptions, because they reflect upon their own perception while taking perceptions of other participants into account (Koppenjan and Klijn 2004). Figure 3 schematizes the creation of a knowledge base and the related learning processes. Cognitive learning takes place if actors' perceptions and the creation of a knowledge base are connected. Strategic learning results from the interaction between various actors, with divergent perceptions.

2.5 Problem–Solution Combination

A problem–solution combination, or the joint formulation of the problem and its solutions, is the substantive outcome of an interactive process. It is the result of a process of problem structuring in which various knowledge sources and actors with diverging perceptions are brought together in an interactive process. A problem–solution combination (or a problem formulation) goes beyond defining the discrepancy between a given state and a desired state. It includes the following three elements: description of present and future situation including causal structure; definition of criteria and objectives; and definition of direction(s) for solutions (Dery 1984; Quade 1980). During a process of problem structuring, the challenge is to produce *negotiated knowledge*. Knowledge is negotiated if actors agree upon the (scientific) validity of the problem–solution combination and consensus exists about the significance and meaning of the knowledge base (Koppenjan and Klijn 2004). Generally, actors will be more likely to accept information if they have been involved

[1] This is also referred to as 'cross-frame reflection' (Rein and Schön 1993) and learning between 'advocacy coalitions' (Sabatier and Jenkins-Smith 1993).

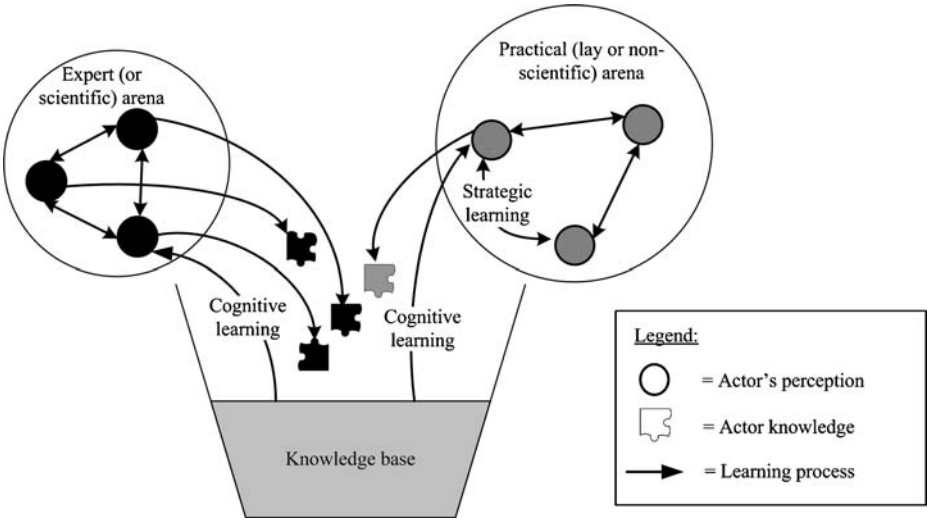

Fig. 3 Conceptual model on the creation of a knowledge base and related learning processes

in the production of knowledge (Eshuis and Stuiver 2005). Therefore, negotiated knowledge is created if actors have the opportunity to contribute to the process with their own information and values (De Bruijn et al. 2002). According to Van de Riet (2003), it is important not to focus too much on the content, as superfluous knowledge might be created; this is knowledge which is irrelevant to the policy process. On the other hand, too much focus on the process may result in negotiated nonsense. While parties do reach agreement, they may do so in such a way that the results produced are meaningless, i.e. scientifically invalid. This risk can be kept within acceptable bounds by routinely submitting the results of investigations to experts for peer review (De Bruijn and Ten Heuvelhof 1999).

However, we argue that scientific validity should not be the only yardstick to assess the validity of knowledge within the context of participatory processes. Because, problem structuring is an ongoing process of formulating and solving a problem, objective assessment of problem formulations or solutions is impossible. Rather formulations become authoritative, i.e. accepted by all parties (De Bruijn et al. 2002). If different knowledge producers are involved in a participatory process, the authoritativeness of knowledge is not derived from independence or scientific procedures. Rather, the resulting knowledge base consists of mutual inter-subjective interpretations of available knowledge sources (Koppenjan and Klijn 2004; Van Buuren and Edelenbos 2005). If expertise from different practices, institutions and actors is used, the validation of knowledge within its disciplinary context does not suffice anymore. Therefore, socially robust knowledge should be aimed at as well. Socially robust knowledge is repeatedly tested, expanded and modified since it is also tested for validity outside the 'laboratory' by an extended group of experts (including laypersons) and society is an active partner in the production of knowledge (Nowotny 2003). Using knowledge from different sources, enhances 'learning in context' and the creation of knowledge which will be useful in different contexts (Eshuis and Stuiver 2005).

3 Case Study Methodology

The analysis of complex decision-making processes requires an approach in which different factors, causes and variables can be dealt with simultaneously. The aim of our analysis is to sketch a picture that justifies the complex relation between all elements. Consequently, the phenomenon and its context need to be studied simultaneously and cannot be meaningfully separated. The approach of *qualitative case studies* meets the above requirements, as using a case study for observations allows investigators to retain the holistic and meaningful characteristics of real-life events (Yin 2003). In this section, we will first describe the kind of observations that were used for the case study analysis. Furthermore, it is explained how the knowledge base, actors' perceptions and the problem–solution combination are measured in the case study. Last, the limitations of the conceptual model are discussed.

3.1 Observations

From February 2006 to September 2006, the authors (two researchers and two process managers) participated in the pilot-project 'Fundamental discussion about the freshwater supply for agriculture on Tholen & St. Philipsland'. The researchers had an observatory role and the course of the process was not adjusted based on their observations (like in an action learning project). Once the fundamental discussion was finished, the researchers started in-depth analysis of the process. Moreover, the results were reflected upon experiences from two other recent case studies: Mainport Rotterdam (Hommes et al. 2008) and Sediment Management by Water Board Rijnland (De Kruijf 2007). The (internal) validity of the analysis is enhanced by a triangulation on methods and sources, to maintain a chain of evidence (Yin 2003). For this purpose a case study database was created and detailed descriptions are available about all relevant aspects of the case study (De Kruijf 2007). Sources used for the analysis include the following:

1. *Observations:* from plenary workshops and group meetings, experiences from process managers;
2. *Written material:* research reports; project documents; ideas, chances, opportunities and preferences expressed by participating actors during workshops or meetings; e-mail conversations; and news paper articles;
3. *Interviews:* with several participating actors, carried out before and after the discussion; reports and observations.

3.2 Measurement of Core Variables

The core variables or the main elements of our analysis are: actors' perceptions, knowledge base and the problem–solution combination. Besides this, we also investigated the interactive process itself, i.e. the role of the commissioner, process managers, experts and participants, the design and course of the interactive process itself (see: De Kruijf 2007). Although, we will not elaborate on this in the present paper, the development of our core variables is investigated in relation to this interactive process.

We used a qualitative approach to measure *actors' perceptions*. During workshops, actors were asked several times to make their preferences explicit. They were asked

to individually write down the main possible opportunities and bottlenecks, preferred solutions and ideas. Together with (written) observations of the researchers and process managers, these noted preferences are used as major data-source for the analysis of the actors' problem perceptions. These findings were complemented and cross-checked with other written data-material, e.g. minutes, news articles and e-mail conversations. Based on this, we identified for every actor their specific interest and the development of their problem formulation, i.e. their perception about chances, bottlenecks and the preferred solution. Thus, we measured actors' perceptions by comparing the individual opinion they expressed at different points in time. Actors' perceptions change as a consequence of learning experiences of actors, e.g. contact with other ideas, new information (Koppenjan and Klijn 2004). This implies that actors' perceptions continue to develop after the process finished. Therefore, we did not cross-check our findings with the actors afterwards. Actors' learning processes were not measured directly. In fact, we used cognitive and strategic learning to explain the relation between the process, perceptions, knowledge and the development of a joint problem–solution combination. We associated cognitive learning with the change in actors' perceptions, i.e. the reframing of the problem. Strategic learning explains why actors support the problem–solution combination even if it does not correspond with their individual problem formulation.

For the analysis of the *knowledge base*, we investigate the following aspects: the collection of knowledge sources at the start of the process; the knowledge questions occurring during the process; the contributions of expert and practical knowledge during the process; and an identification of conflicts and integration between different knowledge sources. Thus, we analyzed all the knowledge sources that were activated, i.e. made more explicit, during the process. Finally, the development of the *problem–solution combination* is measured by comparing the content of the process at the beginning of the process and at the end of the process. The extent to which the developed problem–solution combination is 'negotiated knowledge', i.e. scientifically valid and socially robust, has also been analyzed.

3.3 Limitations of the Conceptual Model

External influences are not explicitly accounted for in the conceptual model. The dynamics of interactive processes may stem from dynamics within the participatory process itself. Apart from this it may also be driven by external developments in the social and natural context of a process. Turnhout and Leroy (2004) state that because of their contingency and context-dependency it is not possible to formulate success- or failure factors for participatory processes (Turnhout and Leroy 2004). Therefore, it is in line with our conceptual model that it is not possible to take these dynamics and external developments explicitly into account.

Furthermore, institutional elements are not explicitly included in the conceptual framework. Complex, unstructured problems involve many actors that work from different institutional backgrounds. Interactions between actors are difficult since each will have their behaviour guided by tasks, opinions, rules and language of their own organization, their own administrative level and their own network (Koppenjan and Klijn 2004). Related with institutional elements is the issue of power (realization or hindrance power). In our conceptual framework, the institutional element is implicitly included in the actors' perceptions. Our argument is that in reality people,

from different organizations, are interacting and not the organizations itself. Therefore, there is no need to specifically focus on institutional elements in the process of problem structuring. Finally, the (role of a) process manager is not explicitly taken into account in our conceptual model. However, process management plays an important role in the creation of an agreed upon and valid problem–solution combination. The consequences of this limitation will be discussed in Section 6.

4 Case Study: Decision-Making Process for Sustainable Development of the Delta-Region, The Netherlands

4.1 Background

In several areas in the Delta-region in the southwest of the Netherlands, the ecological quality decreased due to hydraulic constructions for storm water safety, the Delta Works (see e.g.: Borger 2004; Colijn and Binnendijk 1998; d'Angremond 2003). With the construction of the Delta Works the characteristic freshwater–saltwater transitions and the estuarine dynamics disappeared. Freshwater lakes replaced the original tidal dominated areas. Among the ecological problems in the Delta-region is the excessive growth of blue-green algae in one of these freshwater lakes, the Volkerak-Zoom lake (Fig. 4). To improve the ecological quality of this lake, the Dutch government regards the re-establishment of estuarine dynamics in the area as the most important solution (Ministeries van VROM et al. 2004). It is conceivable that this solution solves the existing problems with blue-green algae in the lake. However, the impact on the overall ecological quality is still uncertain. Moreover, re-establishment of estuarine dynamics will affect other uses and other users of the lake. Among the affected users are the farmers in the surrounding areas, who use freshwater from the lake for agricultural purposes.

In 2003, the Delta Provinces formulated the integrated vision 'Delta in Zicht' to solve the ecological problems in the Delta-region in the southwest of the Netherlands (Provincie Zuid-Holland et al. 2003). This vision is laid down in a memorandum by the Delta Provinces, the Ministries of Transport, Public Works and Water Management (V&W) and of Agriculture, Nature and Food Quality (LNV). The subscribers of the memorandum jointly strive for a well-balanced development of the Delta, taking into account the vision 'Delta in Zicht'. To implement this vision, they decided to establish the Delta Council. In this council the subscribers of the vision are all represented by an administrative or representative delegate. One of the projects directly headed for by the Delta Council is a fundamental discussion with a variety of actors on the integration of a more natural Delta and a more natural, sustainable freshwater situation for agriculture. This project is explored and managed by a consortium of four independent governmental and non-governmental institutes.[2] This consortium advised the Delta Council to distribute the discussion

[2]The consortium consists of the Netherlands Organization for Scientific Research (TNO, project leader), National Institute for Coastal and Marine Management (RIKZ), the research institute and specialist consultancy WL|Delft Hydraulics and the Government Service for Land and Water Management (DLG).

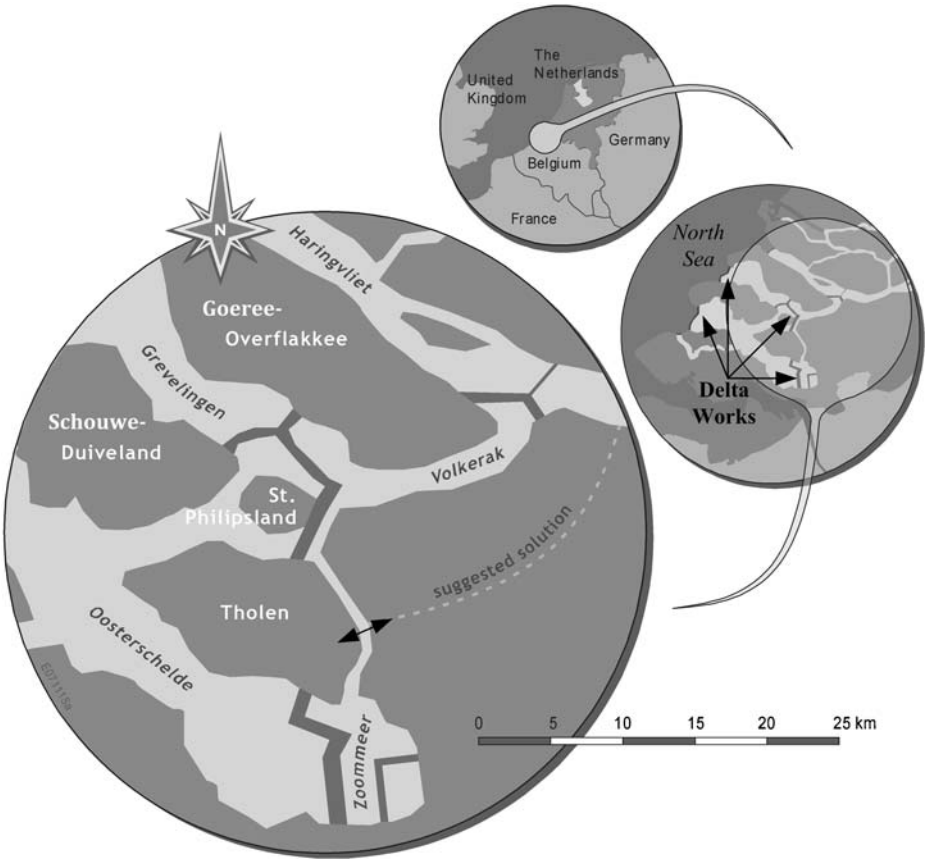

Fig. 4 Location of the case study. In the figure the Delta Works, the Volkerak-Zoommeer (VZ-lake), the islands of Tholen and St. Philipsland and the suggested solution (pipeline) are shown

over several local discussions and to start with a pilot-project on the islands Tholen and St. Philipsland. These two islands are located in the eastern part of the Province of Zeeland (Fig. 4). Agriculture on these islands directly depends on the freshwater supplied by the Volkerak-Zoom lake (VZ-lake). Following this, the Delta Council initiated the pilot-project 'Fundamental discussion on the freshwater supply for agriculture on Tholen & St. Philipsland'. This project is used as a case study in the present paper.

4.2 Process Description: Fundamental Discussion Tholen & St. Philipsland

The objective of the pilot-project on Tholen and St. Philipsland was: "…*A fundamental discussion with all relevant actors about a more natural, sustainable freshwater situation in a more natural Delta-region*…(Reijs 2006a, in Dutch, translated by: J. Vinke-De Kruijf)" in order "…*to develop a shared insight and agreement*

about the most desirable directions for solutions or development..."[3] Participating actors in the fundamental discussion were (representatives from): local farmers; an agricultural interest organization; agricultural business; national, regional and local nature societies; local and regional water managers; local, provincial and national public servants and delegates. In total, the agricultural sector is represented by about ten people, the nature sector by five people and the public sector by six people. The process design consisted of successive diverging and converging rounds of three plenary and several small-scale meetings.

4.2.1 Exploration

Preceding the discussion the working group 'Freshwater Supply Delta Agriculture', which was established by the Delta Council, initiated several research activities. One study concerned the future of agriculture in the Delta. This study, carried out by a research institute, aimed to directly support the fundamental discussion with respect to the content (Stuyt et al. 2006). Prior to the start of the discussion, Stuyt et al. (2006) and other research reports were summarized in the 'Tholen-note' (Reijs 2006a). The process managers delivered Reijs (2006a) to all participating actors. Reijs (2006a) provided facts and figures, and also sketched the problem situation, the policy framework and the opinions of a variety of actors. The primary aim of the note was not to present an objective knowledge base. The aim was merely to accelerate the discussion by providing an overview of existing information (Reijs 2006a).

4.2.2 Kick-off Meeting

During the kick-off meeting participants were informed about the process design, the freshwater situation in the Delta, the policy context and the boundary conditions of the discussion. Participants also had the opportunity to get acquainted with each other. During the kick-off meeting especially the farmers reacted with great scepticism to the earlier performed research activities of professional experts, as presented in Reijs (2006a). Among the criticized elements were the prospective business models for agriculture, which were based on future outlooks and scenario-studies.

4.2.3 Workshop I: Opportunities & Bottlenecks

Preceding the first workshop (WSI), an excursion to the nature and agricultural areas on the islands was organized. During WSI, every participant was asked to express what they perceived as opportunities and bottlenecks, in relation to the possible developments of the VZ-lake. Two possible future scenarios for the VZ-lake were taken into account:

1. Scenario A: development of the VZ-lake to a healthy freshwater lake, without blue-green algae;
2. Scenario B: development to a lake with estuarine dynamics; salt-brackish lake.

[3]Minutes Kick-off meeting, May 31, 2006 (in Dutch, translated by: J. Vinke-De Kruijf).

It should be noted that these scenarios were formulated within another decision-making process ('Planning study VZ-lake'), which is focussing primarily on finding solutions for the poor water quality in the VZ-lake. The fundamental discussion Tholen & St. Philipsland aims to support this planning study, by providing insight in consequences and possibilities for agriculture on the islands for these two scenarios. However, which scenario for the VZ-lake is most achievable or realistic is not a topic of discussion in this framework.

During WSI, it became clear that the Tholen-note and other available research reports were not able to answer the specific questions arising during the process. These questions focused on: the required water quality and quantity for agriculture, the possible solutions for blue-green algae, the available quantity of water and impacts of salinization. To prevent a substantive stagnation of the process, the process managers decided to address these questions to scientific experts. However, they were not able to answer them at that moment.

4.2.4 Small-Scale Meetings: Development of Directions for Solutions

After WSI, the project team developed and discussed possible solutions in small, sector-related meetings. The project team consulted every group of actors separately and used the outcomes of these meetings as input for the following meeting with other actors. During this period, actors also gathered new information and contributed with their own specific knowledge and experiences. The project team found that it was possible to assess impacts of solutions with the experiences and knowledge of various actors. Farmers used experiences from tests with alternative freshwater supply systems, which had recently been applied on the island of Tholen, to estimate the relation between freshwater and their incomes. Representatives from nature organizations assessed possible ecological impacts and local water managers from the Water Board and the Province provided recent information about available water resources and the freshwater demand.

4.2.5 Workshop II: Desirable Direction for Solutions

During the small-scale meetings, participating actors appointed solutions for supplying freshwater in each scenario (A and B). This resulted in a total of five directions for solutions. In the last plenary meeting (second workshop, WSII), the participants were asked to vote for the direction of solutions they prefer. Initially, this resulted in two equally preferred solutions, one within scenario A and another one within scenario B. During WSII, the process managers pushed the actors to reach an agreement on one solution. The process managers did this by pointing out to the participants that only within scenario B (re-establishment of estuarine dynamics) the nature and agricultural sector would be able to reach consensus and thereby make a statement to the (national) government, i.e. to allow joint action. After some discussion, the participants themselves concluded that a realistic solution is only available within scenario B.

4.2.6 Conclusions of the Fundamental Discussion

The process managers and a delegation of the participating actors further detailed the conclusion from the fundamental discussion in a final report (Reijs 2006b). The

conclusion in the final report states that actors agree on an adequate alternative freshwater supply for agriculture on the islands of Tholen and St. Philipsland, and that joint action is only possible if the VZ-lake develops towards a lake with estuarine dynamics (Scenario B). This direction for a solution should involve the construction of a pipeline which connects the islands with an upstream freshwater system (see Fig. 4). Following this, steps can be taken to re-establish estuarine dynamics in the VZ-lake. Besides this, the final report presented a first overview of the costs and benefits of investigated solutions, the distribution of costs and benefits and related boundary conditions. Eventually, participating actors from the agricultural and nature sector expressed the explicit wish to lay down these conclusions in a covenant with the Delta Council and other actors (Reijs 2006b). Currently, the Delta Council investigates the support for the preferred solution among farmers. Finally, they are planning to conduct similar fundamental discussions at the local level in other areas as well, at the least in the areas surrounding the VZ-lake.

5 Analysis

In this section, we present our analysis of the process described in the previous section. This is done by reflecting on the development of the knowledge base, actors' perceptions and the problem–solution combination.

5.1 Knowledge Base

Before the start of the fundamental discussion Tholen & St. Philipsland a starting document (Reijs 2006a) was formulated by the project team, i.e. a knowledge base was created. This knowledge base consisted of the main findings from several research reports. During the participatory process it became clear that this knowledge base was not sufficient to answer the specific questions that arose during the process. This corresponds with the findings of Eshuis and Stuiver (2005) that "*…knowledge that is relevant to a specific context is not always readily available…* (p. 143)". Therefore, different knowledge sources were contributed to the knowledge base during the process. Practical knowledge was contributed by farmers, nature organizations, local water managers and the Province. Furthermore, the process managers addressed some questions to scientific experts, which were involved in the research included in the starting document (Reijs 2006a). However, they could not contribute any knowledge at that moment.

Practical knowledge provided by farmers, was easily accepted by participants from the agricultural sector. However, actors from other sectors were more reserved with respect to this knowledge. The government placed the remark that they want an additional social cost–benefit analysis. On behalf of the nature sector figures are accompanied by the remark that more specific calculations are necessary to confirm some of the findings (Reijs 2006b). Such additional requests for knowledge show that if parties are involved in the production of knowledge, like the farmers, they are more likely to accept it (De Bruijn et al. 2002; Eshuis and Stuiver 2005). Trust also plays an important role in the reception of information. According to Carolan (2006) trust relates to previous relational experiences and the interests of the trusted party. The interests of the knowledge provider, the trusted party, also played an important

role in the case study. Although the validity of information was doubted it was not always contested, because the knowledge provider had an interest to create valid knowledge. In our case study, a representative of the nature sector explained that he had problems judging the validity of some figures. The figures do not conflict with the interests of the nature sector. However, according to this actor they are not undisputable and therefore fragile to decision-makers.

In the case study, it was observed that some parts of the knowledge base conflicted, for example: the prospective business models for agriculture conflicted with the practical knowledge by farmers in the testing area with alternative freshwater supply. Although the research institute put a lot of effort into creating these business models, their findings do not match with farmers' expectations of the future of agricultural business. Actually, these business models are a typical example of expert knowledge that does not fit the practices and epistemology of farmers (Eshuis and Stuiver 2005). Therefore, these business models are an example of 'superfluous knowledge'. Knowledge that is irrelevant to the policy debate, even though it is scientifically valid (Van de Riet 2003).

Finally, the process managers connected the practical knowledge, from the small-scale meetings, with insights from research reports. The conclusions of the final report (Reijs 2006b) are a mix of agreed upon knowledge from: research reports, practical knowledge, assumptions, estimates, objectives and restrictions. These results correspond with our conceptual model (Fig. 3), which describes that context-specific knowledge is constructed by giving meaning to existing knowledge from various sources. If one uses a variety of sources it is important to develop knowledge through interaction and not to present one source of knowledge as superior (Eshuis and Stuiver 2005). In the case study, the process managers succeeded in doing so and the actors successfully constructed useful knowledge on the basis of science and practice. Benefits of this approach are that actors are forced to support the process with their own information, which enriches the process and creates support (Mostert 2003; Rinaudo and Garin 2005).

5.2 Actors' Perceptions

At the start of the process, we observed that basically two extremes in perceptions exist: an economy- and an ecology-oriented formulation. The *economy-oriented* problem formulation was as follows: agriculture on the islands is important for socio-economic reasons. To develop and function well, agriculture needs freshwater, which until then has been provided from the VZ-lake. Therefore, the VZ-lake should remain a freshwater lake. The *ecology-oriented* problem formulation was the following: the VZ-lake is suffering from blue-green algae, which negatively affects the ecological system. The only solution to solve this problem is the re-establishment of estuarine dynamics. Therefore, the VZ-lake should become an estuarine lake. In general, the agricultural sector adhered to the economy-oriented problem formulation and the nature sector to the ecology-oriented problem formulation. However, individual perceptions were diverging because interests and experiences differ. Some farmers depend directly on freshwater from the VZ-lake, while others do not. Some farmers were mainly afraid of possible impacts of salinization; others were mainly worried about loosing freshwater for irrigation. Some representatives from the nature sector were mainly worried about the ecological status of the whole Delta

area, while others only focus on (freshwater) nature *on* the islands. Within the public sector, even within one organization, actors adhered to various problem formulations. Some representatives from the government wanted to focus on the local socio-economic situation; others wanted estuarine dynamics to be re-established. Thus, it becomes clear that in the case study actors' perceptions diverge. Furthermore, our observations confirm that actors in the same social group or sector adhere to similar problem perceptions, although they have individual differences (Klijn 2005; Koppenjan and Klijn 2004; White 1992).

Between the start and closure of the process, one or more elements of the actors' problem perceptions, i.e. their perception of the present situation, the expected situation or the desirable direction for solutions, were adjusted. Thus, cognitive learning was observed for all participants. For example, a farmer argued before the process that the re-establishment of estuarine dynamics is no option for farmers. However, at the end of the process the same farmer prefers the re-establishment of estuarine dynamics. Nevertheless, his main objective, a continuous supply of freshwater all year round, never changed. This supports the idea that part of the perceptions is static and that part of the perceptions is dynamic (Sabatier 1988). Especially, the part of perceptions that is based on previous experiences is static. One farmer, who once experienced negative impacts of salinization in the case of a saltwater system, still explains at the end of the process that salinization is a problem in the case of an estuarine VZ-lake. Thus, although perceptions converged, we also observe that actors' perceptions did not become identical. In the next section, we will explain in more detail how cognitive and strategic learning contribute to the development of a joint problem–solution combination.

5.3 Problem–Solution Combination

Despite the divergence of actors' perceptions at the start of the process, at the end of the process all participants reached an agreement (covenant), i.e. negotiated knowledge was created. The process contributed to this by creating interaction between actors with diverging perceptions and by creating a connection between actors' perceptions and the knowledge base. In the beginning, actors did not have any knowledge or understanding of the perceptions of other actors. However, during the participatory process actors were encouraged to share, discuss and reflect upon the various interpretations of the problem and available information. It was in the small-scale meetings that substantive breakthroughs were realized. During these meetings the project team developed and discussed possible solutions in sector-related actor groups, in which actors started to contribute to the process with their own knowledge and experiences. The result of the plenary and small-scale meetings was that the actors involved successfully learned about one or more elements of the problem situation; cognitive learning. Although, we observed that actors' perceptions converged they did not become entirely identical. However, as a covenant was formulated, we conclude that actors also learned about their mutual dependencies and each others positions; i.e. strategic learning took place. Thus, we conclude that reaching an agreement results from two learning processes: cognitive *and* strategic learning (Fig. 3).

These learning processes develop quite different for different actors. Innes and Booher (2003) explain that the learning capacity of a system relates to individual,

organizational, relational and governance capacities. In our case study, we observed that individual farmers can easily adapt their strategy, since they are less institutionally anchored than representatives of interest organizations or the public sector. Pahl-Wostl et al. (2007) explain that one of the major tasks of representatives is to manage the boundaries between their own organizations and the multi-actor context, because the traditional boundaries of hierarchy, structure, role and task are often not available. The so-called "dilemma of the negotiator" refers to the fact that, the more the representative tries to transform the positions of his/her constituency, the greater the chance to come to an agreement that is satisfactory for all actors involved. However, the same efforts to transform these positions may pose a risk for the representative when the constituency starts to question his/her legitimacy (Pahl-Wostl et al. 2007). This is also related to the fragmentation of decision-making processes in the public sector. Meijerink (2004) explains that the fragmentation of decision-making in the Netherlands often complicates the learning capacity of actors from the public sector. The case study also confirms insights from the configuration approach that perceptions of reality (cognitive elements) and interaction (social elements) are closely related (Termeer 1993). In our case study, we observed that an actor with less interaction inside its own sector and a relatively extreme view within his sector left the process halfway. Another actor who was less active in the process strongly opposed the conclusions of the process during the last meeting.

In our case study, a context-specific knowledge base was created that existed of practical knowledge and expert knowledge. This confirms the findings of Eshuis and Stuiver (2005) that using knowledge from different sources creates knowledge that is valid and useful within different practices and epistemologies. The case study also shows that a variety of actors finally still attach a different value to the constructed knowledge base. The case study also shows that it was difficult to determine the validity of the practical knowledge. It is, for example, hard to value the relation between freshwater availability and the income of farmers (practical knowledge) similarly as the validity of the business models from the research institute (expert knowledge) was determined. Therefore, a context-specific knowledge base demands a new yardstick to assess its validity. Actually, the aim of a participatory process should be to construct scientifically valid knowledge as well as socially robust knowledge. To create socially robust knowledge active involvement of actors, in the production and valuation of knowledge, is needed. The basic principles for the production of reliable knowledge remain the same. However, this approach admits that knowledge from actors, although it differs from scientific knowledge, is just as valuable as that from experts (Nowotny 2003).

6 Discussion

In this section, we will discuss the topic of process management, which was not explicitly taken into account in our conceptual model and the case study analysis. Firstly, process management should be adaptive, as decision-making processes are very dynamic. Adaptive management refers to systematic process for continually improving management policies and practices by learning from the outcomes of

implemented management strategies (Pahl-Wostl 2007). The importance of adaptive process management draws from the results of the comparison of six other participatory processes in the Netherlands (Edelenbos and Klijn 2005) and is also confirmed by this case study. Furthermore, it is important that facilitation, thus process management, is independent. Independent process managers lacking direct interests in local issues can support the process and make links for addressing all development needs of a certain area (Sultana et al. 2008). The Delta case study showed that the project managers were able to connect different knowledge sources. This made a face-to-face dialogue between actors and professional experts unnecessary. The successful fulfilment of this intermediary role can be explained by the fact that process managers had no interest in the issue and were trusted by the participants.

Literature about process management emphasizes that (scientific) research should not be organized as a separate phase in the process. It should be organized in a second arena parallel to the negotiation arena (De Bruijn and Ten Heuvelhof 1999; Koppenjan and Klijn 2004). Furthermore, knowledge questions and conflicts emerging during a participatory process can be brought into the research arena as research questions, through a scientific forum. These research questions that emerge at various points in the game can be very different by nature and may not fit into a chronological order (Koppenjan and Klijn 2004). Therefore, connecting different knowledge arenas may cause content-related difficulties as well as process-related difficulties. Temporal misfits may hinder the use of research in a participatory process, since research processes often ask time to generate some degree of clarity and certainty (Van Buuren et al. 2004). This was also found in our case study, as one of the research institutes could not provide more knowledge during the process (see Section 5.1).

7 Conclusions

This paper presented a complex, unstructured water resources management issue. This issue involved the sustainable development of ecology, economy and society in the Delta region, in the southwest of the Netherlands. The participatory process, which addressed this problem, was used as a case study in the present paper. We investigated how the creation of a knowledge base and the development of actors' perceptions contribute to the formulation of an agreed upon and valid problem–solution combination. In the Delta case study, a knowledge base existing of expert knowledge was created before the start of the participatory process. During the process we observed that parts of this knowledge base conflicted with practical knowledge and that there was not sufficient knowledge available to answer specific questions that arose during the process. Therefore, actors involved were stimulated to contribute their own practical knowledge. We observed that this practical knowledge was disputed by some participants, who were not involved in the production of this knowledge, whereas other participants easily accepted it. This shows that if parties are involved in the production of knowledge, they are more likely to accept it. Moreover, we found that actors will interpret and value knowledge differently, based on their practices and epistemologies.

At the start of the process, we observed that actors' perceptions were divergent. These perceptions were adjusted and became more similar during the process of problem structuring. We conclude that this change in perceptions resulted from the actors' reflection on and contribution to the knowledge base, i.e. cognitive learning took place. Moreover, it was found that although actors' perceptions converged, they did not become identical. Despite this, a joint problem–solution combination was formulated at the end of the process, i.e. the participants signed an agreement in which they propose a solution. We explain this by the fact that actors also learned about their position in the network and their mutual dependency with other actors, i.e. strategic learning took place. Therefore, it is concluded that reaching a joint problem formulation results from a combination of cognitive and strategic learning. Also, the case study showed that it is possible to connect different knowledge sources—expert and practical—and use this knowledge base as a basis for the formulation of a problem–solution combination which is supported by all actors. Since various knowledge sources have been used to arrive at this knowledge, its validity goes beyond scientific validity. The resulting knowledge base is an inter-subjective and context-specific interpretation of available information; i.e. socially robust knowledge. This kind of knowledge can only be created in a participatory process in which different types of knowledge are combined and actors with divergent perceptions interact with each other.

In general, we state that solving water management problems benefits from a problem structuring approach. Problem structuring is based on the ideas of: (1) creating interaction and communication between actors with diverging perceptions and; (2) creating a connection between these perceptions and the uncertain knowledge base. Therefore, we argue that problem structuring is an adequate approach to deal with ambiguity and uncertainty. Our conceptual framework together with the Delta case study findings are an argument for practitioners in water resources management to adopt such a problem structuring approach in order to explicitly deal with uncertainty and ambiguity. Problem structuring requires a participatory process in which all problem formulations of all relevant actors are involved and government partners interact with actors. Process managers should stimulate participants to contribute to and to reflect upon the knowledge base with their own knowledge and experiences to enhance cognitive learning. They should also enhance strategic learning by stimulating participants to reflect upon their perception and perceptions of others. Finally, different knowledge sources—expert and practical knowledge—should be integrated, by process managers, to create a context-specific knowledge base, which is scientifically valid and socially robust. What still needs more attention in the problem structuring approach is how to design and manage a participatory process. Also, the linkage between participatory processes and formal decision-making needs further research.

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