CONQUERING COMPLEXITY

Water management problems are embedded in a natural and social system that is characterized by complexity. Knowledge uncertainty and the existence of divergent actors' perceptions contribute to this complexity. Consequently, dealing with water management issues is not just a knowledge uncertainty problem; it is a problem of ambiguity too. In this thesis, three case studies of complex water management issues are presented, two explorative case studies from practice and a comparative experiment. This thesis investigates how a decision-making process, for a complex water management issue, influences the creation of a knowledge base, the development of actors' perceptions and the formulation of a problem-solution combination.

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CONQUERING COMPLEXITY S. Hommes

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Dealing with uncertainty and ambiguity in water management

Saskia Hommes

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CONQUERING COMPLEXITY

DEALING WITH UNCERTAINTY AND AMBIGUITY IN WATER MANAGEMENT

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te Roermond

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CONTENTS

1 INTRODUCTION

1.1 Scope of this thesis

1.1.1 Large-scale water systems as problem context

Water is of vital importance for human life. Civilization has historically flourished around large-scale water systems, i.e. rivers, estuaries and coastal zones. The ancient society of the Egyptians depended entirely upon the river Nile. Still, low-lying river basins and coastal areas are becoming increasingly densely inhabited. Approximately 60 percent of the world population lives in a delta area and this number is increasing. Large metropolises like Rotterdam, London, Montreal, Paris, New York City, Shanghai, Tokyo, Chicago, and Hong Kong owe their success in part to their easy accessibility via water and the resultant expansion of trade. Not only are many of the cities and mega-cities of the world located in coastal areas, but rural densities near coastlines are also increasing. Many of these locations are below or very close to sea level and the likelihood of flooding is growing as sea levels rise and the intensity and occurrence of storms increase. The vulnerability of populations in such regions poses additional challenges for the civil authorities responsible (Ministerie van Verkeer en Waterstaat, 2007; United Nations, 2006).

The Netherlands is a country on a delta, dominated by the sea and the mouths of four major European rivers: the Rhine, Meuse, Scheldt and Ems. The coastal zone is bordered by coastal barriers, in the north in the form of barrier islands, a large (former) lagoon, tidal inlets, and coastal plains. The total length of the Dutch coastline is more than 400 kilometres, which can be divided into three different parts: the tidal inlets and estuaries in the south (now mostly controlled by open or closed barriers), the uninterrupted duned Holland coast and the Wadden Sea area in the north. At present, almost one third of the country lies below sea level, and without the protective dunes and dykes, two-third of the country would be flooded regularly (Figure 1.1).

While the Netherlands is a small country (34.000 km^2), it is highly urbanized and densely populated (460 inhabitants/km^2). The Netherlands has the highest concentration of people and farm animals per hectare in Europe and also a high level of mobility and economic activity. This high density of socio-economic activities in the Netherlands puts a lot of pressure on the water system and the environment (Van Dijk, 2008; Van Koningsveld et al., 2008).

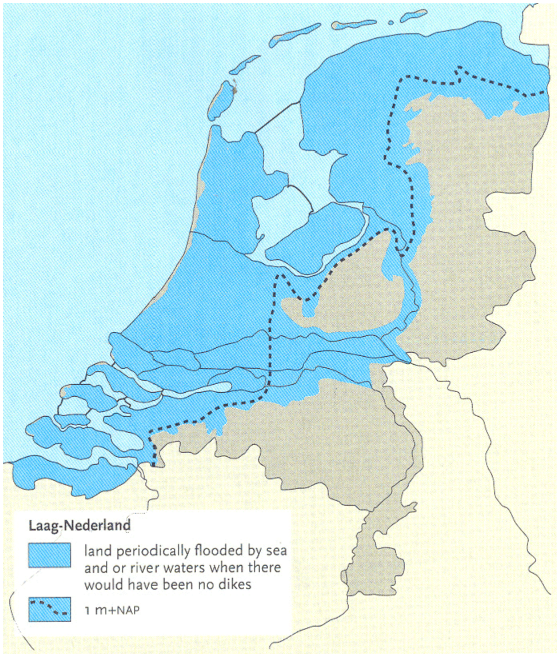

Figure 1.1 – Map of the Netherlands. Blue area is land periodically flooded by sea or river waters when there would have been no dikes (approximately 65% of the country). The dotted line indicates 1 m + NAP (Van de Ven, 2003).

For centuries, people have altered the natural flow of rivers and fixed coastlines, for example through the construction of dikes, seawalls and reservoirs. Also in the Dutch large-scale water systems many human interventions are carried out. These interventions are designed to improve the well-being of people, for example by increasing protection against flooding, improving environmental quality or stimulating the national economy. Decision-makers involved in these kinds of interventions have to deal with societal aspects, economic costs and benefits, physical effects, ecological effects and technical feasibility. The decisions that they have to take can be conceptualized as 'trade-offs' between these different aspects. A 'trade-off' refers to the political, value-based decision-making in which decision-makers balance the relevant interests (Van Dijk, 2008). At the same time decision-makers operate within a complicated web of interactions between policy, regulations, and social and political processes. So, the natural water system itself is complex, because it consists of several interrelated aspects, e.g. water quality and -quantity, surface- and groundwater, up- and downstream systems. These different aspects of water systems require the integration of different disciplines, e.g. hydrology, geology, spatial planning. Besides the complexity of the water system, management of large-scale water systems is also embedded in a complex social system with multiple actors[1] and thus, multiple perspectives.

Uncertainty of knowledge and the existence of divergent actors' perceptions contribute to the complexity of water management issues. Uncertainty is the result of the lack or incompleteness of (scientific) knowledge or necessary information. Actors' perceptions are based on frames, which 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). Ambiguity results from the fact that within a problem situation, various actors with diverging perceptions are involved. It implies that a problem situation can be approached and interpreted in many ways (Dewulf et al., 2005; Koppenjan and Klijn, 2004).

1.1.2 Policy and decision-making for complex water management issues

To deal with complex water management issues policy is formulated by governments, authorities and companies. The policy process determines how and why certain human interventions in large-scale water systems as solutions to complex water management issues take place. This process is characterized by dynamism and mutual influences (interaction) between factors (e.g. power and information) and actors that are involved in the process. A policy process is hardly ever a one-actor process, but usually a multi-actor process. Before a certain policy can be implemented specific plans have to be formulated, by gathering and analyzing information (*policy preparation*), and decisions on these plans have to be taken. These decisions are made during a *decision-making process* (Hoogerwerf and Herweijer, 2003).

[1] In this thesis we will use the term actor (instead of stakeholder) to refer to any person, group or organization with an interest in an issue, either because they will be affected or because they may have some influence on its outcomes.

Natural resources management in general, and water resources management in particular, are currently undergoing a major paradigm shift (Cortner and Moote, 1994; Gleick, 2003; Pahl-Wostl, 2007a; Pahl-Wostl, 2007b). Until recently, management was often the exclusive task of technical experts working under the auspices of the state. Their activities were based on the assumption that water and natural resources can be predicted and controlled, by means of infrastructural works. However, at the moment, participatory management and actor involvement are becoming increasingly important (Bouwen and Taillieu, 2004; Mostert, 2003; Pahl-Wostl, 2007a). In several European countries, governments are experimenting with participatory processes on all kinds of policy domains (Edelenbos and Klijn, 2005b). The development of participatory approaches is related to the recognition that a government alone does not determine societal developments; in fact they are shaped by many actors. Actually, we live in a network society in which resources are fragmented and where public and private actors are mutually dependent (Teisman, 2000). A network society is not governed at one level, but at multi-levels, by multi-actors, with multi-instruments and multi-resources (Bressers et al., 2004; Rhodes, 1997; Sabatier and Jenkins-Smith, 1993; Scharpf, 1997). From this network or multi-actor perspective, policy is formed through interactions between interdependent actors with their own perspectives and strategies (Teisman, 2000).

In summary, water management issues developed from a technical approach, e.g. building dikes for protection against flooding, to integrated and participatory management, where different aspects, values and actors are taken into account. Decision-making for human interventions in water systems is no longer only a technical issue; it is more and more a societal issue too. This asks for an integral approach to policy and decision-making.

1.2 Research objective and questions

The shift in the character of water resources management thus implies a change in the role fulfilled by technical knowledge or (scientific) knowledge on natural water systems. In this thesis, we aim to improve water resources management by better connecting technical knowledge to the renewed character of decision-making. This will be done by formulating a conceptual model based on literature review and by conducting three empirical case studies on decision-making processes for complex water issues. Thus we aim for empiricism to provide a better applicable theoretical basis for management practice. The central research question for this thesis is as follows:

How can divergent actors' perceptions and knowledge uncertainty in decision-making processes for complex water management problems be dealt with to reach a valid and agreed upon problem-solution combination?

The following research questions (RQ) are formulated to achieve the research objective:

RQ1. What are characteristics of complex water management problems?

RQ2. What are characteristics of policy and decision-making for these complex water management problems?

RQ3. How does the decision-making approach, for a complex water problem, influence the creation of a knowledge base?

RQ4. How does the decision-making approach, for a complex water problem, influence the development of actors' perceptions?

RQ5. How does the decision-making approach influence the formulation of a problem-solution combination?

1.3 Research methodology

1.3.1 Policy-related interdisciplinary research

The kind of research that is presented in this thesis can be labelled as policy-related interdisciplinary research. Policy-related interdisciplinary research is defined by Otter (2000) as *"…the integration of scientific disciplines in order to tackle complex societal problems…(Otter, 2000)"* She describes that the need for interdisciplinary research arises is, due to the complexity of the problems, a mono-disciplinary approach is inadequate. In Section 1.1.1, we already described the complex nature of the water management issues we wish to study in this thesis. Thus, policy-related interdisciplinary research seems to match our object of research quite well. The question arises: how is policy-related interdisciplinary research conducted? The answer to this question is not that straightforward. The difficulty lies in the combination between natural science and social science. It is clear that natural sciences and social sciences focus on different objects of research.

Natural sciences focus on natural phenomena, which are considered to exist independently of our human thought and perception. Regarding natural sciences, an epistemic theory is the ideal, and it is the dominant type of theory in modern science in general. A theory in the epistemic sense is completely independent of context; independent of time, place and circumstances. By using a theory about a constant, complete accurate predictions can be made. Exactness, quantifiability, causal relationships and predictive power of theories play an important role. On the other hand, social sciences take human behaviour as the main object of research. At the individual level, human behaviour is characterized by intentions, emotions, rationality, rules, responsibility and liability. Human behaviour does not follow a strict set of laws, it is not fully causal, and therefore accurate prediction of future behaviour is impossible. At the collective level the issues are systems of rules, statistical relationships between actions, power relationships, public opinion and ideology. Due to their characteristics, the issues of exactness, quantifiability, causal relationships and predictive power or theories play a much smaller role in the social than in the natural sciences (Flyvbjerg, 2004; Flyvbjerg and Sampson, 2003; Meijers, 1998; Otter, 2000; Van Dijk, 2008).

Logical positivism and the standard model of science have been especially successful in the natural sciences. Logical positivism has its roots in empiricism, positivism and logic (Bruinsma and Zwanenburg, 1992; Koningsveld, 1987). Empiricists claim that a priori knowledge, independent from experience, is impossible. Positivism is strongly linked with empiricism and it is based on 'given' facts. Logic deals with reasoning in a systematic manner. Logical positivism has become the standard model of empirical science. This standard model makes use of the 'empirical cycle' in which two forms of reasoning, i.e. induction and deduction, are combined (Koningsveld, 1987). However, due to the characteristics of humanity and society explanations in the social sciences do not fit into this standard model of science. Flyvbjerg (2004; Flyvbjerg and Sampson, 2003) explains that social science can only imitate the natural sciences if it excludes the specific context of human activity, yet, by excluding that context, it becomes impossible to offer explanations. What does this imply for interdisciplinary research? Perhaps we need a dualistic model of science, in which natural and social sciences employ different scientific methodologies, as there is no 'unified science'. We follow the suggestion put forward by Otter (2000), who speaks of methodological dualism.

1.3.2 Type of knowledge: practical knowledge

As concluded in the previous section, studying the objects of respectively natural and social sciences may require different approaches and methodologies. Whilst some of these differences may be attributed to personal characteristics of scientists involved, most of them can be referred to inherent differences between epistemology in the natural and social sciences. Thus, interdisciplinarity is not merely an organizational issue of bringing monodisciplinary scientists together, but more so an epistemological problem (Rutgers, 1993).

Flyvbjerg (2004; Flyvbjerg and Sampson, 2003), following Aristotle, distinguishes three modes of knowledge: *episteme* (theoretical), *phronesis* (practical) and *techne* (productive). Episteme is knowledge about things with fixed principles, such as necessary and universal truths. As described in the previous section, this is the ideal of natural sciences. Phronesis is practical knowledge that is not about constants, and therefore may be interpreted differently, depending on the context. It is about what should be done in a given situation. It is an ethical mode of knowledge, based on experience and judgment, which includes deliberations on value-laden questions. Techne refers to crafts and arts. Value-laden questions are outside the scope of techne. With techne, one applies technical know-how and skills in an instrumental way (Flyvbjerg, 2004; Flyvbjerg and Sampson, 2003; Van Dijk, 2008). In this thesis we aim for practical knowledge (*phronesis*) on the role of perceptions and knowledge in complex water issues, which can assist different actors (e.g. governmental actors, companies, etc.) in improving the effectiveness of planning processes for human interventions in large-scale water systems (*techne*).

Aristotle's three types of inference are: deduction, induction and retroduction. Deduction is reasoning from the general to the specific. Induction starts with the specific and infers to the general. The phronetic approach is neither deductive, nor inductive. It is more open and dynamic than the deductive approach, because one draws from general concepts what is relevant and applicable to the actual phenomena being studied. Phronetic is at a higher level than induction, because it is more than just the accumulation of impressions. It requires attentiveness and an insightful dealing with practice (Dunne, 1993; Van Dijk, 2008). Retroduction merely suggests that something may be. It also starts with the specific, but results in an explanation rather than just a summary of data. Retroduction tentatively explains why something is as it is, requiring insight and judgment. Retroduction can be positioned at the intersection of the general and the specific and infers a probable explanation (Van Dijk, 2008).

1.3.3 Research strategy: Case studies

In this thesis, we present results from three case studies of complex water issues. Case studies allow a researcher to study contemporary, complex processes in an integrated manner (Yin, 2003). We use insights from 'phronetic' planning research for our case studies. Phronetic research aims to provide concrete examples, through in-depth studies of cases and their context and detailed narratives of the way values and power work. This type of research does not aim to generate unequivocally verified knowledge, but to contribute to an ongoing dialogue (Flyvbjerg, 2004). The case study methodology that is used in our first two case studies is further described respectively in Section 3.3.2 and Section 4.3. Finally, the participatory decision-making approach is compared to the analytical decision-making approach using an experimental setup. The methodology of this case study is described in Section 5.2.

1.3.4 Case study selection and overview of research activities

In this thesis, three case studies will be analysed in depth. On beforehand, we formulated four preconditions to select these case studies. They must comprehend the following characteristics:

i. Large-scale: impact on national level (spatial) and long-term (temporal);
ii. Infrastructural: real-estate facilities like roads, waterways, airports, harbours, etc.;
iii. Intervention in natural, surface water system: i.e. river, estuary or sea;
iv. Multiple objectives and stakeholders: due to other spatial developments, e.g. house building, nature development

To further select case studies, we formulated three selection criteria:

1. Phase of the project (decision-making process);
2. Access to information (documents, actors);
3. Contacts with third parties.

The first criterion describes the phase of a project, which phases have been finalised (research phase; design phase; final/decision phase). The second and third criteria are mainly for practical reasons, to ensure (easy) access to information needed to analyse the case studies. In Table 1.1, an overview of the research activities conducted during this PhD-research is given.

Table 1.1 - Overview of research activities

Year → **Case study activity ↓**	**2005**	**2006**	**2007**	**2008**
Case study 1: Extension Mainport Rotterdam				
- observations	X			
- analysis		X	X	
Case study 2: Sustainable Development Delta-region				
- observations		X		
- analysis			X	X
Case study 3: Comparative experiment of decision-making approaches				
- preparation			X	
- observations				X
- analysis				X

1.4 Reading guide

This thesis is organized as follows. In Chapter 2, the theoretical framework is described. This theoretical framework deals with the following aspects: characteristics of complex water management issues; policy preparation and decision-making; decision-making models for problem structuring; and the role of actor's perceptions and a knowledge base (**RQ1 to 4**). The Chapter ends with a conceptual framework for problem structuring in complex water issues. This conceptual model is used to analyze two explorative case studies from practice.

The first case study, described in Chapter 3, focuses on the decision-making process for the extension of Mainport Rotterdam, which is one of the largest ports in the world. The Dutch government wants to expand the Mainport by land reclamation in the North Sea. This may affect the Wadden Sea, a unique wetlands area protected by the European Bird and Habitat Directives. To assess the impact of the port extension on the Wadden Sea, an Appropriate Assessment procedure was carried out. Our first case study focuses on how actors' perceptions were dealt with and how knowledge was used (**RQ3 & 4**).

The second case study focuses on the sustainable development of ecology, economy and society in the Delta region, in the southwest of the Netherlands. In several areas in this region the ecological quality has decreased due to engineering works for storm surge 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 functions and users, e.g.: farmers. This problem has been addressed in the pilot-project 'Fundamental discussion on freshwater supply for agriculture in the Delta-region in the southwest of the Netherlands', which was used as a second case study in this thesis. In Chapter 4, we analyze 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 (**RQ3 to 5**). We would like to bring to the readers' attention that Chapter 3 and 4 have been published as separate journal papers (Hommes et al., 2008a; Hommes et al., 2008c). Therefore, some (theoretical) parts are presented in Chapter 2 as well as in these two Chapters.

In our third case study, two decision-making processes are compared using an experimental setup. The comparison between the two decision-making processes was carried out within the framework of a multidisciplinary design project for Civil Engineering Bachelor-students of the University of Twente. This design project focuses on the extension of Schiphol Airport on an island in the North Sea. In Chapter 5, we aim to determine how a decision-making approach influences the creation of a knowledge base, the development of actors' perceptions and the substantive outcomes (**RQ3 to 5**).

In Chapter 6, the findings from our three case studies are compared by reflecting upon the main elements from our conceptual model (**RQ3 to 5**) and the results of the research are discussed in a broader perspective. Finally, Chapter 7 draws conclusions the main research question: how to deal with diverging actors' perceptions and knowledge uncertainty in complex water management problems. Also, recommendations for further research and water management practice are presented in this final Chapter. In Figure 1.2, the outline of this thesis is shown.

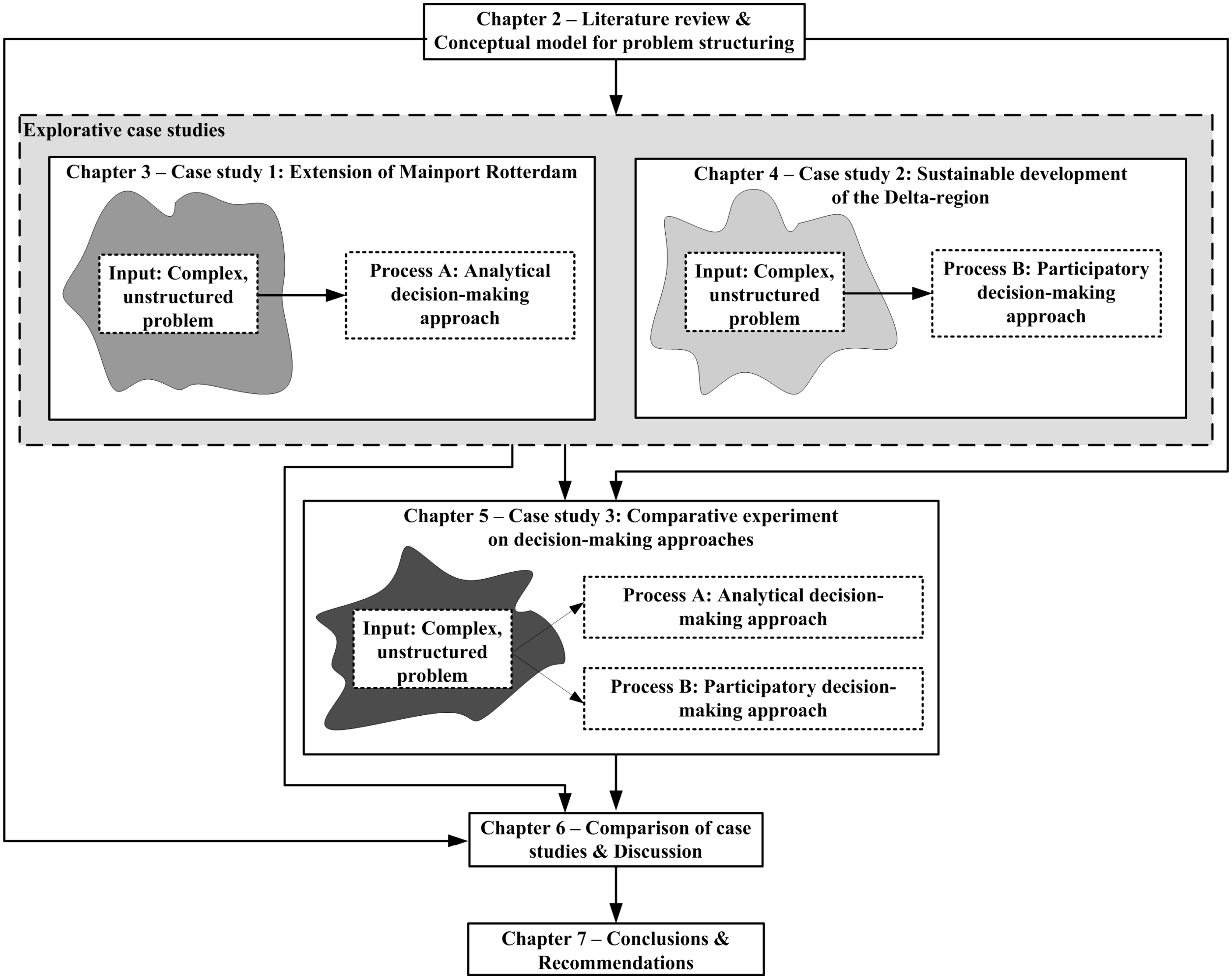

Figure 1.2 - Outline of the thesis

2 LITERATURE REVIEW & CONCEPTUAL MODEL FOR PROBLEM STRUCTURING

2.1 Introduction

In the previous Chapter, we introduced management of large-scale water systems as being embedded in a complex natural and social context. Furthermore, it was explained that water management issues are often unstructured problems due to uncertain knowledge and diverging actors' perceptions. In section 2.2, the complex and unstructured nature of water management issues is further investigated. In this thesis, we focus on the role of knowledge and perceptions in decision-making for complex water management issues. Therefore, we first investigate two decision-making approaches, i.e. analytical and participatory, and the history of water management in The Netherlands in Section 2.3. Then the creation of a knowledge base and interpretation and valuation of knowledge is described in Section 2.4. In Section 2.5, the topic of actors' perceptions is further investigated. Finally, we present our conceptual model on the role of knowledge and perceptions in analytical and participatory decision-making approaches in Section 2.6. This conceptual model is used to analyze two case studies from practice (Chapter 3 and 4) and a comparative experiment (Chapter 5).

2.2 Complex water management problems

2.2.1 Complexity and complex adaptive systems

There are many scientific definitions of 'complexity'. Complexity in a physical system focuses on *non-linearity*, *interactions* and *order/self-organization*. Thus the main aspects of a general description of complex systems are the non-linear interconnectedness of the elements and their ability to organize themselves into a certain structure (Otter, 2000; Rosser, 1999). An important difference between complexity in physical and in human systems is the ability that humans have to adapt to their situation. People learn from interacting with their environment and with other humans, this clearly affects their decision-making process. This possibility for adaptation adds an aspect of complexity that does not exist in other disciplines (Otter, 2000). These natural-technical-social systems (see Section 2.2.4) are more appropriately described as complex adaptive systems. Geldof (2001) defines a complex adaptive system as: *"…a dynamic system with stable behaviour, that distinguishes oneself by a structure of wide diversity. It reacts and anticipates on developments in the environment/context by means of change in structure…(Geldof, 2001)"* Pahl-Wostl (2007a) explains that complex adaptive systems are characterized by self-organization, adaptation, heterogeneity across scales and dispersed control.

The increased awareness of the complexity of systems seems to be an overall trend in different fields. On one hand the systems to be managed and the problems to be tackled have indeed become more complex. The pace of change in socio-economic conditions and technologies is tremendous. Uncertainties arising from global change in general and climate change in particular pose major challenges for the management of large-scale water systems. On the other hand the awareness for the need to take the complexity of problems fully into account has increased (Pahl-Wostl, 2007a). Van Asselt (2000) explains that decision-making for such complex issues satisfies the following characteristics: there is not one problem, but a tangled web or related problems (*multi-problem*); the issue lies across or at the intersection of many disciplines, i.e. it has an economic, environmental, social-cultural and institutional/political dimension (*multidimensional*); and the underlying processes interact on various scale levels (local, regional, national, continental and global) and on different temporal scales (*multi-scale*).

2.2.2 Problem types

A problem occurs when a factual situation is in discrepancy with a desired situation. This implies that a problem always consists of normative and factual/empirical elements. Therefore, problems cannot be regarded as objective givens, but as 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 problems. The first dimension is consensus about values and norms (normative standards). The other dimension relates to the certainty of the knowledge base or content. Using these two dimensions, four types of problems can be distinguished (Figure 2.1). Structured problems (type 1) are problems for which a certain knowledge base and consensus about values and norms exists. Some problems are moderately structured because disagreement exists about values and norms standards (type

2) or because knowledge is uncertain (type 3). When objectives are at stake and knowledge is uncertain, a problem is unstructured (type 4) (Douglas and Wildavsky, 1982; Hisschemöller, 1993; Van de Graaf and Hoppe, 1996). Water management issues arise in a social and natural system that is characterized by complexity, uncertainty and disagreement (Kolkman et al., 2005). Consequently, they often exhibit complex and (partly) unstructured problems, i.e. type 2, type 3 or type 4.

Knowledge base → **Values and norms ↓**	**Certain**	**Uncertain**
Consensus	**1. Well structured** Knowledge use: Instrumental/Data Policy process: Routine	**2. Moderately structured** Knowledge use: Strategic/Argument Policy process: Negotiation
Disagreement	**3. Moderately structured** Knowledge use: Conceptual Policy process: Compromise	**4. Unstructured** Knowledge use: Enlightment/Ideas Policy process: Learning

Figure 2.1 – Classification of policy problems, use of knowledge and policy process (adapted after: Boogerd, 2005; Hisschemöller, 1993; Van de Graaf and Hoppe, 1996)

Figure 2.1 also shows the way knowledge is used and the type of policy process per problem type. Experts play a dominant role in well structured problems and take on the role of problem solver. In this case, policy is highly expert-driven (Turnhout, 2003). The type of policy process is *routine*. In moderately structured problems with disagreement on values and norms (type 3), knowledge can accommodate the policy process. Such an accommodating role for science suggests 'under-critical' acceptance of science (Collingridge and Reeve, 1986). Decision makers will try to pacify or depoliticize potential conflict and seek *compromise*. An important pacifying strategy is to produce vague or symbolic policy and to use shared concepts. It is not hard to agree with a symbolic policy goal. This may play an important role in facilitating what Lindblom (1959) has called incremental policy or 'muddling through'. The adoption of shared concepts and vague, symbolic policy can also lead to stagnation or controversies. That is, moderately structured problems (type 2) may emerge after the establishment of vague policy or shared concepts (Turnhout, 2003). For these moderately structured problems consensus exists on values and norms, but as the knowledge base is uncertain it is not clear which means and knowledge should be used to solve the problem. Therefore, the use of knowledge is strategic. Willingly or unwillingly, knowledge becomes part of the debate, as the different sides tend to strengthen their position by the use of scientific arguments. Collingridge and Reeve's (1986) 'overcritical' model can be recognized here. The type of policy process that will be used in this type of problem is *negotiation*. Last, in the case of unstructured problems no consensus exists on norms and values and knowledge is uncertain. In the case of unstructured problems, knowledge can play a role as problem signaller. In doing that, knowledge takes the shape of ideas and can be used as enlightenment. The type of policy process that characterizes this problem is *learning* (Boogerd, 2005; Hisschemöller et al., 1998; Turnhout, 2003).

2.2.3 Uncertainty terminology

Uncertainty is defined differently by different authors, see Walker et al. (2003) for a review. Each of these definitions makes emphasis on different aspects of uncertainty, reflecting different views on the topic and implying different coping strategies. Amid the discrepancies/variety in definitions, one thing upon which many authors agree is in the distinction between the ontological and epistemic nature of uncertainty. Ontological uncertainty is uncertainty due to inherent variability of the system. Epistemic uncertainty is uncertainty due to imperfect knowledge of the system. A fundamental difference is that while epistemic uncertainty can in principle be reduced with the necessary time and means, ontological cannot. The possible means to reduce the epistemic uncertainty depend on its type and source (Van der Keur et al., 2008). Dewulf et al. (2005) describe that uncertainty, indeterminacy and ambiguity are often used interchangeably to refer to situation where things are unclear. They argue, however, that it seems more useful to understand the concepts as referring to different phenomena or states of affairs. In general terms, they refer to *indeterminacy* as the inherent unpredictable and chaotic nature of certain phenomena in the outside world (ontological uncertainty); to *uncertainty* as incomplete knowledge or information about a phenomenon (epistemic uncertainty); and to *ambiguity* as the simultaneous presence of multiple frames of reference (actors' perceptions) to understand a certain phenomenon. Although for conceptual clarity these three qualities can be analytically distinguished, it may not always be possible to distinguish them in practice (Dewulf et al., 2005). Brugnach et al. (2007) too incorporate ambiguity as a third dimension of uncertainty, i.e. next to the ontological and epistemic nature of uncertainty. They draw on work in the management and organizational sciences on dealing with uncertainty, where a distinction between uncertainty and ambiguity is made (Daft and Lengel, 1986; Weick, 1995). In this thesis, we distinguish between uncertainty in the knowledge base and ambiguity of actors' perceptions. These topics are further discussed respectively in Section 2.4 and 2.5.

Indeterminacy, uncertainty and ambiguity can be located in Walker et al.'s (2003) comprehensive map of the various dimensions of uncertainty involved in modelling. Variability uncertainty, defined as uncertainty due to inherent variability in the phenomenon, corresponds to indeterminacy. Context uncertainty is clearly related to the way we conceive of ambiguity, in that it points the attention to "*…the choice of the boundaries of the system, and the framing of the issues and formulation of the problems to be addressed within the confines of those boundaries…(Walker et al., 2003)*" Model structure uncertainty and inputs uncertainty can play a role in ambiguity too, insofar as they concern the definition of relevant variables to be included or excluded in the problem framing. The remaining aspects of uncertainty in the Walker et al. (2003) model can be readily understood as different forms of incomplete knowledge about a phenomenon, including epistemic uncertainty as imperfection of our knowledge which may be reduced by more research and empirical efforts; parameter uncertainty related to calibration issues; technical model uncertainty related to computer implementation issues; model outcome uncertainty or prediction error; and the different levels of uncertainty ranging from statistical uncertainty to recognized ignorance. We distinguish indeterminacy, uncertainty and ambiguity in this way because these concepts are applicable to different phenomena. Indeterminacy is an inherent characteristic of some phenomena in the outside world, while uncertainty is a characteristic of our knowledge about that world, and ambiguity, as we will argue further, is a characteristic of social situations in which multiple actors bring in multiple perceptions.

2.2.4 Objects of knowledge

In this thesis the following systems, and knowledge on these systems, are considered:

- Natural system: this includes the natural system with its aspects of climate impacts, water quantity, and ecosystem.
- Technical system: this includes the technical elements that are deployed to intervene in the natural system, like infrastructure, technologies.
- Social system: this includes the social system with its economical, legal, political, organizational and actor aspects.

Although we assume that these systems are closely interlinked in a complex natural-technical-social system, it is useful to distinguish them for analytical reasons.

The OECD (Organisation for Economic Co-operation and Development) developed the DPSIR (Driver-Pressure-State-Impact-Response) model to structure its work on environmental policies and reporting. According to this systems analysis view, social and economic developments exert *Pressure* on the environment and, as a consequence, the *State* of the environment changes, such as the provision of adequate conditions for health, resources availability and biodiversity. Finally, this leads to *Impacts* on human health, ecosystems and materials that may elicit a societal *Response* that feeds back on the *Drivers*, or on the state or impacts directly, through adaptation or curative action (Figure 2.2).

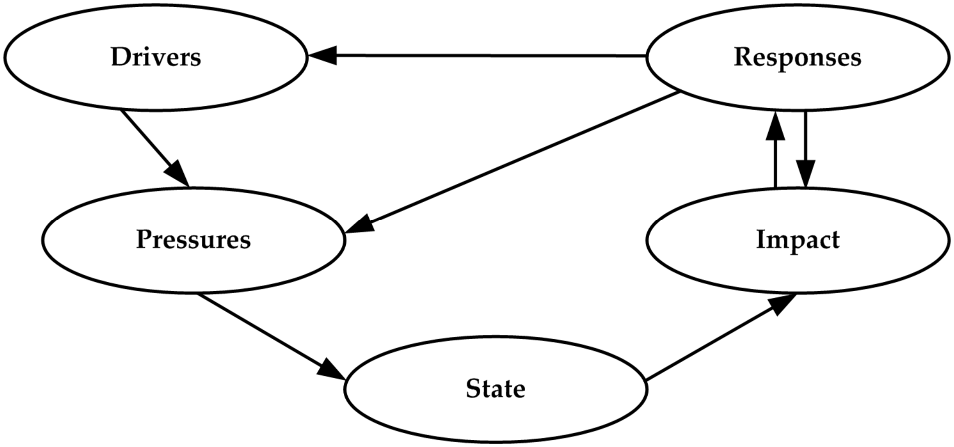

Figure 2.2 - DPSIR framework (EEA, 1999)

Obviously, the real world is far more complex than can be expressed in simple causal relations in systems analysis. There is arbitrariness in the distinction between the environmental system and the human system. And, moreover, many of the relationships between the human system and the environmental system are not sufficiently understood or are difficult to capture in a simple framework. Nevertheless, from the policy point of view, there is a need for clear and specific information on the different aspects of the DPSIR framework (EEA, 1999). The DPSIR model highlights these cause-effect relationships, and helps decision-makers and the public see environmental, economic, and other issues as interconnected (OECD, 2003).

A similar distinction is made by the Dutch Ministry of Spatial planning, Housing and the Environment, who uses the so-called *layer approach* to picture land use in the Netherlands. In this approach, land use consists of three layers:

(1) Base, i.e. water, soil and the flora and fauna in those environments;

(2) Networks, i.e. all forms of visible and invisible infrastructure; and

(3) Occupation, i.e. spatial patterns due to human use.

Each layer influences the spatial considerations and choices with respect to the other layers. In the planning stage, the processes in the different layers need to be considered in relation to each other. This can prevent conflicts between different users of the same land, as well as creating greater coherence in the measures to be taken. After all, intervention can serve more than one policy objective at the same time. This approach allows plans that consider all three layers and the constraints they put on land use to be future-oriented, sustainable and usable. The government wants to improve spatial quality throughout the Netherlands by preserving the basic quality standards and improving them where possible, while focusing extra attention on the National Spatial Structure (Ministeries van VROM et al., 2004a). In Figure 2.3, the three layers are shown for the Netherlands.

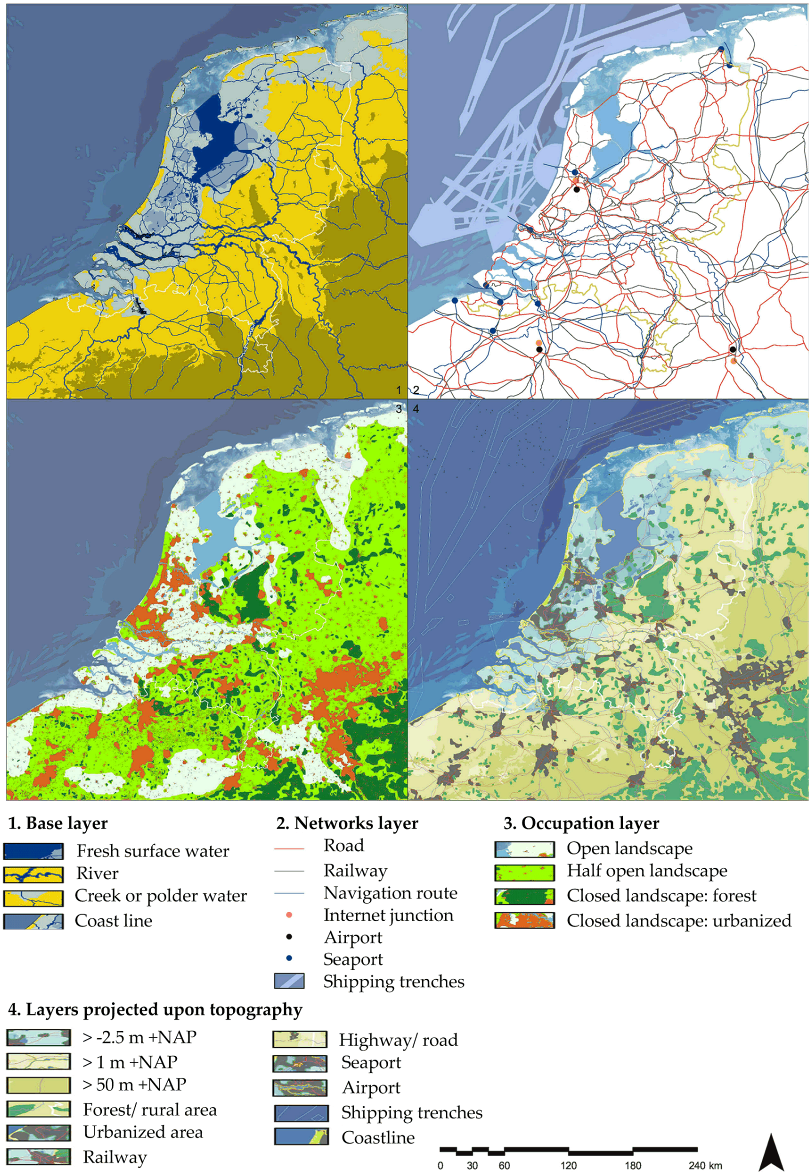

Figure 2.3 - Layers of the Netherlands (adapted after: Ministeries van VROM et al., 2004b)

In Figure 2.4, a schematized world view is shown. In this figure we combined the different systems, natural, technical and social system with the layer approach and ideas from the DPSIR-framework. The different layers from the layer approach are used as an analogy, as not all layers refer to spatial layers.

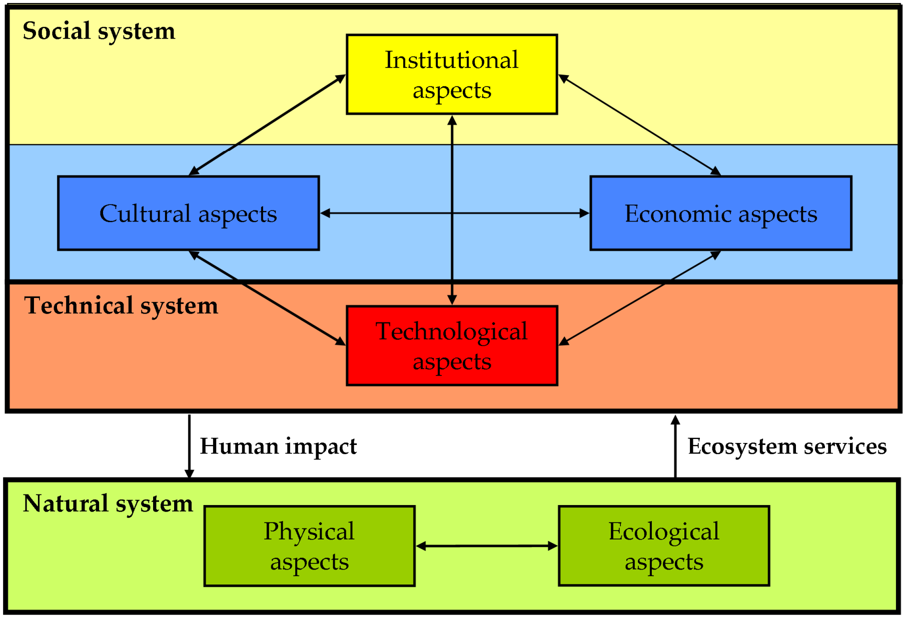

Figure 2.4 - Schematized world view. The colours are used in analogy to the different layers from the layer approach. Green = base layer; Red = networks layer; Blue = occupational layer; Yellow = institutional layer

2.2.5 Synthesis: Characteristics of complex water management problems

The characteristic of complex water issues is that they are embedded in a complex natural and social system, i.e. a complex adaptive system. Uncertain knowledge and the existence of divergent actors' perceptions contribute to this complexity. The objects of knowledge that are considered in this thesis are: natural system, technical system and social system. The DPSIR framework and the layer approach are methods to reflect the interconnectedness between these three systems and uncertainty in the different systems. In this thesis, we focus on how a decision-making process, for a complex water management issue, influences the creation of a knowledge base and the development of actors' perceptions. The topics of knowledge base and actors' perceptions are further investigated in respectively Section 2.4 and Section 2.5. We first investigate decision-making in general and two decision-making approaches in specific, i.e. analytical and participatory, in the next two sections.

2.3 Policy and decision-making for complex water management problems

In general, policy can be defined as *"…striving for certain goals with certain means and choices of time, i.e. to act willingly and knowingly…(Hoogerwerf and Herweijer, 2003)"* Policy is aimed at providing a solution to a certain problem. However, policy does not only concern possible solutions, but also the question which problems to focus on (*agenda forming*). So, how and why certain human interventions in large-scale water systems as solutions to complex water management issues take place, is determined in policy. These policy frames develop during a policy process, which is "…*the course of acts and interactions between actors with respect to a policy…(Hoogerwerf and Herweijer, 2003)"* This process is characterized by dynamism and mutual influences (interaction) between factors (e.g. objectives, power and information) and actors that are involved in the process. A policy process is hardly ever a one-actor process, but usually a multi-actor process. Before a certain policy can be implemented specific plans have to be formulated, by gathering and analyzing information (*policy preparation*), and decisions on these plans have to be taken. These decisions are made during a *decision-making process* (Hoogerwerf and Herweijer, 2003). There are many different approaches for decision-making. In general, we can distinguish two 'extreme' approaches: the analytical and the participatory approach. The analytical[2] approach to decision-making tries to break down a problem in smaller pieces and focuses on reducing uncertainties in knowledge of these pieces. The participatory[3] approach, on the other hand, focuses on the problem 'as a (complete) entity' and on the different actors, and their interests and knowledge, involved. This section first presents two 'extreme'

[2] Other naming found in literature: classical, rational, linear, traditional, hierarchic, technocratic, top-down, intellectual, (neo-) positivism

[3] Other naming found in literature: interactive, communicative, adaptive, collaborative, consensus

models which are used to conceptualize and understand policy processes: the *phase model* and the *rounds model*. Then Dutch policy and decision-making for water management issues is analyzed.

2.3.1 Analytical decision-making approach: Phase model

The phase model is a widely used linear model and fits within the analytical, hierarchic approach of policy processes. Analytical decision-making refers to the approach that originates from system analysis. This approach arose after World War II when policy makers embraced the analytical approach of operations research, as a result of the successes it achieved in military issues during the war (Quade, 1989). The analytical decision-making approach aims to support decision-making on the basis of (scientific) knowledge. Therefore, the solution is sought in acquiring more knowledge and data on the basis of (policy analytical) research (Arentsen et al., 2000; Koppenjan and Klijn, 2004; Twaalfhoven, 1999). A key concept of this approach is *rationality*. Decision-making should be analytical and be supported by rational analysis. Crucial to the achievement of rational outcomes is *objectivity*. This means that knowledge should be gathered about reality as it is and that facts should be separated from subjective and normative insights, theories and prejudices; the 'fact-value dichotomy' (Hawkesworth, 1988). Thus, in this approach, a policy problem is perceived to be of a technical nature (Hoppe, 1999). Furthermore, the analytical decision-making approach rests on the assumption that a central actor, usually the government, formulates objectives and solves problem in relative autonomy (Koppenjan and Klijn, 2004; Rhodes, 1997; Scharpf, 1997; Teisman, 2000; Van de Riet, 2003). The process of the analytical decision-making approach can be conceptualized by the phase model (Figure 2.5). The phase model describes a decision-making process as subsequent phases with a clear beginning and end (Koppenjan and Klijn, 2004). A process starts with the definition of problems and goals, and the identification of constraints and criteria. Based on this, an assessment (or evaluation) framework is constructed. Next, alternatives are designed and assessed using the assessment framework, and compared with each other. A decision is made and the solution is implemented (1994; Miser and Quade, 1985; Parsons, 1995).

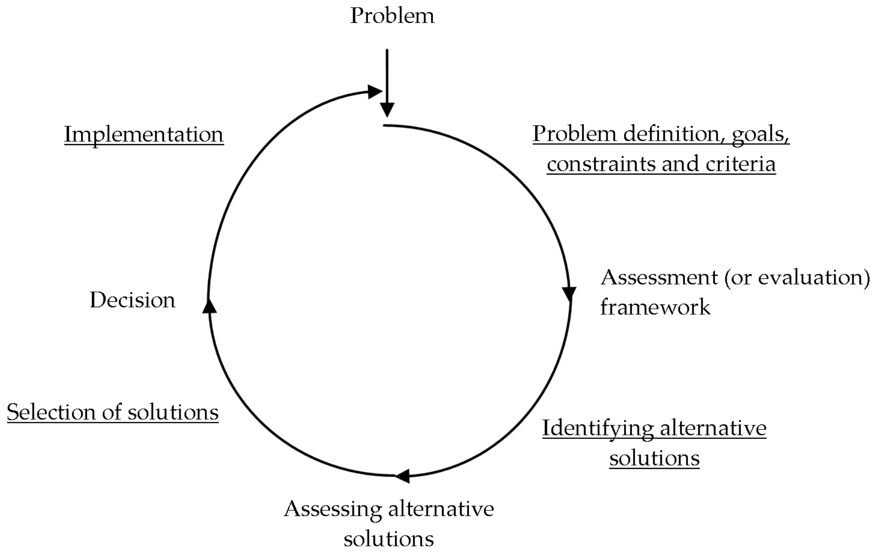

Figure 2.5 – Phase model: underlined terms represent processes (adapted after: Koppenjan and Klijn, 2004; Parsons, 1995)

2.3.2 Participatory policy processes

In several European countries, governments are experimenting with participatory processes on all kinds of policy domains (Edelenbos and Klijn, 2005b). The development of participatory approaches is related to the recognition that a government alone does not determine societal developments; in fact they are shaped by many actors. Actually, we live in a network society in which resources are fragmented and where public and private actors are mutually dependent (Teisman, 2000). A network society is not governed at one level, but by multi-actors, at multi-levels, with multi-instruments and multi-resources (Bressers et al., 2004; Rhodes, 1997; Sabatier and Jenkins-Smith, 1993; Scharpf, 1997). From this network or multi-actor perspective, policy is formed through interactions between interdependent actors with their own perspectives and strategies (Teisman, 2000).

Arnstein (1969) developed a ‘ ladder of participation’, which indicates that significant gradations of actor involvement can be distinguished. An adapted version of the ladder of participation is shown in Table 2.1. The lowest level of participation, *informing*, applies to situations in which the public is informed about the policy process, although they do not have the opportunity to influence it. At the next level, *consulting*, the government regards actors as useful partners for discussion. *Advising* indicates that actors have the opportunity to raise problems and formulate solutions. *Co-producing* means that the problem-solving agenda and the search for solutions is a joint activity of government actors and actors. It also implies that the government commits itself to the results of the process. If the government fulfils an advisory role and leaves the development and decision-making process to actors (within a certain framework) this is called *co-deciding* (Edelenbos, 2000; Edelenbos and Klijn, 2005b). In general, analytical decision-making is not-interactive, i.e. actors are only informed or consulted. Participatory decision-making on the other hand focuses on the three highest levels of participation, which are forms of interactive policy-making. Only at these levels government partners really interact with actors (Pröpper and Steenbeek, 2001; Van Ast and Boot, 2003).

Table 2.1 – Ladder of participation (adapted after: Edelenbos, 2000)

	Level of participation:	*Contributions of participants:*	*Policy-making:*
5.	Co-deciding	Policy development and decision-making	Interactive
4.	Co-producing	Policy development, used for decision-making	
3.	Advising	Policy development, decision may deviate	
2.	Consulting	Setting agenda, discussion	Not-interactive
1.	Informing	No input	

2.3.3 Participatory decision-making: Rounds model

A model to describe a participatory decision-making process is the rounds model, developed by Teisman (1992). This model describes policy-making from a network or process-management perspective, in which decision-making processes are described as 'rounds of interaction'. Actors can make contributions to the content of a process in terms of problem formulations and preferred solutions within an arena. Crucial decisions, which form the concluding point of a certain round and the starting point of a next round, may result from interaction within one or more arenas of actors. The start of a new round is defined by the outcomes of the former round. However, the direction of the game can also change; the content of the process is dynamic and influenced by developments in the network, the management of the process or external developments. Each round results in decisions which are related to the content, the process and/or the institutions (Koppenjan and Klijn, 2004). In Figure 2.6, the rounds model is shown.

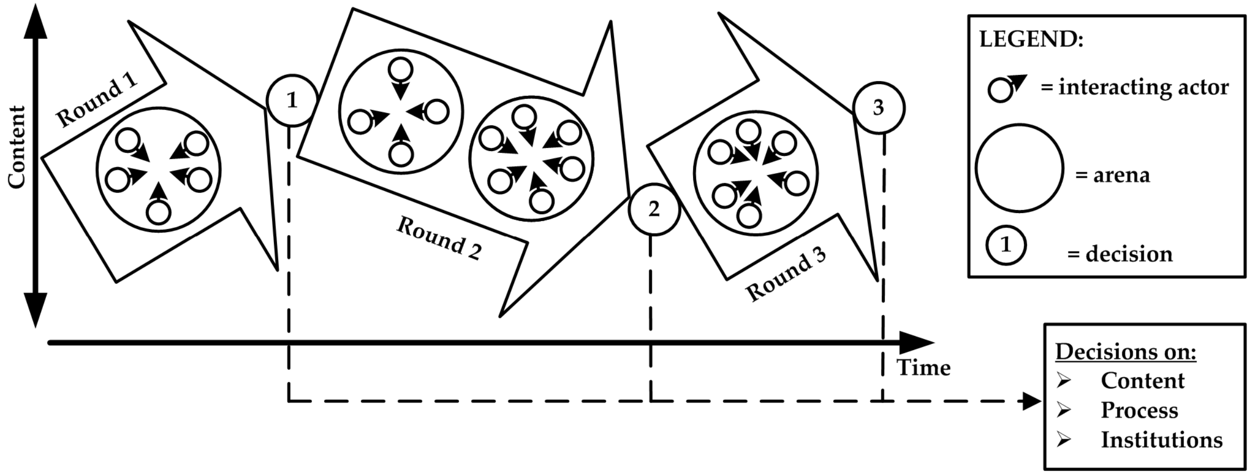

Figure 2.6 – Rounds model: conceptualization of a policy process as 'rounds of interaction' (adapted after: Koppenjan and Klijn, 2004; Teisman, 2000)

2.3.4 Water management in the Netherlands

In the Netherlands, policy and decision-making for water management has a long history. As early as the 11th and 12th century, local communities started to organize themselves to manage water systems. Dikes were built to protect against flooding from the sea and the rivers. Several tributaries of the Rhine and Meuse were dammed up. The two lower reaches of the Scheldt changed into sea arms, and the Scheldt got a new sea mouth (later called the Western Scheldt). Before 1200, there are no direct records of river floods, this is logical because the rivers were largely non-diked. And overtopping of the river banks was not considered a disaster. In this period, an important development was the establishment of regional water-boards. These regional water-boards were governmental bodies, whose task was water management in a certain area. They could oblige certain self-governing village communities to maintain hydraulics works. Thanks to the establishment of the regional water-boards the drainage system of an entire region or a dike ring could now be maintained. In the period from 1250 to 1600 the coastal regions of the Netherlands were still strongly influenced by the sea. At about 1300 the system of the rivers was still largely intact. However, in the period after 1300 the rivers systems were influenced further by damming up and by the increased influence of the sea in the Southwest in particular. As a result several river branches disappeared in the extending sea arms. Further inland the encircling dikes were closed. Technical development made a significant progress during these centuries: windmills, the handling of constructions of osier and reeds, dike building and reclamation and the construction of sluices. On the other hand, the growing need for fuel had caused the peat moor land to be dug up for fuel. This created a lot of lakes. In the period between 1600 and 1800 huge areas of land were reclaimed by coastal and lake reclamations in particular. This gain of land could also be realized thanks to technical innovations in drainage by windmills.

For many centuries the water boards have been able to resist pressure from the central state. However, throughout the 18^{th} century various flood disasters in Dutch river basins demonstrated that the rather small scale approach of water boards lacked central coordination and a broader scope. In 1798, a state water authority 'Rijkswaterstaat' was established to take lead in a nationally coordinated approach to water governance. Due to strong resistance from the still powerful and autonomous water boards, it lasted until the end of the 19^{th} century before a clear demarcation of central and regional powers was settled in the field of water management. In the period from 1916 on, the state water authority commenced large-scale engineering projects and huge land reclamation projects. The most spectacular lake reclamation of the nineteenth century was that of the Haarlemmermeer in 1852, with a size of 180 km^2. Thanks to the progressing technological developments, the huge Zuiderzee project could be started in the twentieth century. As early as in 1667, Henric Stevin published the first plan for reclamation of the Zuiderzee. However, it was not until 1891 that a plan of Cornelis Lely was published, which turned out to be feasible. It was a plan consisted of the closure of the Zuiderzee at its 'neck' with a 30 kilometre-long dam. The decision for the Zuiderzee project was taken in 1918. The floods of 1916 and the apparent vulnerability of the Dutch food supply during the First World War had sped up the decision-making. Realisation of the project would shorten the coastline by 300 kilometres and 2250 km^2 of land would be gained, plus a fresh water reservoir of 1200 km^2. The Enclosing Dam of the IJsselmeer was completed in 1932, the Wieringermeerpolder was pumped dry in 1930 and the Noordoostpolder in 1942. After the

Second World War, the Flevoland polder was reclaimed as well. It is still doubtful whether the planned Markerwaard polder will ever be realized; now there has been a decision of the central government that impoldering of the Markerwaard is excluded until 2030.

The Delta project was the second large-scale twentieth century project to improve safety and water management of the Netherlands. The 1953 disaster - flooding 1650 km^2 of land, claiming 1835 lives and causing gigantic damage – was the decisive factor. The Netherlands had to be secured against such disasters in the future. The sea inlets had to be closed, except the Nieuwe Waterweg and the Westerschelde, shortening the coastline. This made it much easier to defend the Netherlands from flooding. In 1958 the Delta Act was passed and work was started. Between 1960 and 1978 the large sea arms were closed off. However, environmental aspects became increasingly important and under pressure of the public opinion the Oosterschelde was not closed off entirely, but a storm surge barrier was built, which enabled the seawater to pass through. Thus the tidal movements partly continued to exist. Around 1990 it was, decided to construct a movable storm surge barrier in the Nieuwe Waterweg, to improve the protection of Rotterdam and its hinterland against storm surges.

Until the 1950s the Dutch national water regime was mainly a matter of flood prevention, water level control, and sanitation. In the 1950s water supply received attention as a problem of how to meet future demands of an increasing population. There was a rising awareness that water management should be based on a deliberation of interests. Water infrastructural works became a subject of the public debate. Other values than water security entered into the discussion, such as the natural value, the recreational value and the spatial value of water. In the 1970s several water infrastructural projects were reconsidered, to better account for ecological effects. Until 1985 separate plans were made for water quality management, taking care of the progress of surface water quality protection, and water quantity management. Around the mid-eighties, policy-making for water issues developed from a sectored water resources management approach towards an integrated water resources management approach to quantity and quality management.

In the years 1993 and 1995, the Netherlands escaped from heavy floods and in 1998 excessive rainfall caused huge damages. These water hazard situations generated a discussion about water management in the country. Due to the century long 'fight' against water and an intensification of land use in The Netherlands, the total area of waterways, lakes and rivers has been strongly reduced. The result is a water system designed with minimal dimensions and without the resilience to cope with unexpected climatic situations. During the discussions, a new paradigm emerged which was named 'water accommodation'. The essence of 'water accommodation' is that human society and the physical water environment are interdependent. The design and the dimensions of human made water systems must take into consideration the unpredictable behaviour of a natural phenomenon such as the hydrological system. This vision also proclaims that more space around rivers is needed, especially in response to flood problems in river flood plains, and to better anticipate climate change. Presently, the trend of participatory water resources management is visible. This management approach states that water managers are in continuous interaction with the water system and with different actors in society (Kuks, 2004; Van Ast, 1999; Van de Ven, 2003; Van Slobbe, 2002).

2.3.5 Synthesis: Characteristics of policy and decision-making for complex water management problems

In general, policy and decision-making is aimed at providing a solution for a certain problem. A policy and decision-making process is usually a multi-actor process. There are many different approaches to decision-making. We can distinguish two 'extremes': analytical decision-making approach and participatory decision-making approach. In the analytical approach, decision-making is based on rationality and objectivity. This process can be conceptualized by the phase model and is not-interactive, i.e. it assumes one steering actor. On the other hand, participatory decision-making is interactive. During the process several actors contribute to problem structuring. This process can be described by the rounds model.

In the Netherlands, policy and decision-making for water management has a long history, starting as early as the 11^{th} century when regional water-boards were established. In the centuries that followed water management developed from a technical approach, e.g. building dikes for protection against flooding, to integrated and participatory management, where different aspects, values and actors are extensively taken into account. So, making plans for human interventions in water systems is no longer only a technical issue, but have become more and more a societal issue. In complex water projects, problem structuring with various actors takes place and knowledge and perceptions play an important role in this process.

In this thesis, we focus on the role of knowledge and perceptions in decision-making for complex water management problems. Now that we have investigated decision-making in general and two decision-making approaches in specific, i.e. analytical and participatory, we will focus on the topics of knowledge and actors' perceptions and relate these topics to analytical and participatory decision-making.

2.4 Knowledge base

In this section, the topic of knowledge is described. First, we will investigate the creation of a knowledge base, during a process of problem structuring. Next, the interpretation and valuation of such a knowledge base is presented. Finally, the role of knowledge in analytical and participatory decision-making is discussed and preliminary conclusions are drawn.

2.4.1 Creation of a 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 can also increase uncertainty, because it reveals the presence of uncertainties that were unknown or understated until then (Walker et al., 2003). Sometimes uncertainty is more structural or systematic, because it concerns future aspects which are relevant to the policy process. However, these aspects are unknown and unknowable at the time of analysis (Walker, 2000). The reduction of uncertainty by means of knowledge production is only possible if there are facts that can be measured objectively (De Bruijn and Leijten, 2007). If problems are not clearly defined because knowledge is uncertain, several knowledge sources are needed to solve a problem. Pahl-Wostl (2002) describes that for these unclear problems 'hard' problem solving (factual and analytic knowledge) needs to be combined with 'soft' actor policy-based design (local and subjective perceptions of actors).

Various actors hold, produce and value knowledge that differs in both content and orientation. We can distinguish between two types of knowledge: expert (or scientific) knowledge; and practical (or lay, non-scientific) knowledge (Eshuis and Stuiver, 2005; Pahl-Wostl, 2002; Rinaudo and Garin, 2005). Scientific 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. Actor knowledge is often grounded in experiences of actors. Actors can provide context-related knowledge about the environment and the specific case. 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).

Involving actors' knowledge 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 actor 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…(Mitroff, 1983)"*. 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).

2.4.2 Interpretation and valuation of the knowledge base

Actors interpret information using their cognitive framework; this contributes to their perception of a problem situation. This cognition or construction of knowledge is done through interaction with the physical and social environment (Nooteboom, 2000; Nooteboom, 2001). Actors develop knowledge relevant to their specific situation that fits their practice and epistemology (Eshuis and Stuiver, 2005). Therefore, knowledge is contextual; it must be placed within an interpretative context to have meaning. Since knowledge is created through interaction with its context, it is also embedded in the practices and epistemologies of actors (Latour, 1987; Law, 1994). The extent to which actors have developed knowledge in different social and physical surroundings is reflected by their 'cognitive distance'. If people interact closely and share experiences, their cognitive distance will be reduced (Nooteboom, 2000; Nooteboom, 2001). How actors interpret information also relates to trust. Knowledge is only valuable after actors place it within a certain social network. If actors believe a social network is trustworthy, they are likely to feel the same about the knowledge produced within this social network. Trust is not fixed or stable, it changes over time. We can distinguish between active trust and trust people have because they have no other or better choice to trust. Active trust bears on previous relational experiences and depends on the interest the trusted party has to fulfil someone's trust, i.e. there should be an incentive for the trusted party to be trustworthy (Carolan, 2006).

2.4.3 Decision-making approaches

Van de Riet (2003) claims that the analytical approach focuses on the requirements that single-actor complexity puts on decision-making. Single-actor complexity arises on the one hand from fuzzy objectives and on the other hand from system complexity and uncertainty about the effects of solutions (Koppenjan, 1990; Van de Riet, 2003; Van Heffen, 1993). Koppenjan and Klijn (2004) and Arentsen et al. (2000) describe two types of responses to uncertainty in analytical decision-making. The first response is information gathering, using expert knowledge and (scientific) research, and sorting things out before taking steps. *"…The assumption behind this reaction to uncertainty is that of neo-positivism: that scientific research into causal relations will lead to objective knowledge about the nature of the problem, the background causes, the possible interventions and their consequences* […] *In this neo-positivist vision, science is separate from other societal domains such as government and the market, and is presumed to produce true, objective and universal knowledge…(Koppenjan and Klijn, 2004).*" However, 'facts' are the product of definitions and principles, influenced by people's view of the world, their so-called conceptual orientations, perceptions, mental maps and frames (see e.g.: Edelenbos et al., 2003; Schön, 1983). The second response is that of counter-expertise. This results in a debate in which the various parties provide support for their own claims of truth. Research and policy analysis then acquire the function of policy advocacy (Koppenjan and Klijn, 2004). The ideal analytical-decision maker bases their decision on complete and perfect information. In practice, however, the available information is limited and it is impossible for the decision-maker to take all alternatives, impacts, possible consequences and ends into consideration. There is 'bounded rationality': the decision maker does not have all of the information and his capability to process information is limited (Simon, 1976).

While the analytical approach generates knowledge that can probably withstand the test of scientific validity, it is unlikely to be useful in a multi-actor setting, because no attention is paid to the multi-actor complexity. Multi-actor complexity is the result of the diversity of problem perceptions among the actors involved (Bennett et al., 1989; Rosenhead, 1989; Van de Riet, 2003). As a consequence, the analytical approach risks producing so-called *superfluous knowledge*; this is knowledge which is irrelevant to the policy process. On the other hand, Van de Riet (2003) explains that it is important not to focus too much on the process, as *negotiated nonsense* might be created. This is knowledge which is agreed upon by all actors involved, although it is scientifically invalid. Negotiated nonsense is one of the risks of the participatory decision-making approach. Furthermore, an area of critique is that participatory decision making undermines representative democracy and formal decision-making. Therefore, the democratic accountability and legitimacy of participatory decision-making are being questioned. In the ideal situation, all individuals representing all the important interests in the issue must be at the discussion table. In practice, participation is often selective. This results in interactive processes in which only the key interests and active people are represented (Woltjer, 2000).

2.4.4 Synthesis: Creation of a knowledge base in decision-making processes

At first sight, uncertainty about the problem situation can be reduced by providing more and more relevant or adequate information. However, new information can also increase uncertainty, because it reveals the presence of uncertainties that were presently unknown or understated. Therefore, several knowledge sources are needed to solve a complex problem and 'hard' problem solving (factual and analytic knowledge) needs to be combined with 'soft' actor policy-based design (local and subjective perceptions of actors). All actors develop knowledge relevant to their specific situation. Therefore, knowledge is contextual. We distinguish between two types of knowledge: scientific (or expert) knowledge; and stakeholder knowledge. The role of knowledge differs between the two decision-making approaches. The analytical decision-making approach focuses on reducing uncertainties by information gathering and counter expertise. Thereby it risks creating so-called superfluous knowledge, i.e.

knowledge which is probably scientifically valid, however not useful in a multi-actor setting in which ambiguity is present. On the other hand, participatory decision-making focuses on creating consensus among different actors with the risk of creating negotiated nonsense, i.e. knowledge which is agreed upon by all actors involved, although it is scientifically invalid.

2.5 Actors' perceptions

In this section, we describe the topic of actors' perceptions. First, we explain of what kind of elements perceptions consist. Then the subject of ambiguity is introduced. After that, the role of perceptions in the two different decision-making approaches, described in the previous section, is discussed and preliminary conclusions are drawn.

2.5.1 Elements of actors' perceptions

Actors' perceptions are based on frames or frames of reference. 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 which are 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 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 a actors' strategy (Koppenjan and Klijn, 2004). 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).

Different perceptions can find their origin at several levels. They can originate out of different scientific disciplines, like the social and natural sciences (as explained in Section 1.3.1), or different levels of government within different electoral, scale and responsibility frames. On a higher level, cultural traditions or beliefs can inform different ways of making sense of a situation, as can very personal experiences. In this research, we do not aim to classify or use a classification of actors types and perceptions as is done for instance in 'Cultural Theory' by Douglas (1978) or in the individual frames by Courtney (2001). However, our focus is on what the relevant differences in perceptions are in the specific situation at hand. As Pahl-Wostl et al. (1998) observe: *"…any theoretical framework…is generally considered merely one possible scheme of classification* […] *The value system of people engaged in actual debates are generally agreed to be more hybrid than stereotypes can account for…(Pahl-Wostl et al., 1998)"*

2.5.2 Ambiguity

Ambiguity results from the fact that within a problem situation, various actors are involved. These 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. Ambiguity may result from an overload of information, confusion and knowledge conflicts (Dewulf et al., 2005; Koppenjan and Klijn, 2004; Van Buuren and Edelenbos, 2005).

Weick (1995) defined ambiguity not as a lack of information, but as too many interpretations of a situation. Brugnach et al. (2007) give the following example, a situation of water shortage can be seen as a problem of 'insufficient water supply' for one actor, and one of 'excessive water consumption' for another one. Formulating a problem in a different way will elicit distinct preferences and point towards other solutions. In the first interpretation technical solutions that can help providing more water can be favoured (e.g. building a dam). A decision maker in this situation will be concerned with knowing as best as possible, the amount of water available. However, when the problem is framed as an excessive water consumption issue, other solutions can be favoured, such as to change the way in which water is used and consumed (e.g. change land use). Dewulf et al. (2005) explain that the relevant dimension for ambiguity is not the one from complete knowledge to complete ignorance, but something ranging from unanimous clarity to total confusion caused by too many actors voicing too many different but equally valid interpretations of the situation.

2.5.3 Decision-making approaches

Analytical decision-making assumes that the problem is exclusively of a technical nature (Hoppe, 1999). Therefore, technical experts play a dominant role; the problem is handled as a well-structured problem. However, problems are often more complex as actors have different perceptions and knowledge is uncertain. If parties do not sufficiently consider the fact that they have different problem frames (perceptions), like in the analytical decision-making approach, typical results are knowledge conflicts and asymmetrical debates, i.e. 'dialogues of the deaf' (Koppenjan and Klijn, 2004; Van Eeten, 1999). Information gathering, the use of experts, and conducting research will then prove to be counter-productive: the variety of interpretations and the impasse between the parties is strengthened rather than reduced. This makes solving complex societal problems more than an intellectual design activity aimed at taming uncertainties, it merely is a strategic game in a multi-actor and multi-purpose setting. Only through engaging in interaction will parties gain information and only then will positions and standpoints become clear (Koppenjan and Klijn, 2004). In the analytical decision-making approach, this interaction turns out to be insufficient, as the problem is handled as a technical problem.

Participatory decision-making processes focus explicitly on taking relevant actors and their diverging perceptions into account. As suggested by several authors (Brugnach et al., 2007; Duijn et al., 2003; Pahl-Wostl, 2007a), being explicit about such diversity of views is important because it allows analyzing multiple views on problem situations and discovering more innovative methods of actions than the ones that are usually considered within a single view on the problem, i.e. analytical decision-making. However, the ideals of participation are never fully met in practice. One of the limitations is that it is impossible to achieve complete understanding. No one can know themselves completely, and neither can they clarify their perceptions fully to others. Therefore it is also impossible to completely understand the perceptions of others. Actors may assume understanding, but no matter how complete that understanding may appear to be, there will always be a part of their perception that may influence action in a planning process, while remaining implicit and invisible. This is why it is often difficult for decision-makers to be explicit about the knowledge they use in their decisions (Hillier, 2002; Innes, 1998). Even if complete understanding were possible, this would not presuppose full consensus. In practice, conflict and disagreement is inevitable. Some differences between actors, for example in culture, class and gender, are deeply rooted. To succeed in changing core values and vested interests is usually impossible or at least very difficult (Hillier, 2002; Huxley, 2000).

2.5.4 Synthesis: Development of actors' perceptions in decision-making processes

Actors' perceptions are based on frames, which function as filters through which information or a problematic situation is interpreted. When multiple interdependent users frame issues in very different ways, ambiguity results, i.e. the existence of two or more equally plausible interpretation possibilities. In the analytical decision-making approach, diverging actors' perceptions are usually not sufficiently taken into account, which may lead to knowledge conflicts and 'dialogues of the deaf'. The participatory decision-making approach, on the other hand, explicitly focuses on diverging actors' perceptions. However, the following problems may arise from this approach: complete understanding of perceptions is impossible, conflict and disagreement are inevitable and power distorts the ideal of consensus.

Here is where the literature review part of this Chapter ends. In the next Section, the most relevant parts of this review, for our research topic, are integrated and combined by the author of this thesis. This creates our conceptual model for problem structuring that is used in the next Chapters to analyze our case studies and reflect upon the creation of a knowledge base and the development of actors' perceptions in decision-making.

2.6 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. The formulation of a complex problem 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 (De Bruijn et al., 2002). Therefore, we talk about a problem-solution combination.

In this section, we present our conceptual model for the process of problem structuring, which will be used to analyze two case studies from practice (Chapter 3 and 4) and a third case study, a comparative experiment (Chapter 5). Figure 2.7 shows 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 focus on 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.

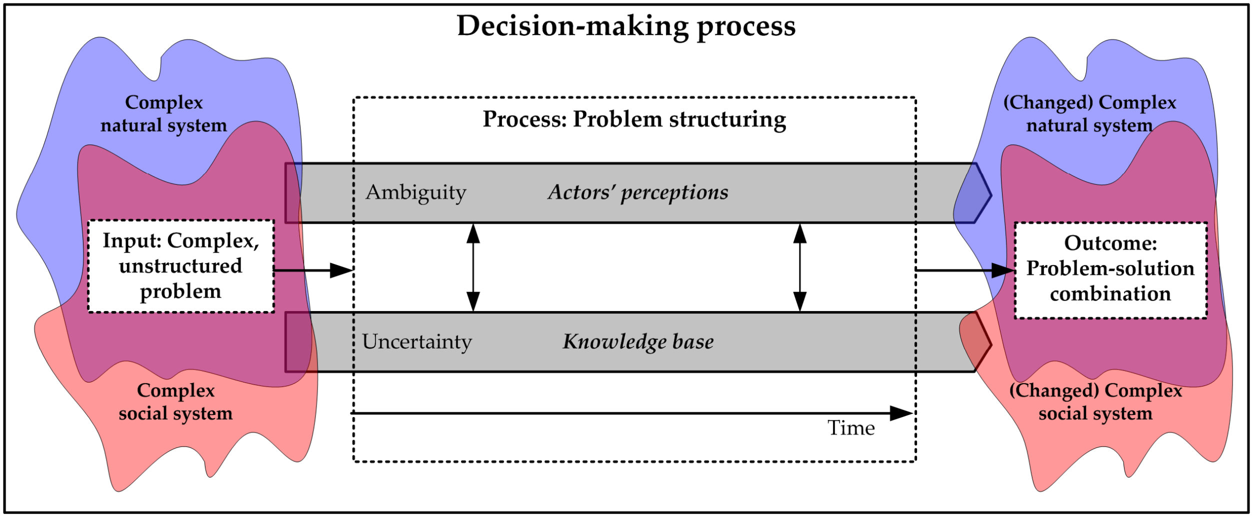

Figure 2.7 – Conceptual model on the input, process and outcome of problem structuring.

2.6.1 Development of actors' perceptions

Actors' perceptions develop and change as a consequence of learning processes. Learning is inevitably connected with *change*. Bateson (1972, cited from: Blackmore, 2007) states that *"…the word 'learning' undoubtedly denotes change of some kind. To say what kind of change is a delicate matter…"*. Notions of learning can be traced back to very early philosophers, psychologists and biologists. Much has been written on theories of learning and knowing. Most of it focuses on individual theories and theorists and what links and differentiates them and on epistemology, the branch of philosophy concerned with the nature of knowledge. There are too many contributors to mention them all here, for an overview of categories of learning theories we refer to Blackmore (2007). One of these theories, we do wish to mention briefly, is *social learning*.

Recently, the concept of social learning has been used and developed extensively in the context of sustainability and integration in the water and environmental domain, within several EU-projects (e.g.: SLIM, HarmoniCOP and NeWater). Key ideas of social learning are that it requires the involvement of and collaboration between actors, learning processes and a form of organization is necessary. Social learning is structured as context, process, outcomes and a feedback loop between outcomes and context, which takes into account structural changes in a cyclic and iterative way. The context includes the governance structure and the natural environment. The process refers to multi-party interactions. These interactions have two major aspects: processing of factual information about a problem (content) and the solving of management problems (process). Similar to the dual nature of the interactions, its outcomes are the implementation of measures to deal with an environmental problem (technical qualities) and the capacity of stakeholders to deal with the problem as well (relational qualities) (Craps, 2003; Mostert et al., 2007; Pahl-Wostl et al., 2007). We will use the experiences from empirical case studies, executed in the framework of social learning projects, to investigate the international value of our research findings (Section 6.3).

After Koppenjan and Klijn (2004), we distinguish two types of learning processes of individuals in a network context: *cognitive* and *strategic* learning. 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. Koppenjan and Klijn (2004) distinguish between two types of cognitive learning: joint image building and goal intertwinement. Joint image building has been accomplished if better insight into the nature of the problem and the consequence of solutions has emerged as a result of interaction and (scientific) research and parties have come to an agreement, i.e. the creation of a common ground to enable mutual adjustment of strategies and joint action. Actors become aware of the divergence of perceptions, because they reflect upon their own perception while taking perceptions of other participants into account. When joint image building does not take place ambiguity continues to exist. Goal intertwinement is regarded as win-win solutions; solutions that can realize the objectives of multiple parties simultaneously.

Besides cognitive learning, actors can learn about the involvement of other parties and mutual dependencies. This learning about social aspects is called strategic learning. Strategic learning is determined by the occurrence of deadlocks, the length and the quality of the process. If blockades and stagnation emerge, then we can conclude that actors are unable to define mutual interest as the basis for mutual action. Breakthroughs indicate that – from a process point of view – actors have progressed and have learned. By definition, blockades and stagnation are not always wrong since they do contribute to the articulation of interests and objectives. They are, in fact, necessary conditions for goal intertwinement (Koppenjan and Klijn, 2004).

2.6.2 Creation of a knowledge base

Actors from both the scientific (or expert) arena and the practical (lay or non-scientific) arena should contribute their knowledge during the process of problem structuring (Figure 2.8). Scientists or experts add (conceptual) models based on scientific or applied research, whereas practitioners add knowledge from experiences. When these two knowledge sources are integrated, e.g. by the process managers, a context-specific knowledge base is created, which can be used to deal with a specific problem. 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). Knowledge questions and conflicts emerging in the first arena are 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, i.e. as assumed in the phase model (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).

To deal with ambiguity actors should not only contribute their knowledge, they should also be stimulated to reflect upon the knowledge base. This enhances that actors learn about the nature, causes and effects of the problem, i.e. cognitive learning. Furthermore, as actors interact with each other, they become aware of their mutual interdependencies and of other actors' perception. Then strategic learning takes place. The strategic and cognitive dimensions of actors are closely related. Therefore, adjustment of cognitions, i.e. cognitive learning, is only possible if actors are confronted with other cognitions. In Figure 2.8, the production of a knowledge base and the related learning processes in a problem structuring process are shown. As a metaphor we state that 'the soup [knowledge base] should boil'.

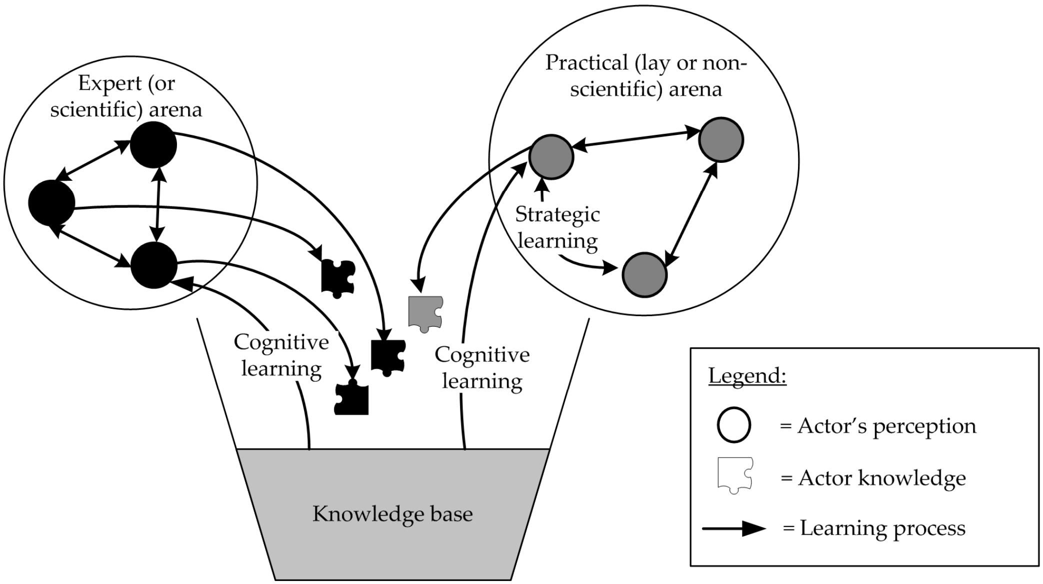

Figure 2.8 – Conceptual model on the creation of a knowledge base and related learning processes

2.6.3 Problem-solution combination

A problem-solution combination, or the joint formulation of the problem and its solutions, is the substantive outcome of a process of problem structuring. It is the result in which various knowledge sources and actors with diverging perceptions are brought together. 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 a *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 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).

2.6.4 Decision-making approaches and the conceptual model

In literature many authors support the point of view that for complex, unstructured problems a participatory decision-making approach should be adopted, which pays attention to participation, interaction, communication and divergent perceptions (e.g.: De Bruijn et al., 2002; Edelenbos et al., 2003). Besides, many authors claim that an analytical decision-making approach, in which the problem is assumed to be exclusively of a technical nature and focuses on single-actor complexity and reducing substantive uncertainty, is inadequate for complex issues (Arentsen et al., 2000; Koppenjan and Klijn, 2004). The analytical decision-making approach, thereby risks producing superfluous knowledge and is not likely to result in a joint problem-solution combination.

In the next Chapters, we will analyze the main elements from our conceptual model, i.e. knowledge base, actors' perceptions and substantive outcomes, in decision-making processes through two case studies from practice and one experimental case study. The first case study (Chapter 3) focuses on the decision-making process for the extension of Mainport Rotterdam. This process can be characterized as an *analytical decision-making process.* The second case study (Chapter 4) focuses on the sustainable development of ecology, economy and society in the Delta region, in the southwest of the Netherlands. This is a typical example of a *participatory decision-making process*. Furthermore, in Chapter 5, the participatory decision-making approach and the analytical decision-making approach will be compared using an experimental case study.

Based on our conceptual model presented in this section, we expect the following results for our case studies. An analytical decision-making approach causes problems with divergent actors' perceptions, because it does not explicitly deal with ambiguity. Therefore, such a process of problem structuring is not likely to result in an agreed upon and valid substantive outcome. A participatory approach, on the other hand, enhances convergence of actors' perceptions by strategic and cognitive learning. Furthermore, it produces negotiated knowledge about the problem-solution combination by integrating different knowledge sources, i.e. expert and practical knowledge.

2.6.5 Limitations of the conceptual model

Process manager

The (role of the) process manager is not explicitly taken into account in our conceptual model. However, process design and -management plays an important role in the creation of an agreed upon and valid problem-solution combination. Since, decision-making processes are very dynamic, process management should first of all be adaptive. Adaptive management refers to systematic process for continually improving management policies and practices by learning from the outcomes of implemented management strategies (Pahl-Wostl, 2007b). This conclusion can also be drawn from the results of the comparison of six other participatory processes in the Netherlands (Edelenbos and Klijn, 2005b). 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).

Dynamics and external developments

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. These external influences are not explicitly accounted for in the conceptual model. 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.

Institutional uncertainty and power issues

Institutional elements are not explicitly included in the conceptual model. Complex, unstructured problems do not only involve many actors, but these actors also work from different institutional backgrounds, this causes so-called institutional uncertainty. Institutional uncertainty is the uncertainty which results from the fact that unstructured problems often cut across the existing demarcations between organizations, administrative levels and networks. In water management issues different sectors and thus Ministries are involved, e.g. Ministry of Transport, Public Works and Water Management (V&W), Ministry of Spatial planning, Housing and the Environment (VROM) and Ministry of Agriculture, Nature and Food Quality (LNV), and different governmental layers - international, national, regional -, different types of actors (power issues). This might result in institutional uncertainty due to lack of communication or authority issues.

Institutional uncertainty emerges from closedness of networks and institutional complexity. Because of fixed interaction patterns (i.e. rules and resources), largely shared perceptions and all sorts of implicit rules, networks can become inaccessible to other actors. It is evident that closedness of networks has consequences for interactions in the networks and policy processes between them. If actors cannot gain access, their interests are not represented. 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. Related with institutional elements is the issue of power, i.e. realization or hindrance power (Koppenjan and Klijn, 2004). Finally, the implications of problem structuring processes for formal decision-making (administrative and politics) are outside the scope of our conceptual framework. We will discuss the consequences of these limitations in Section 6.3.

2.7 Synthesis

In this Chapter, we presented a literature review on the characteristics of complex water management problems and policy and decision-making for these problems. Furthermore, literature on (the creation of a) knowledge base and (the development of) actors' perceptions in decision-making processes was investigated. Finally, the most relevant parts of this literature review were poured into a conceptual model for problem structuring. This model will be used to analyze the case studies presented in the next three Chapters.

3 Case study 1: Extension of Mainport Rotterdam[4]

Abstract

The Dutch government wants to expand Mainport Rotterdam, one of the largest ports in the world, by land reclamation in the North Sea. This may affect the Wadden Sea, a unique wetlands area protected by the European Bird and Habitat Directives. To assess the impact of the port extension on the Wadden Sea, an Appropriate Assessment procedure was carried out. We investigated how actors' perceptions were dealt with and how knowledge was used in this decision-making process. Our findings form an argument for practitioners in coastal management to choose a process-oriented approach to deal with complex issues.

3.1 Introduction

Rotterdam was established as a fishing village at the western coast of The Netherlands in the second half of the 13th century. The village gradually developed into a prosperous merchant port. The first harbours were constructed at the beginning of the 17th century. The area began to fill up with warehouses, breweries, sugar refineries, gin distilleries, shipyards and ropeyards. Following the setting up of the United East India Company (VOC), trade and shipping rapidly increased. Nowadays, Mainport Rotterdam is one of the largest ports in the world. The most important activities of the port take place approximately 40 kilometres from the centre of Rotterdam on reclaimed land in the North Sea. In the 1990s, the Dutch government started a project to strengthen the port's position on the world market by expanding the reclaimed land area further into the North Sea. However, growth of the Mainport is not the only issue at stake, since the economic function fulfilled by Mainport Rotterdam puts pressure on the environment. Additionally, the port and industries with their associated living, working and infrastructure requirements make a large demand on the available space in the Rotterdam region.

[4] This Chapter is also published as: Hommes, S., Hulscher, S.J.M.H., Mulder, J.P.M., Otter, H.S., and Bressers, J.T.A. (2008a). "Role of perceptions and knowledge in the impact assessment for the extension of Mainport Rotterdam" *Marine Policy*, available online, doi:10.1016/j.marpol.2008.05.006.

Furthermore, the expansion of the port, by means of land reclamation and associated sand dredging, affects other marine and coastal users such as the recreational and fishing sectors.

The extension of Mainport Rotterdam is an example of a complex coastal and marine management issue. Decision-makers involved in these complex issues have to deal with ecological effects, physical effects, economic costs and benefits, and technical feasibility. On top of that, they operate within a complex web of policy, regulations, social and political processes. Therefore, complex management issues can not be handled as purely technical problems. Several Dutch authors state that for these kind of complex issues a process-oriented approach should be adopted, which pays attention to differences in actors' perceptions, and to interaction and communication (De Bruijn et al., 2002; Edelenbos et al., 2003; Grin and Hoppe, 1999; Klijn and Koppenjan, 1997; Koppenjan and Klijn, 2004). However, in practice the analytical decision-making approach is still commonly used. It rests on the assumption that a central actor formulates objectives and solves problems in relative autonomy; that a problem can be solved analytically (Koppenjan and Klijn, 2004; Rhodes, 1997; Scharpf, 1997; Teisman, 2000; Van de Riet, 2003). Therefore, this approach is not adequate for dealing with complex management issues, in which knowledge is uncertain and ambiguous and actors' perceptions diverge. Many authors support this view; however, very few of their papers (e.g: Denters et al., 2003; Edelenbos and Klijn, 2005b; e.g: Grin and Hoppe, 1999; Van Bueren et al., 2003; Wiering and Driessen, 2001) are based on empiricism. Empiricism is therefore what we aim for in the present thesis, thus providing a stronger theoretical basis for management practice in complex coastal and marine management issues.

In this Chapter, we focus on the decision-making process for the extension of Mainport Rotterdam. We examine a specific part of this decision-making process as a case study: the studies for the impact of the port extension on a protected nature area. We investigate whether this process can be characterized as an analytical decision-making process. Furthermore, we analyze how actors' perceptions are dealt with and how knowledge is used. This Chapter is organized as follows. In Section 3.2, the theoretical framework is presented, focusing on the following aspects: analytical decision-making, types of problems, actors' perceptions and use of knowledge. Section 3.3 describes the case study on the decision-making process for the extension of Mainport Rotterdam. In Section 3.4, the case study results are analyzed by using the theoretical framework from Section 3.2. Section 3.5 discusses the shift, in coastal and marine management, from analytical decision-making towards process-oriented decision-making.

Finally, in Section 3.6, conclusions on the decision-making process of Mainport Rotterdam and the role of actors' perceptions and knowledge in this process are drawn.

3.2 Theoretical framework

3.2.1 Analytical decision-making

Analytical decision-making refers to the approach that originates from system analysis. This approach arose after World War II when policy makers embraced the analytical approach of operations research, as a result of the successes it achieved in military issues during the war (Quade, 1989). The analytical decision-making approach aims to support decision-making on the basis of (scientific) knowledge. Therefore, the solution is sought in acquiring more knowledge and data on the basis of (policy analytical) research (Arentsen et al., 2000; Koppenjan and Klijn, 2004; Twaalfhoven, 1999). A key concept of this approach is *rationality*. Decision-making should be rational and be supported by rational analysis. Crucial to the achievement of analytical outcomes is *objectivity*. This means that knowledge should be gathered about reality as it is and that facts should be separated from subjective and normative insights, theories and prejudices; the 'fact-value dichotomy' (Hawkesworth, 1988). Thus, in this approach, a policy problem is perceived to be of a technical nature (Hoppe, 1999).

The process of the analytical decision-making approach can be conceptualized by the phase model (Figure 3.1). The phase model describes a decision-making process as subsequent phases with a clear beginning and end (Koppenjan and Klijn, 2004). A process starts with the definition of problems and goals, and the identification of constraints and criteria. Based on this, an assessment (or evaluation) framework is constructed. Next, alternatives are designed and assessed using the assessment framework, and compared with each other. A decision is made and the solution is implemented (1994; Miser and Quade, 1985; Parsons, 1995).

Some authors criticize the phase model. Sabatier (Sabatier, 1991; Sabatier, 1999) states that it is not a causal theory since it never identifies a set of causal drivers that govern the process within and across phases. Instead, work within each phase has tended to develop on its own, almost totally without reference to research in the other phases. In addition, without causal drivers there can be no coherent set of hypotheses within and across stages. Furthermore, according to Sabatier (1999), the phase model oversimplifies the usual process of multiple, interacting cycles. Also, Deleon (1999) who in principle defends the phase model as being a useful heuristic tool, criticizes the normative usage of the phase model. He states that each specific phase of the process is executed by a different set of actors and that thereby, the process in its entirety is neglected. Besides that, the phase model implies a certain linearity as opposed to a series of feedback actions or recursive loops (e.g. the assessment of alternative solutions can lead back to problem definition rather than to the next phase) that characterize the policy process (Deleon, 1999). Finally, the phase model rests on the assumption that a problem can be solved analytically and that a central actor formulates objectives and solves problems in relative autonomy (Koppenjan and Klijn, 2004; Rhodes, 1997; Scharpf, 1997; Teisman, 2000; Van de Riet, 2003). Therefore, this approach is not adequate for dealing with complex unstructured problems, for which the available knowledge is uncertain and the actors' perceptions diverge. In the following sections, we will explain these aspects.

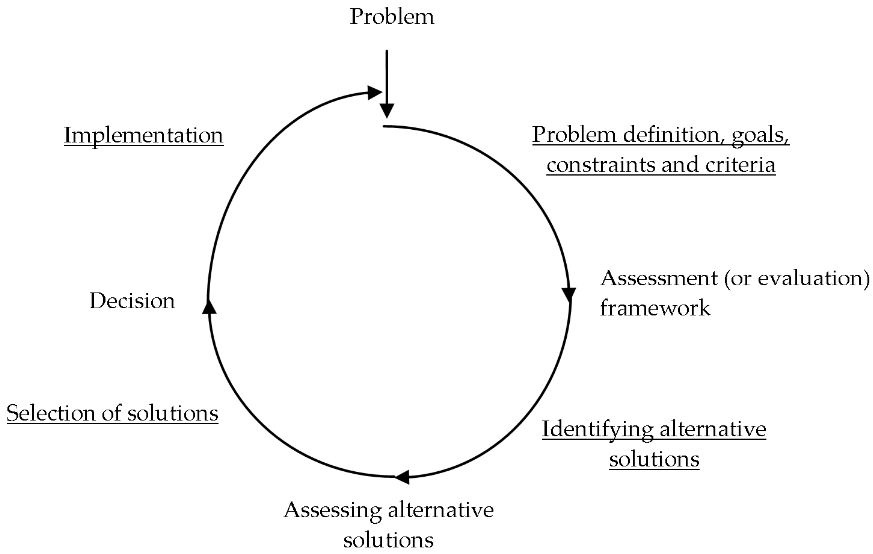

Figure 3.1 (= Figure 2.5) - Phase model, underlined terms represent processes (adapted after: Koppenjan and Klijn, 2004; Parsons, 1995).

3.2.2 Types of problems

A problem occurs when a factual situation is in discrepancy with a desired situation. This implies that a problem always consists of normative and factual/empirical elements. Therefore, problems cannot be regarded as objective givens, but should be regarded as highly subjective social constructs (Dery, 1984; Hisschemöller, 1993; Van de Graaf and Hoppe, 1996). When this subjectivity is taken into account, two dimensions can be used to distinguish between different policy problems (Figure 3.2). The first dimension is consensus about values and norms (normative standards). The other dimension relates to the certainty of the knowledge base or content. By using these two dimensions, four types of policy problems emerge. Well structured problems (type 1) are problems for which a certain knowledge base and consensus about values and norms (normative standards) exist. Some problems are moderately structured because of disagreement about values and norms (type 2) or because knowledge is uncertain (type 3). When objectives are at stake and knowledge is uncertain, a problem is unstructured (type 4) (Douglas and Wildavsky, 1982; Van de Graaf and Hoppe, 1996).

Knowledge base → **Values and norms ↓**	**Certain**	**Uncertain**
Consensus	**1. Well structured** Knowledge use: Instrumental & Data	**2. Moderately structured** Knowledge use: Strategic & Argument
Disagreement	**3. Moderately structured** Knowledge use: Conceptual	**4. Unstructured** Knowledge use: Enlightment

Figure 3.2 (≈ Figure 2.1) - Classification of policy problems and use of knowledge (adapted after: Hisschemöller, 1993; adapted after: Van de Graaf and Hoppe, 1996)

Figure 3.2 shows that the way knowledge is used differs by problem type. Experts play a dominant role in well structured problems and take on the role of problem solver. In this case, policy is highly expert-driven (Turnhout, 2003). In moderately structured problems (type 2) consensus exists on values and norms, but as the knowledge base is uncertain it is not clear which means and knowledge should be used to solve the problem. Therefore, the use of knowledge is strategic. Willingly or unwillingly, knowledge becomes part of the debate, as the different sides tend to strengthen their position by the use of scientific arguments. In moderately structured problems with disagreement on values and norms (type 3), knowledge can accommodate the policy process. In the case of unstructured problems, knowledge can play a role as problem signaller. In doing that, knowledge takes the shape of ideas and can be used as enlightenment (Boogerd, 2005; Hisschemöller et al., 1998; Turnhout, 2003).

3.2.3 Actors' perceptions

Dealing with complex societal problems takes place in an arena in which mutually dependent actors mould and shape problem definitions and solutions. If parties do not sufficiently consider the fact that they have different problem frames, typical results are knowledge conflicts and asymmetrical debates ('dialogues of the deaf') (Koppenjan and Klijn, 2004; Van Eeten, 1999). Information gathering, the use of experts, and conducting research will then prove to be counter-productive: the variety of interpretations and the impasse between the parties is strengthened rather than reduced (Koppenjan and Klijn, 2004). Thus, solving complex societal problems is not only an intellectual design activity aimed at taming substantive uncertainties, but also a strategic game in a multi-actor and multi-purpose setting. Only through engaging in interaction will parties gain information and only then will positions and standpoints become clear (Koppenjan and Klijn, 2004). In the analytical decision-making approach, this interaction turns out to be insufficient, as the problem is handled as a technical problem.

Finally, one can distinguish single-actor and multi-actor complexity. Single-actor complexity arises on the one hand from fuzzy objectives and on the other hand from system complexity and uncertainty about the effects of solutions (Koppenjan, 1990; Van de Riet, 2003; Van Heffen, 1993). Multi-actor complexity is the result of the diversity of problem perceptions among the actors involved (Bennett et al., 1989; Rosenhead, 1989; Van de Riet, 2003). Van de Riet (2003) claims that the analytical approach focuses on the requirements that single-actor complexity puts on decision-making. While this generates knowledge that can probably withstand the test of scientific validity, it is unlikely to be useful in a multi-actor setting, because no attention is paid to the multi-actor complexity. As a consequence, the analytical approach risks producing so-called *superfluous knowledge*.

3.2.4 Use of knowledge

In dealing with complex problems, actors are confronted with *substantive uncertainty* (Koppenjan and Klijn, 2004): uncertainty of problem definition and policy response (Arentsen et al., 2000). One major source of uncertainty has to do with the difficulty the actors experience in determining the nature of the problem, due to lack of information about the input (problem definition), output (policy response) and causal relations. Often, crucial information or knowledge is lacking or not instantly available. However, the problem is not only the lack of information and knowledge, but that it is ambiguous and contested as well (Edelenbos et al., 2003; Koppenjan and Klijn, 2004). Koppenjan and Klijn (2004) and Arentsen et al. (Arentsen et al., 2000) describe two types of responses to substantive uncertainty in analytical decision-making. The first response is information gathering, using expert knowledge and (scientific) research, and sorting things out before taking steps. *"…The assumption behind this reaction to uncertainty is that of neo-positivism: that scientific research into causal relations will lead to objective knowledge about the nature of the problem, the background causes, the possible interventions and their consequences* […] *In this neo-positivist vision, science is separate from other societal domains such as government and the market, and is presumed to produce true, objective and universal knowledge…(Koppenjan and Klijn, 2004)."* However, 'facts' are the product of definitions and principles, influenced by people's view of the world, their so-called conceptual orientations, perceptions, mental maps and frames (see e.g.: Edelenbos et al., 2003; Schön, 1983). The second response is that of counter-expertise. This results in a debate in which the various parties provide support for their own claims of truth. Research and policy analysis then acquire the function of policy advocacy (Koppenjan and Klijn, 2004).

Analytical decision-making assumes that the problem is exclusively of a technical nature (Hoppe, 1999). Therefore, technical experts play a dominant role; the problem is handled as a well-structured problem. However, problems are often more complex; because actors have different norms and values (there is no consensus) and knowledge is uncertain or ambiguous (Koppenjan and Klijn, 2004). Thus, problems are more often moderately structured or unstructured. The latter types of problems imply a different usage of knowledge than is common in analytical decision-making.

In the next sections, a comparison is made between the theoretical framework and observations in the practice of Mainport Rotterdam.

3.3 Decision-making process for the extension of Mainport Rotterdam

3.3.1 Background

Mainport Rotterdam is located in the Southwest of The Netherlands (Figure 3.3). The Dutch government wants to extend the port by 2000 hectares (approximately 3 x 8 km) land reclamation in the North Sea, aiming to strengthen the port's position. Simultaneously, the government wishes to increase the quality of the region's living environment. This is achieved by more intensive utilization of space and the existing port and industrial area, improvement of the quality of the living environment in the Rotterdam area and by creating a 750-hectare wildlife and recreational area near Rotterdam.

In our case study, we only focus on the seaward extension of Mainport Rotterdam. This land reclamation is located in the Voordelta, which is a protected (Natura 2000) site. To compensate for the negative effects on the local ecology, a marine protected area of 31,250 hectares will be established in the vicinity of the new reclaimed land. Figure 3.4 shows the extension of Mainport Rotterdam and the location of the marine protected area (Website Ministry of Transport Public Works and Water Management, 2007). The key measures to be taken in the protected area are termination of fishing that disturbs the seabed, fishing with stationary nets and snares, and mineral extraction, along with regulation and zoning of recreational activities (Project Mainport Rotterdam, 2001).

The decision process for the extension of Mainport Rotterdam took place by means of a Core Planning Decision-plus (CPD+). A CDP+ is a spatial plan formulated by the government. It contains so-called specific policy decisions, which are binding for lower authorities (i.e. provinces, municipalities). The CPD+ procedure for Mainport Rotterdam started in 1998 and ended with the government's position on the project in 2006. The aspects included in the CPD+ were the following: the location and scope of the land reclamation; the area within which sand dredging for the land reclamation may take place; possible locations for compensating natural resources lost through land reclamation (marine protected area); the location(s) and layout of a 750-hectare wildlife and recreational area. Furthermore, for several of the activities from the CPD+, an Environmental Impact Assessment (EIA) procedure was followed. The EIA describes the various projects' effects on wildlife, recreation and the natural environment (Ministerie van V&W, 2001).

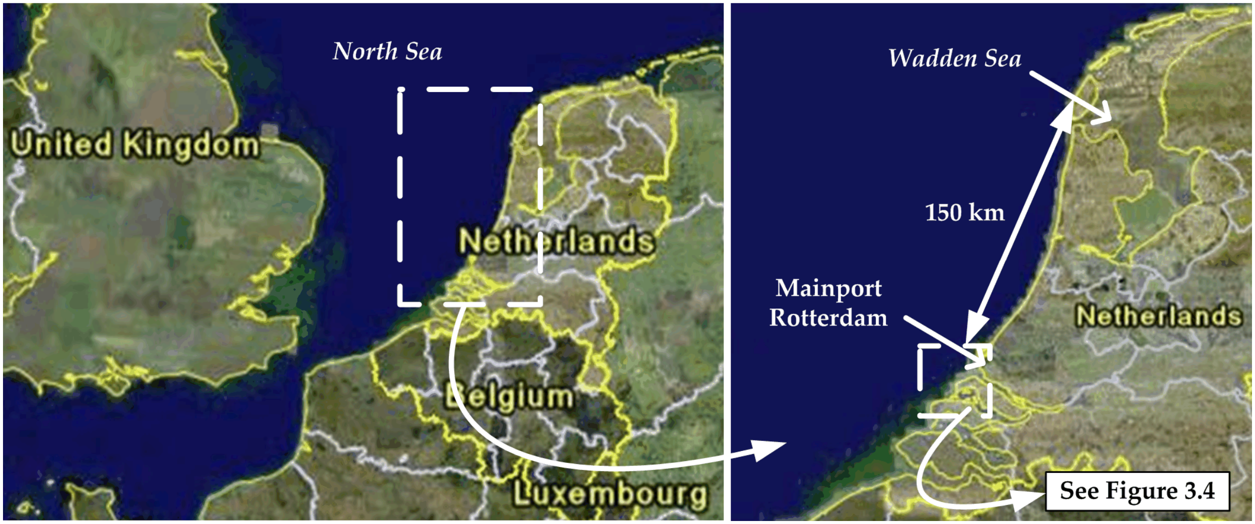

Figure 3.3 - Location of Mainport Rotterdam and the Wadden Sea, in The Netherlands (Google Earth)

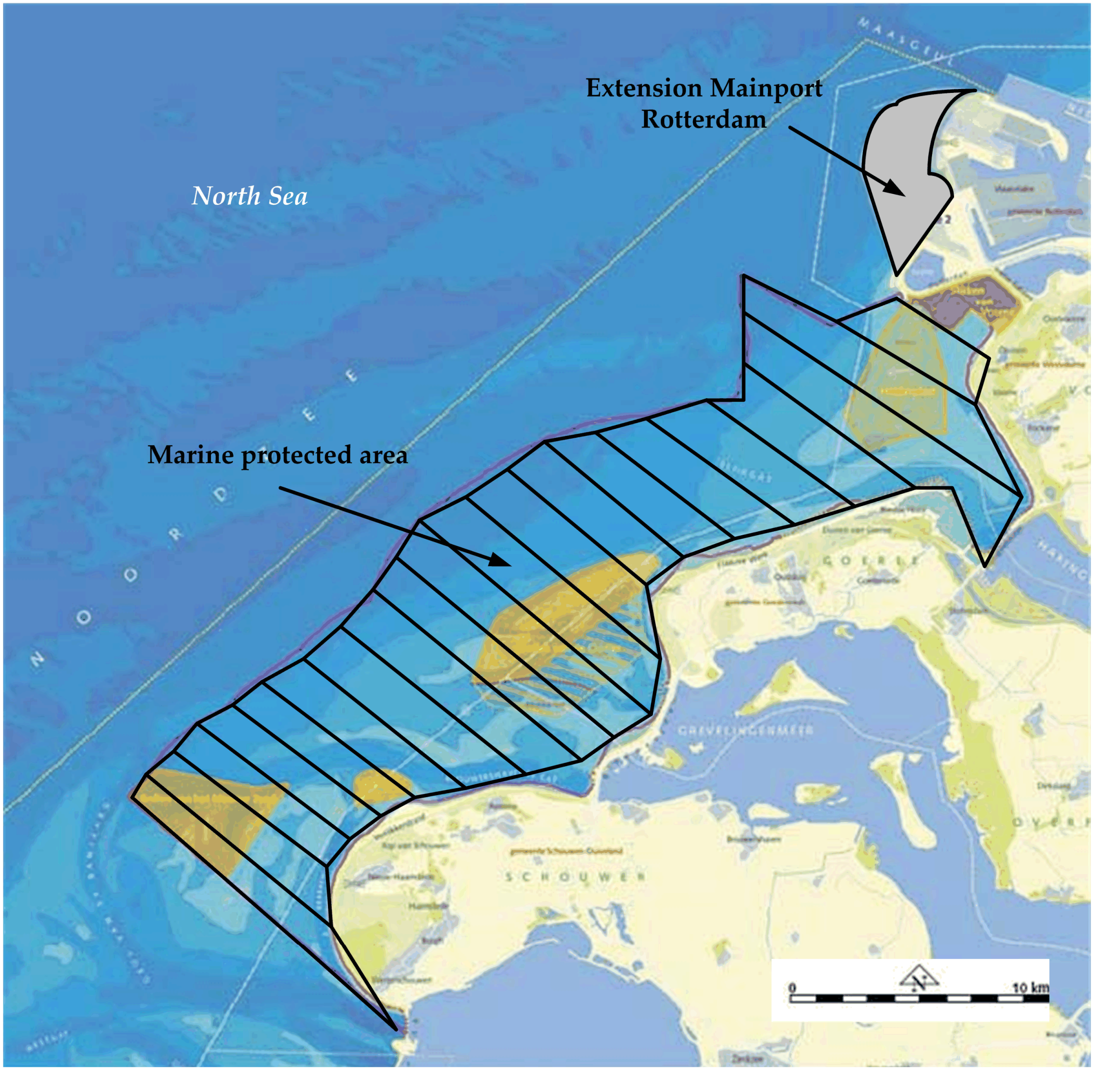

Figure 3.4 - Extension of Mainport Rotterdam and location of marine protected area (Website Ministry V& W, visited on 31 August 2007)

The CPD+ for the extension of Mainport Rotterdam was open for public participation. In 2004, a number of objections to the CPD+ were filed at the Council of State[5]. One of the objectors was the Dutch Fish Product Board[6]. They claimed that, in the CPD+, the effects on fish larvae and mud transport to the Wadden Sea were not sufficiently investigated, as should have been done according to the Habitats Directive. The Wadden Sea is a wetlands area along the North Sea coasts of The Netherlands, Germany and Denmark. The Dutch part of the Wadden Sea consists of an area of approximately 2500 km^2. It is situated between the North Sea and the mainland, approximately 150 kilometres north of Mainport Rotterdam (Figure 3.3), and is sheltered by barrier islands. The Wadden Sea is a highly dynamic ecosystem with tidal channels, sands, mud flats, salt marshes, beaches and dunes. An important aspect of the Wadden Sea is the tidal flats that emerge during low tide and cover about two thirds of the tidal area. The variety in transitional zones between land, sea and freshwater environment is the basis for high species-richness. The Wadden Sea has a rich bottom-living fauna and is therefore an important nursery for many species of fish and crustaceans. Furthermore, it is an important feeding and resting area for many species of coastal and migrant birds (De Jonge et al., 1993; Imeson and van den Bergh, 2006; Turnhout, 2003; Van Berkel and Revier, 1991). For these reasons, a large part of the Dutch, German and Danish Wadden Sea has been designated as a wetland of international importance (Van Berkel and Revier, 1991; Verbeeten, 1999) and is protected by the European Bird and Habitat Directives. Furthermore, the responsible ministries of The Netherlands, Denmark and Germany have been working together on the protection and conservation of the Wadden Sea within the Trilateral Wadden Sea Cooperation since 1978 (Website of The Trilateral Wadden Sea Cooperation, 2008).

In January 2005, the Council of State judged that the objections by the Dutch Fish Product Board were valid. Furthermore, the Council of State judged that a so-called Appropriate Assessment procedure had to be carried out, to investigate the impact of the extension of Mainport Rotterdam on the integrity of the Wadden Sea area. This procedure had not been carried out before. The Council of State stated that it was possible that further research on changes in mud and fish larvae transport could give more insight

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[5] The Department of Administrative Law of the Council of State forms the highest general administrative judge of the Netherlands. This department administers justice in matters of dispute between citizens and government.
[6] Website Dutch Fish Product Board: http://www.pvis.nl

into the impact of the extension of Mainport Rotterdam on the protected Wadden Sea. Due to the Council's decision, the extension of Mainport Rotterdam has become less certain. Therefore, part of the revision of the CPD+ was to perform an Appropriate Assessment procedure and the related investigations (Raad van State, 2005).

The objective of an Appropriate Assessment procedure is to assess whether there will be adverse effects on the integrity of the relevant Natura 2000 area, in this case the Wadden Sea, as defined by the so-called conservation objectives (European Commission, 2001). For the Wadden Sea area, the (provisional) conservation objectives are as follows: *"The policy and management* [...] *are focused on the sustainable protection and development of the Wadden Sea as a nature area, in which human influence is minimized, and on maintaining or restoring a favourable state of preservation for the structures, species, plants and animals that are designated for protection under the Bird and Habitat Directives for the Wadden Sea. To achieve this, the policy and management are focused on carrying out as naturally as possible the sustainable protection and development of* [...] *hydrological processes, water quality, soil and air, and also of the (soil) flora and fauna, including the foraging, breeding and resting areas of birds…(Harte et al., 2005)"*

The Appropriate Assessment Wadden Sea forms the basis for the case study in the present Chapter.

3.3.2 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 was to sketch a picture that does justice to the complex relation between all factors. Consequently, the phenomenon and its context are 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).

From April to November 2005, the research team participated in the decision-making process for the extension of Mainport Rotterdam (project Appropriate Assessment Wadden Sea). We had this opportunity because one member of the research team is employed at the government and introduced us to the project leader. The project leader agreed to let us participate in the project, after we shared the research questions and methodology. The research method that is used in our case study is called *ethnography*. Hammersley and Atkinson (Hammersley and Atkinson, 1995) describe the methodology of ethnography as *"…the ethnographer participating, overtly or covertly, in people's daily lives for an extended period of time, watching what happens, listening to what is said, asking questions – in fact, collecting whatever data are available to throw light on the issues that are the focus of the research …(Hammersley and Atkinson, 1995)"*

Ethnographic research has two suggested forms of validation: respondent validation and triangulation (Seale, 1998). We used the first type, validation, by giving the respondents the opportunity to comment on the interview reports. The second method, triangulation, is to compare different kinds of data from different sources to see whether they corroborate one another (Seale, 1998). In our case study, we used three kinds of data to ensure triangulation of our findings:

- Observations: direct and participant observations[7] (from four expert workshops, a final conference and ten project meetings)
- Text analysis: project documents and news reports
- Interviews: the research team conducted thirteen semi-structured in-depth interviews with ten participants of the project (from October 2005 to August 2007).

3.3.3 Process description: Appropriate Assessment Wadden Sea

The government[8] and the Port of Rotterdam worked together on the Appropriate Assessment Wadden Sea because they were both 'problem owner'. The Port of Rotterdam is responsible for the EIA and the government is responsible for the CPD+. Both are necessary to ensure the possibility of extension of Mainport Rotterdam. The Port of Rotterdam and the government commissioned a consortium for the investigations in the context of the Appropriate Assessment. The investigations took place in three parallel tracks. The government chose to run these tracks simultaneously, because the Dutch Parliament set a time limit of 7 months for the Appropriate Assessment.[9]

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[7] Participant-observation is a special mode of observation in which the researcher is not merely a passive observer (like in direct observations), but may actually participate in the events being studied (Yin, 2003).

[8] Represented by the National Institute for Coastal and Marine Management (RIKZ)

[9] Kamerstuk 2004-2005, 24691, no. 59, Tweede Kamer 22 April 2005

The tracks were as follows:

- Model calculations (track-1): effects (of the extension of Mainport Rotterdam) on mud, nutrients and fish larvae transport to the Wadden Sea were predicted by using models.
- Expert judgment (track-2): possible effects on species and habitats were determined by expert judgment.
- Final assessment (track-3): effects were assessed using the results of track-1, track-2, historical data analysis, and audit and actor meetings.

Model calculations (track-1)

In track-1, the effects of the extension of Mainport Rotterdam on the Wadden Sea were predicted by using computational models. The objectives of the model calculations were to quantify changes in mud concentrations and fluxes; transport of nutrients and primary production; and larvae transport of herring, plaice and sole (De Jong et al., 2005). These effects were predicted starting at the intervention in the water system (the extension of Mainport Rotterdam). In this approach, several models are used; Figure 3.5 shows the relationships between these models[10].

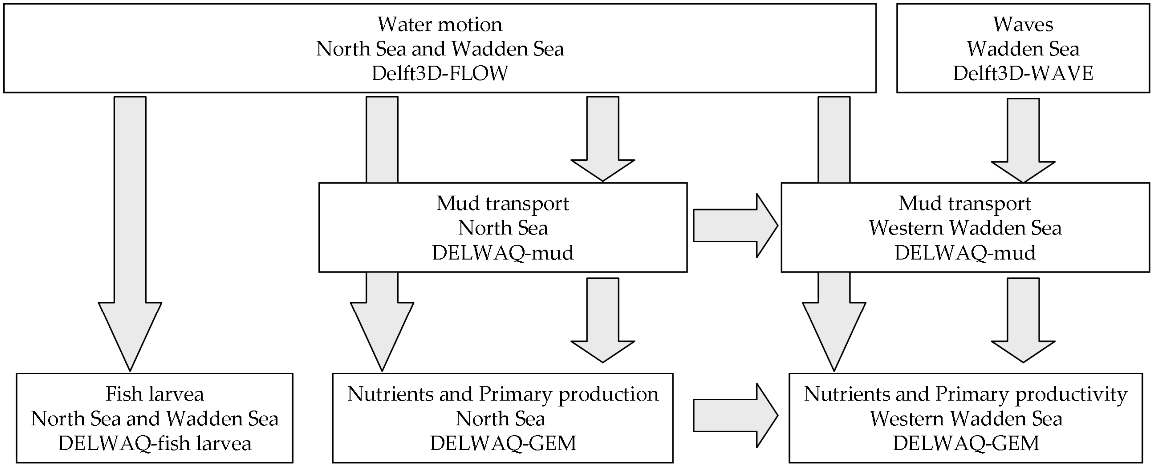

Figure 3.5 - Models and relationships (Van Ledden, 2005): each block lists subject, location and model

[10] For more information on the models see the website of WL|Delft Hydraulics: www.wldelft.nl

Expert judgment (track-2)

In track-2, the effects on species and habitats were estimated by judgment of ecological experts. Starting from protected species and habitats, a reflection was made to non-biological parameters that might be influenced by the extension of Mainport Rotterdam. Based on assumptions of changes in these parameters (nutrients and mud), attention was focused on species and habitats for which effects were expected. The ecological experts were consulted in three workshops. Furthermore, after a request from some of the ecological experts, an ecosystem model (EcoWasp, developed by Alterra[11]) for the Wadden Sea was used.[12] With this model, several scenarios for changes in mud and nutrients based on model results from the earlier performed Flyland study[13], were run to calculate the effect on ecological parameters.[14] These parameters were used as input for the expert workshops. In track-1, another model (DELWAQ-GEM, developed by WL|Delft Hydraulics[15]) was used to calculate the ecological parameters, but the results from this model were not yet available at the time the ecological expert workshop took place.[10]

The assessment framework of track-2 consisted of the following objective and criteria (Heinis et al., 2005). The objective was to determine the *significance of the impact* of the extension of Mainport Rotterdam on the favourable state of conservation. This was a sum of the following three criteria:

- Criterion 1: *extent of impact*, determined by the assessment of intervention-impact chains by expert judgment;
- Criterion 2: *conservation status of the species*, a reference value based on the Wadden Sea Area Birds Directive Assessment Framework (LNV DRZ-Noord 2005, in: Heinis et al., 2005);

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[11] Research institute of the Wageningen University and Research Centre concern, website Alterra: http://www.alterra.wur.nl/

[12] Minutes track-2 workshop, 19 May 2005

[13] Research program (1998-2003), initiated by the Dutch government, on the possibilities of placing Schiphol Airport on an artificial island in the North Sea. For more information on the Flyland studies see: Van der Kleij et al. (2003).

[14] Interview track-2 leader (consortium), 21 June 2006

[15] WL|Delft Hydraulics is a GTI, an officially-recognised technological institute (Dutch: Groot Technologisch Instituut). It is a non-profit foundation under Dutch law. Website WL|Delft Hydraulics: http://www.wldelft.nl/

- Criterion 3: *proportion of the population that is affected*, is determined by the proportion of the biogeographical population that stays in the Wadden Sea.

In the expert judgment track, the significance of the impact on species and habitats was assessed by using this assessment framework. The assessment showed that *"…under the 'basic scenario'* [based on Flyland results] *four* [bird] *species are subject to possibly significant negative impacts from the reduction in nutrient contents associated with the presence of the extension of Mainport Rotterdam...(Heinis et al., 2005)"*

Final assessment (track-3)

Besides these two research tracks, several other activities were initiated by the government to support the final assessment. This is what we call the final assessment track. Two analyses were performed by government experts using historical data. One analysis focused on the eutrophication state of the Wadden Sea and the other analysis investigated sedimentation in the Wadden Sea. Long-term records were used to investigate whether changes in eutrophication state and sedimentation in the Wadden Sea could be related to human interventions along the Dutch coast, such as the Delta Works and the first seaward extension of Mainport Rotterdam. Furthermore, the government requested an international audit panel to check the scientific underpinning and the consistent use of scientific results in the Appropriate Assessment Wadden Sea. The communication with the stakeholders was organized separately from the research investigations, in three stakeholder meetings.

The Assessment Framework for the final assessment by the government consisted of two linked objectives, which were derived from the conservation objectives (see Section 3.3.1) and defined as follows (Harte et al., 2005; Project Mainport Rotterdam, 2006):

- Objective 1: Boundary conditions for dynamic processes that guarantee the existence of the natural relationship between species and habitats are not limited;
- Objective 2: Continued existence of protected species and habitats is guaranteed.

The final assessment was as follows: with regard to objective 1, the conclusion was that *"…the land reclamation* [the extension of Mainport Rotterdam] *will have a very limited impact on the dynamic processes, which are responsible for the existence of the natural relationship between species and habitats…(Project Mainport Rotterdam, 2006)"* With regard to objective 2, the conclusion was that *"...the land reclamation could have an* *effect on four bird species* [as concluded by expert judgment]; *however this effect is not significant. Therefore, the conservation status of protected species and habitats will not be influenced negatively by the land reclamation…(Project Mainport Rotterdam, 2006)"* Thus, the government concluded that the extension of Mainport Rotterdam will not have a significant effect on the integrity of the Wadden Sea.

3.4 Analysis

3.4.1 Decision-making process

In the Appropriate Assessment Wadden Sea both standard responses, use of expert knowledge/research and counter-expertise, to deal with substantive uncertainty in analytical decision-making (Arentsen et al., 2000; Koppenjan and Klijn, 2004) can be recognized. The Appropriate Assessment Wadden Sea was a large research project (budget approximately 2.5 million dollars) in which many investigations were carried out and much information was gathered. The used methods were model calculations (track-1), expert judgment (track-2), historical analyses (track-3) and audit and actor meetings (track-3). Also, counter-expertise was used in the Appropriate Assessment Wadden Sea. First, the ecological model EcoWasp (Alterra) was used as counter-expertise for the ecological model DELWAQ-GEM (WL|Delft Hydraulics). Second, the historical analyses on nutrients and sediment transport were used as counter-expertise for the model calculations in track-1 on nutrients and mud transport. In Hommes et al. (2007), it is argued that for complex management issues a parallel modelling approach is significantly more helpful in addressing management questions than a single modelling approach. For the Appropriate Assessment Wadden Sea, this would imply that model calculations (track-1), expert judgment (track-2), historical analyses (track-3) and audit and actor meetings (track-3) should have been used to answer different management questions. This way, it would have been possible to address more management questions effectively in comparison with using them as counter-expertise.

The case study shows that the solution of the problem is sought in acquiring more knowledge, indicating that the problem is handled as a purely technical problem, which can be solved by rational analysis. There is no discussion on, for example, the underlying model-assumptions. These assumptions are based on values rather than on facts (this might not be recognized by the model experts). By not discussing the values, the model outcomes are presented as facts. This is a typical characteristic of analytical decision-making.

The process of the Appropriate Assessment Wadden Sea is roughly divided into the following phases:

1. The problem and goal were defined in respectively the judgment of the Council of State and the conservation objectives.
2. The effects of the extension of Mainport Rotterdam on the Wadden Sea were investigated in three research tracks.
3. An assessment framework was formulated by the government.
4. The effects were assessed by the government, using the results of the research tracks.
5. The results of the Appropriate Assessment Wadden Sea formed the input for the revision process of the CPD+.

These are all sequential phases with a clear beginning and end. Furthermore, the government defined and solved the problem; a central steering actor. This is similar to the phase model.

In the literature (Sabatier, 1991; Sabatier, 1999), it is criticized that the phase model does not identify a set of causal drivers that govern the process within and across phases. In the case study, the communication between track-1 (model calculations) and track-2 (expert judgment) took place via the track leaders of the consortium. However, it was not possible to make adjustments in the model calculations (track-1). A project member of the consortium remarked that there was little room for changes, due to the combination of short time period and a heavy methodology: *"…a tanker that went in a certain direction…"*[16] was the metaphor he used to explain this. For example, when in the track-2 workshop the remark was made that from an ecological point of view, the year that was used for validation of the models in track-1 was inappropriate, it was not possible to adjust this because the model calculations had already been done.[17] We observed that there is no causality between different phases as the work within each research track tended to develop on its own and no repeating, interacting cycles

[16] Interview project member WL|Delft Hydraulics, 14 February 2006

[17] Interview track-1 leader (consortium), 31 July 2006

were incorporated. This is also illustrated by the fact that some knowledge, e.g. on mud transport to the Wadden Sea, that was brought up in the actor meetings was not included in the investigations.[18]

Next, it is criticized in the literature (Deleon, 1999) that the phase model implies a certain linearity as opposed to a series of feedback actions or recursive loops that characterize the policy process. In the Appropriate Assessment Wadden Sea, we observed that the track-2 leader claimed that at the time, the effects calculated in track-1 proved to be less strong than assumed in track-2, the whole expert judgment reasoning should have been repeated, but was not.[19] Thus, linearity in the process was applied, whereas the outcomes of the model calculations (track-1) in fact lead to a change in the input of the expert judgment (track-2). Finally, it is claimed in the literature (Deleon, 1999) that each specific phase of the process is executed by a different set of actors and that thereby, the process in its entirety is neglected. In the Appropriate Assessment Wadden Sea, the consortium had the task of determining the effects of the extension of Mainport Rotterdam on the Wadden Sea whereas the government carried out the assessment of the effects.[20] This separation of responsibilities was seen positively by the government participants.[21] However, the track-2 leader of the consortium claimed that *"…the scientists should have the feeling that they would have formulated the assessment in the same way; they must agree on the conclusions and this was not the case."*[22] Also, the track-1 leader remarked that *"…as the government has a stake in the extension of Mainport Rotterdam* [different caps], *one could argue that the assessment should have been done by an independent party; e.g. the consortium."*[23]

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[18] Interview Dutch Fish Product Board, 7 August 2007; Minutes actor meeting 15 July 2005 and 26 September 2005, Heinis et al. (2005), Project Mainport Rotterdam (2006) and Van Ledden (2005)
[19] Interview track-2 leader (consortium), 21 June 2006
[20] Interview project leader RIKZ, 13 March 2006
[21] Interview project member RIKZ, 22 November 2005
[22] Interview track-2 leader (consortium), 21 June 2006
[23] Interview track-1 leader (consortium), 31 July 2006

3.4.2 Actors' perceptions

The formal problem perception of the objector, the Dutch Fish Product Board was made explicit in its claim to the CPD+. The Board claimed that the effects on fish larvae and mud transport to the Wadden Sea had not been sufficiently investigated, as should have been done according to the Habitats Directive. However, during an interview with the Dutch Fish Product Board, we observed that its (implicit) problem perception is actually wider than that. Firstly, the Dutch Fish Product Board was not satisfied with the decision-making process, because it was not allowed to participate in the negotiations with the minister at the time the project had just started (in the 1990s).[24] Secondly, the Dutch Fish Product Board was concerned about income losses, due to the loss of fishing area where the extension of the Mainport Rotterdam (3000 hectares) is envisaged and especially where the marine protected area (31,250 hectares) is planned. Finally, as it was not actively involved in the decision-making process, no (financial) compensation was arranged for the fishing industry until its objection to the CPD+ in 2005.[25] From these remarks, we concluded that the implicit problem perception of the Dutch Fish Product Board is *socio-economic*.

The problem perception by the government and of the Port of Rotterdam is that, by the invalidation of the CPD+, the extension of Mainport Rotterdam is no longer ensured by legal means. Thus, they perceive it as a *procedural* problem. Furthermore, project members from the government and the parties that executed the Appropriate Assessment Wadden Sea had the feeling that they must 'work on the edge of what is possible' to investigate the effects of the extension of Mainport Rotterdam on the Wadden Sea. According to them, the problem was that there was not sufficient knowledge on the effects; they perceived the problem as a *technical* problem. Therefore, the investigations did not focus on the implicit socio-economical problem of the objector, the Dutch Fish Product Board. Thus, the problem of the objector is not addressed or eliminated by these technical investigations. Finally, as the diverging actors' perceptions were not taken into account, we can conclude that the knowledge that is produced is an example of *superfluous knowledge*.

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[24] Interview Dutch Fish Product Board, 7 August 2007

[25] Idem

3.4.3 Use of knowledge

Regarding the use of knowledge, we found that there was no agreement on the argumentation for the final assessment. The project leader from the government stated that the results from the expert judgment (track-2) form a worst-case scenario and that the model results from track-1 are used to 'tune' these worst-case conclusions.[26] However, the track-2 leader claimed that at the time the effects calculated in track-1 proved to be less strong than assumed in the expert judgment, the whole track-2 argumentation should have been redone. Nevertheless, the government, to the contrary, claimed that *"…the effects are less* [than assumed in track-2]*, thus the effects are not significant"*.[27] Furthermore, the track-2 leader states that: *"…too many other things* [historical analyses; policy developments] *were used as arguments to formulate the assessment. These arguments were not well* [scientifically] *underpinned and were not audited. This way the research results from track-1 and 2 are undermined. And it is a shame for the goodwill that was obtained from the scientists* [participants in expert workshops, track-2]*, as they now have the feeling that the government does what it wants and does not really listen to them…"*[28]

In short, the ecological experts (in track-2) claim that the final assessment should have been a scientific one. This is probably because the government asked the experts in track-2 to give a non-normative/ objective assessment of the effects on species and habitats.[29] Thereby, the government made sure that the experts would handle the problem as a well-structured problem. The experts were assumed not to be actors in the process. However, in the final assessment the government used the knowledge (from track-1 and 2) in a strategic way; thus the problem was handled as a moderately structured (type 2) problem (see Figure 3.2). This caused that both parties look upon the use of knowledge in the final assessment differently. Also, the Netherlands Commission for Environmental Assessment concluded that from the reports it is not clear of the final assessment is agreed upon by all experts (Commissie voor de M.E.R., 2006).

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[26] Interview project leader RIKZ, 13 March 2006
[27] Interview track-2 leader (consortium), 21 June 2006
[28] Idem
[29] Minutes track-2 workshop, 19 May 2005

As for actors that were not directly involved in the investigations, the Wadden Sea Society[30] finds the conclusion of the Appropriate Assessment Wadden Sea too definite, as the models that are used are not validated and the effects are uncertain. The North Sea Foundation[31] reacted that the sand extraction could also have a direct effect, which is not taken into account in the investigations. The Fish Product Board states that the conclusion that the effects on mud are not significant, is subjective (Ministerie van Verkeer en Waterstaat, 2006).

3.5 Discussion

Several authors argue that the analytical decision-making approach, in which a central actor formulates objectives and solves problems in relative autonomy, is inadequate for complex management issues. Instead, a process-oriented approach is needed to deal with, in our case, the complex marine and coastal management issues at hand. These process-oriented approaches for decision-making can be found in the literature and are also referred to as process management (e.g.: De Bruijn et al., 2002), network management (e.g.: Koppenjan and Klijn, 2004), co-management (e.g.: Suárez de Vivero et al., 2008), pluri-centric approach (e.g.: Teisman, 1992), social learning (e.g.: HarmoniCOP, 2005), interactive/ participatory policy making (e.g.: Edelenbos, 2000; Edelenbos and Klijn, 2005b) and integrated assessment (see e.g.: Rotmans, 1998; Rotmans and Van Asselt, 2001; Van Asselt, 2000).

In The Netherlands and in a wide variety of other European countries, governments are experimenting with process-oriented, participatory decision-making processes on all kind of policy domains (Edelenbos and Klijn, 2005a). This development is related to the recognition that governments alone do not determine societal developments, but that these developments are shaped by many actors. A so-called network society where public and private actors are mutually dependent, because resources are fragmented (Teisman, 2000), is not governed at one level, but by multiple actors, at multiple levels, with multiple instruments and multiple resources (Bressers et al., 2004; Rhodes, 1997; Sabatier and Jenkins-

[30] An environmental NGO promoting the protection and sustainable use of the Wadden Sea area, Website Wadden Sea Society: www.waddenvereniging.nl

[31] Dutch environmental NGO that stands up for the North Sea, Website North Sea Foundation: www.noordzee.nl

Smith, 1993; Scharpf, 1997). From a network or multi-actor perspective, a decision is formed through interactions between interdependent actors with their own perspectives and strategies (Teisman, 2000).

The recognition of a network society is also visible in the field of coastal and marine management. In The Netherlands, in the mid 1980s, a change became visible from a sectored approach to integrated coastal and marine management which takes all the elements of the coastal and marine system into account. Presently, the trend to interactive/participatory coastal and marine management is visible. This management approach states that managers are in continuous interaction with the coastal and marine system and with various actors in society (Van Ast, 1999). This shows that marine and coastal management is indeed shifting from analytical decision-making to interactive/ participatory decision-making.

3.6 Conclusions

This Chapter is a case study of the decision-making process for the extension of Mainport Rotterdam. We focused on the studies for the impact of the port extension on a protected nature area (the Appropriate Assessment Wadden Sea). We found that this process can be characterized as an analytical decision-making process as:

- The problem was perceived to be of a technical nature and was solved based on rationality and objectivity.
- The two standard responses (information gathering and counter-expertise) to deal with substantive uncertainty in analytical decision-making were observed.
- The phase model and the criticism on it were recognized.

We analyzed how actors' perceptions were dealt with and how knowledge was used.

The Dutch Fish Product Board objected to the extension of Mainport Rotterdam. This was their formal problem perception, which is based on ecological and procedural grounds. However, their implicit problem perception is a wider; socio-economic problem (not satisfied with the decision-making process, concerned about income losses, due to the loss of fishing area, no (financial) compensation was arranged for the fishing industry). Nevertheless, the parties that executed the Appropriate Assessment Wadden Sea perceived the problem to be procedural and technical. Thus, the investigations only focused on the formal problem perceptions of the objector, not taking into account the implicit socio-economical problem of the objector. Therefore, the socio-economic problem of the Dutch Fish Product Board was not eliminated by these technical investigations. We conclude that the investigations focused on single-actor complexity and reducing uncertainty in the knowledge base. This resulted in a valid, context-specific knowledge base. However, the diverging actors' perceptions (multi-actor complexity) were not addressed in the investigations. Thus, the knowledge that was produced is an example of *superfluous knowledge*.

Furthermore, with regard to the use of knowledge, we conclude that the ecological experts treated the problem as a well-structured problem, whereas the government treated it as a moderately structured problem. We also conclude that the government used the knowledge that was generated in the research tracks in a strategic way. This resulted in a lack of consensus on the use of knowledge in the final assessment, among the ecological experts as well as actors that were not directly involved in the investigations.

4 CASE STUDY 2: SUSTAINABLE DEVELOPMENT OF THE DELTA-REGION[32]

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 Chapter 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 Chapter. 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 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

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[32] Also published as: Hommes, S., Vinke-De Kruijf, J., Otter, H.S., Bouma, G. (2008c), Knowledge and perceptions in participatory policy processes: Lessons from the Delta-region in The Netherlands, *Water Resources Management*, available online, DOI 10.1007/s11269-008-9345-6.

water resources management to adopt a problem structuring approach in order to deal explicitly with uncertainty and ambiguity.

4.1 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., 2004b, 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 Chapter 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. (2008a), 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, 2007b). Many authors support this point of view. However, very few of their papers (e.g.: Denters et al., 2003; Edelenbos and Klijn, 2005b; Grin and Hoppe, 1999; Van Bueren et al., 2003; Wiering and Driessen, 2001) are based on empiricism. In this thesis, 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 Chapter is organized as follows. In Section 4.2, 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 4.3 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 4.4, this case study is described. In Section 4.5, the case study is analyzed on the core variables from the conceptual model. Finally, the results are discussed in Section 4.6 and conclusions on actors' perceptions and knowledge in participatory processes are drawn in Section 4.7.

4.2 Theoretical framework

4.2.1 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 (Figure 4.1). 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 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).

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

Figure 4.1 (≈ Figure 2.1) – Classification of policy problems (adapted after: 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, 2005b)*" 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 Chapter, 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.

4.2.2 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 4.2 shows 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 Chapter. 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).

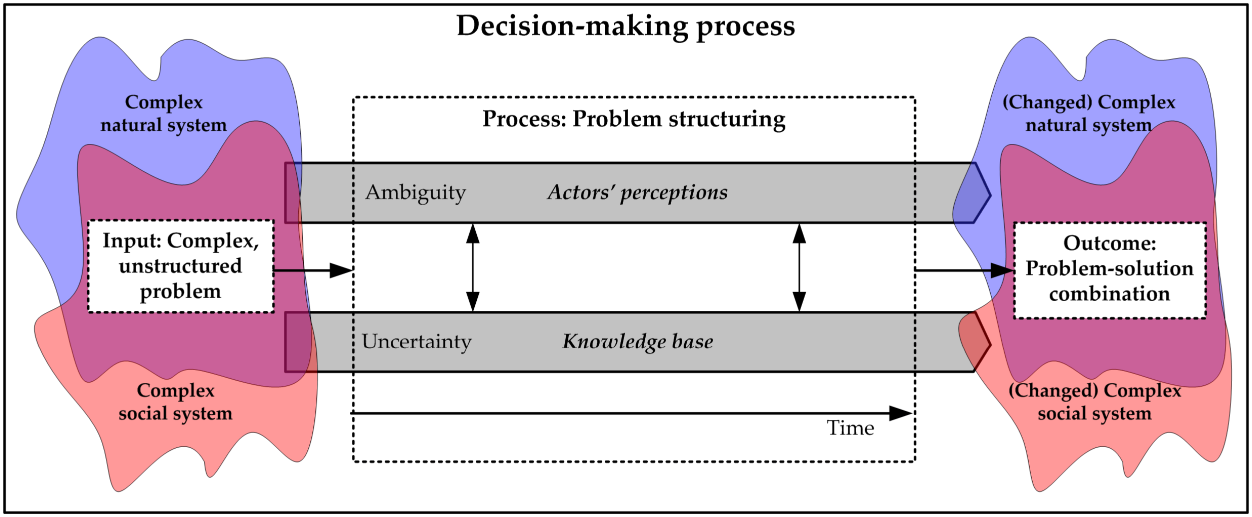

Figure 4.2 (= Figure 2.7) – Conceptual model on the input, process and outcome of problem structuring.

4.2.3 Knowledge base

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 Figure 4.2). 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…(Mitroff, 1983)*". 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).

4.2.4 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).[33] 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 4.3 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.

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

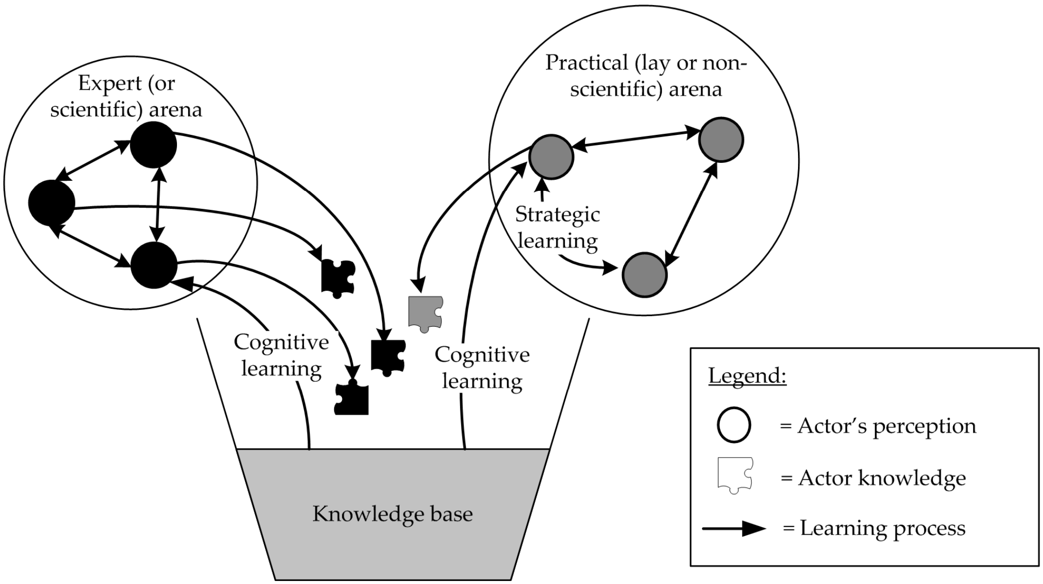

Figure 4.3 (= Figure 2.8) – Conceptual model on the creation of a knowledge base and related learning processes

4.2.5 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 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).

4.3 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.

4.3.1 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., 2008a) 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. <u>Observations:</u> from plenary workshops and group meetings, experiences from process managers;
2. <u>Written material:</u> 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. <u>Interviews:</u> with several participating actors, carried out before and after the discussion; reports and observations.

4.3.2 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 Chapter, 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.

4.3.3 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 4.6.

4.4 Decision-making process for sustainable development of the Delta-region

4.4.1 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 (Figure 4.4). 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., 2004b). 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.

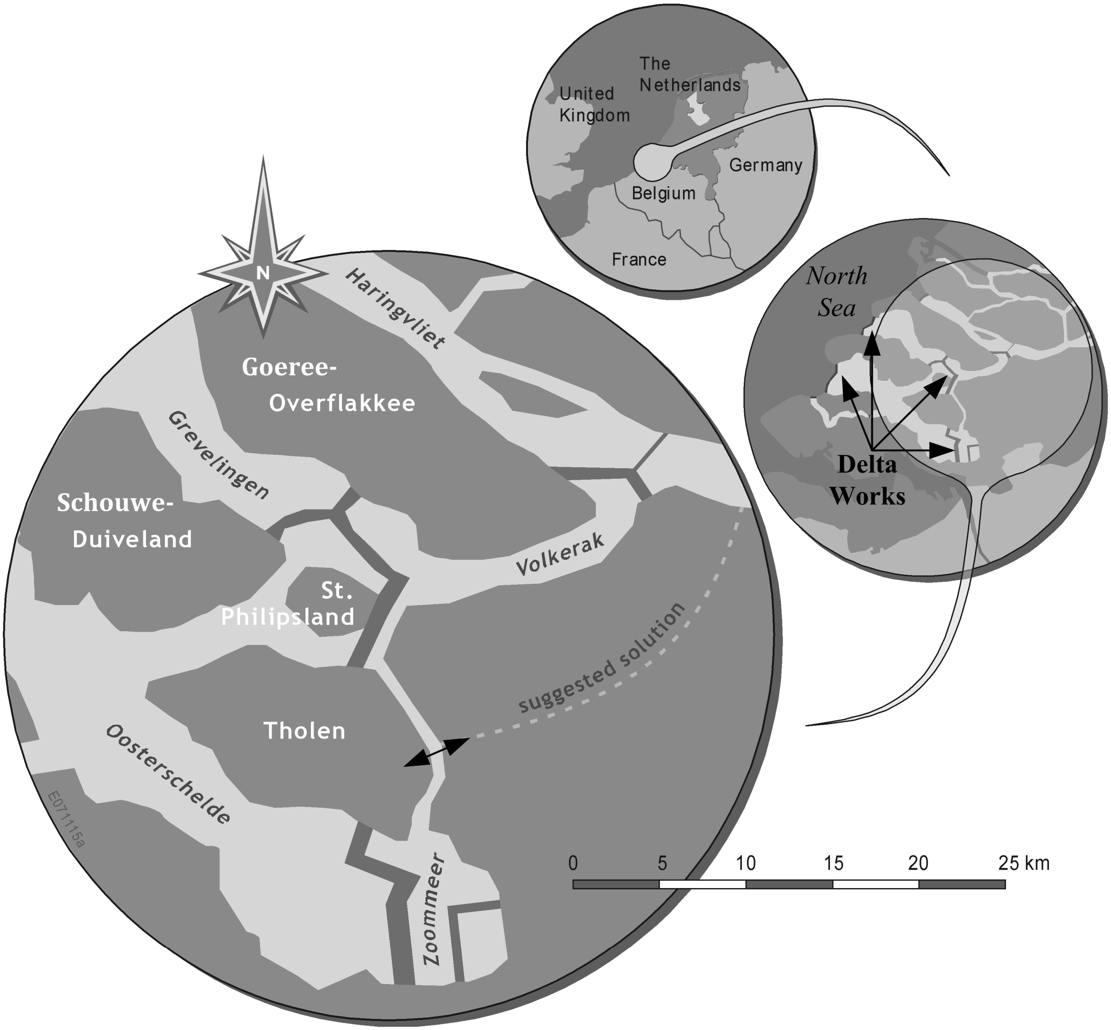

Figure 4.4 – Location of the case study. In the figure the Delta Works, the Volkerak-Zoommeer (VZ-lake), the islands of Tholen and St. Philipsland and the suggested solution (pipeline) are shown.

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[34]. This consortium advised the Delta Council to distribute the discussion 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 (Figure 4.4). 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 Chapter.

4.4.2 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*…”[35] Participating actors in the fundamental discussion were (representatives from): local farmers; an agricultural interest organization; agricultural

[34] The consortium consisted 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)
[35] Minutes Kick-off meeting, May 31, 2006 (in Dutch, translated by: J. Vinke-De Kruijf)

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.

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).

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.

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:

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

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.

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.

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.

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 Figure 4.4). 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.

4.5 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.

4.5.1 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…(Eshuis and Stuiver, 2005)*". 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 (Figure 4.3), 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).

4.5.2 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.

4.5.3 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 (Figure 4.3).

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).

4.6 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, 2007b). The importance of adaptive process management draws from the results of the comparison of six other participatory processes in the

Netherlands (Edelenbos and Klijn, 2005b) 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 4.5.1).

4.7 Conclusions

This Chapter 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 Chapter. 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.

5 CASE STUDY 3: COMPARATIVE EXPERIMENT ON DECISION-MAKING APPROACHES

Abstract

This Chapter describes a case study on a comparative experiment between two decision-making processes, i.e. a participatory and an analytical process. This comparative experiment was carried out within the framework of a multidisciplinary design project for Civil Engineering Bachelor-students of the University of Twente. The aim of this case study is to determine how a decision-making approach influences the creation of a knowledge base, the development of actors' perceptions and the substantive outcomes. It was found that the substantive outcomes of the analytical decision-making approach were not agreed upon by the relevant actors, as they did not represent the relevant actors' perceptions. On the other hand, the substantive outcomes of the participatory approach are an example of a *joint problem-solution combination*. We conclude that this resulted from *strategic learning*.

5.1 Introduction

The case study presented in this Chapter focuses on a comparison between two decision-making processes, i.e. a participatory and an analytical process. From literature and our two previous case studies on Mainport Rotterdam (Chapter 3) and the Delta-region (Chapter 4), we found that the kind of decision-making process influences the knowledge base, actors' perceptions and the substantive outcomes. However, as every decision-making process is unique, it is difficult to compare results from different case studies. Therefore, the aim of this case study is to make such a comparison using two decision-making processes, which focus on the same problem situation. This comparative experiment was carried out within the framework of a multidisciplinary design project for Civil Engineering Bachelor-students of the University of Twente. The students' design project focuses on the extension of Schiphol Airport, the biggest airport in the Netherlands, on an island in the North Sea. For the comparative analysis of the two decision-making processes, we will focus on the main elements from our conceptual model (Section 2.6): knowledge base; actors' perceptions; and substantive outcomes.

The outline of this Chapter is as follows. In Section 5.2, the case study methodology for the comparative experiment is described. In Section 5.3, the two decision-making processes within the students' design project are presented. Next, we analyze these two processes in Section 5.4. In Section 5.5, the external validity of the experimental setup is discussed. Finally, conclusions on the decision-making processes, actors' perceptions, knowledge base and substantive outcomes are drawn in Section 5.6.

5.2 Case study methodology

In this Section, first some methodological background on the characteristics of experiments and quasi-experimentation is given. In Section 5.2.2, we will explain the formation and characteristics of groups used in the experiment. Then, the two decision-making approaches, which are given to each project team in the form of a corporate identity, are described in Section 5.2.3. Last, Section 5.2.4 describes how the case study observations were gathered.

5.2.1 Experiments and quasi-experiments

The setup of this case study is similar to an experiment. An experiment in its purest form, which is also called a laboratory experiment is characterized by Verschuren and Doorewaard (2000):

1. The formation of (at least) two groups, an experimental group, and a control group;
2. A random assignment of participants or research objects to either group, which is called randomizing;
3. The researcher determines which group is subjected to the intervention and what happens further within the groups;
4. The researcher makes sure that there are as few external influences as possible;
5. In addition to an ex-post measurement, an ex-ante measurement is carried out before the intervention takes place.

The first requirement is the formation of (at least) two groups, an experimental group, and a control group. In a laboratory experiment the control group receives no influencing factor; in our experimental setup it is given another influencing factor (i.e. decision-making approach). This means that the first condition is not completely satisfied. However, as our analysis focuses on the relative differences between the two decision-making approaches, this does not influence the validity of the experiment. The second condition is the random assignment of participants to either group. Through randomization, two groups are created that are as identical as possible. In our experiment, the students are divided into project teams by the experiment leader. The following stratification was used in this division: women are equally divided over the groups; and friends are separated, so within project teams no one knows each other closely. This is what is called 'matching' (Verschuren and Doorewaard, 2000). Although this is not a fully random division, we argue that the group characteristics are in principle identical.

The third condition states that the researcher determines which group is subjected to the intervention and what happens further within the groups. This condition is met as the teams were divided into two types, i.e. analytical and participatory, by the experiment leader. And the content of the intervention – the corporate identities and the different workshops – was also determined by the experiment leader. The fourth condition for an experiment is that the experiment leader ensures that there are as few possible external influences. This way, cause and effect are known, as well as the relationship between them. In our comparative experiment, project teams from different decision-making approaches could have influenced each other by discussing their results, etc. This was mitigated by: informing the students at the start of the project that they were participating in an experiment; organizing separate workshops for each group; stressing that the final products resulting from the two approaches can be different. Therefore, we can assume that the two approaches did not influence each other significantly. The last prerequisite states that in addition to an ex-post measurement, an ex-ante measurement should be carried out before the intervention takes place. The measurements that are executed in this experiment are measurements during the experiment ('ex-durante') and ex-post measurements, no ex-ante measurements where included. This is not done because we aim to measure the (decision-making) *process*, thus not the change in characteristics of the objects (students).

The advantage of an experiment is its high degree of internal validity. Internal validity indicates the certainty of the causal link that is found. In experiments, this causal link is explicitly known, which means a high degree of internal validity. A disadvantage of the experiment is the external validity of the results. External validity refers to the domain in which a study's findings can be generalized (Yin, 2003). In experiments, the context in which the experiment is conducted is artificially created in order to minimize the influence of that context. Thus it can be questioned as to what degree the findings of the experiment represent daily life (Verschuren and Doorewaard, 2000). Quasi-experimentation aspires to approximate the 'experimental method', usually in settings where 'full experimentation control' is not possible because researchers are trying to identify the consequences of social changes in naturalistic contexts. The drive to generalize research results to naturalistic settings precludes use of laboratory experiments (Cook and Campbell, 1986). A quasi-experiment is a class of experiments in which one or more of the five conditions described above is not (completely) satisfied. A causal interpretation in this case has less internal validity. However, these experiments are usually more lifelike, which improves the external validity of the results (Verschuren and Doorewaard, 2000). In the experiment that is used in this research, the setup is indeed slightly different from a laboratory experiment, i.e. not all conditions described above are met. Therefore, it is an example of a quasi-experiment. Cook and Campbell (1979) describe that *"…all* [quasi] *experiments involve at least a treatment, an outcome measure, units of assignment and some comparison form which change can be inferred and hopefully attributed to the treatment…(Cook and Campbell, 1979)"* In our experiment, the treatment is formed by the decision-making process that the students will follow; this will be described in Section 5.3. The outcome measures are: knowledge base; actors' perceptions and problem-solution combination. The units of assignment are formed by the groups of students, i.e. the project teams. Finally, the comparison is made between the two decision-making processes.

5.2.2 Formation and characteristics of groups

The multidisciplinary design project, which is used as a framework for the comparative experiment, was a third year Bachelor course of the program in Civil Engineering. The Civil Engineering Bachelor program at the University of Twente aims at inclusion of technical as well as non-technical aspects, and combining them. Therefore, the students also focus on business and public administrative subjects, besides the technical subjects in the field of construction, infrastructure and water systems. The learning objective of this course in particular was an integrated problem approach, in which general design frames were translated in specialist actions (e.g. formulating requirements, making a design). Furthermore, knowledge of several subjects, such as infrastructure, water, finances, should be integrated into an overall design.

In the multidisciplinary design project of this comparative experiment, a total amount of 29 students participated. Halfway, one of the students had to quit the project, so in the end there were 28 students left. The project lasted for eight weeks, from February 2008 until April 2008. Each student was supposed to spend 28 hours each week on the project. All participants had the same education, i.e. Civil Engineering, and were approximately in the third year of the Bachelor program. The students worked in a project team of four or five people. This means that six project teams were created: four teams of five people, two teams of four people. The students were divided into project teams by the experiment leader[36]. Furthermore, at the start of the project the experiment leader informed the students that they were divided into two types of teams for the purpose of research. We also let them know that the aim of the research was to compare the different decision-making processes. It was stressed that the aim is not to find out which approach gives 'better' results, as this might create bias for one of the approaches. Finally, all project teams received an identical assignment, that is described in a 'start-note' (Hommes et al., 2008b). During the multidisciplinary design project three parallel workshops were conducted; separate for the analytical and the participatory decision-making process. These workshops took place in the first, second and fifth week of the project. The content of the assignment and the different workshops, which was determined by the experiment leader, is described in Section 5.3.

5.2.3 Decision-making approaches and corporate identities

The project teams had the role of a professional consultancy, who executes a project for a client. And the teams were required to work according to a corporate identity. The experiment leader divided the project teams into two types, both groups consisted of three project teams. The A(nalytical)-teams[37] worked according to the corporate identity of *analytical decision-making*[38]. The corporate identity that the students received is based on the characteristics described in Section 2.3.1. The corporate identity for the analytical decision-making approach describes that "…*the technical contents of spatial development projects, such as the*

[36] The author of this thesis, S. Hommes, was the leader of the experiment.

[37] Further on we will refer to specific project teams. A1 to A3 followed the analytical approach and P1 to P3 followed the participatory approach.

[38] In the students' description of the corporate identity, the term 'planning-oriented' (in Dutch: planmatig) is used, because this has a neutral connotation.

extension of Schiphol Airport, deserves much attention. Therefore knowledge is a central issue. [...] *Furthermore, steering of the client, in this case Province of Noord-Holland, is essential. The preferences of different actors also play a role, so the technical design is presented to actors for consultation at the end of a project. Designs are made with knowledge from different disciplines (e.g.: water, infrastructure, finances). Multidisciplinarity is most important in our projects...*"[39]

The P(articipatory)-teams were required to work according to the corporate identity of *participatory decision-making*. This corporate identity that the students received is based on the characteristics described in Section 2.3.3. It expresses that "*…not the technical content* […but…] *process management is most important for spatial development projects.* [...] *Therefore, relevant actors are co-producing, in our projects. Furthermore, openness and flexibility in the problem formulation is essential. This way the problem perceptions of different actors can be taken into account and it is possible to anticipate on external changes.* […] *The most important aim is to create consensus, from which cooperation of all actors is created…*"[40]

5.2.4 Observations on the comparative experiment

The following observations were done during the comparative experiment and are used in the analysis (Section 5.4):

- Workshop observations; during the workshops the experiment leader and a second facilitator observed and made notes on several points, e.g. the group process and content of the group discussions.
- Logbooks and process reports; Each project team filled out a logbook at the end of each project week. In these logbooks questions were answered on: the group process, progress of the project, information that was used, how the corporate identity was used and a mark (and argumentation) for the project week was given. At the end of the multidisciplinary design project, a process report was handed in by each team. This is an evaluation of the group process, and represented more or less an

[39] Planning-oriented corporate identity, handed to A-teams at the first workshop, formulated and translated by: S. Hommes.

[40] Participatory corporate identity, handed to P-teams at the first workshop, formulated and translated by: S. Hommes.

overview of all the logbooks that were filled out.

- Products; During the process the project teams handed in three products: a) Product I: Action plan; b) Product II: SWOT-analysis and alternative strategies; c) Final product: Growth strategy for Schiphol Airport on an island in the North Sea. Furthermore, after each strategic planning workshop each project team handed in a brief report on the results of their workshop.
- Questionnaires; Two individual questionnaires were done during the comparative experiment. The first was done halfway of the project and focused on: how the corporate identity was experienced, how the provided information was appreciated and how the progress was evaluated. The response on this questionnaire was 97% (28 out of 29 students[41]). In the second questionnaire the respondent (students, teachers and actors) was asked to give a grade for the presentation and the poster on the growth strategy and to mention expected difficulties and strong points of the proposed growth strategy. These questionnaires were used in the analysis of the case study. The response on this questionnaire was 100% (28 students, 3 actors and 6 teachers).
- Interviews; The P-teams interviewed five actors and made interview reports. Also, the experiment leader interviewed two actors after the project, as they could not participate in the final presentations.

5.3 Case study: Comparative experiment on decision-making approaches

5.3.1 Introduction on Schiphol Airport

Schiphol Airport is the biggest airport in the Netherlands and it has leading position within Europe and the world. Schiphol Airport is located in the Province of Noord-Holland, southwest of the city of Amsterdam. The airport has six runways as is shown in Figure 5.1. In 2006, it distributed 46,1 million passengers and 1,53 ton of cargo, this was an increase of 4-5% compared to 2005. For these numbers a total amount of 423.000 flights were needed, with a peak capacity of 107 flights per hour. Besides an origin-destination function Schiphol Airport also has a so-called hub-function. This means that there are a lot (41,6% in 2006) of passengers that transfer at Schiphol and from there travel to their final destination (Amsterdam Airport Schiphol, 2007).

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[41] The questionnaire was executed before one student left the project.

Schiphol Airport is of strategic importance to the economy of the Netherlands. Schiphol generates 1,5% of the gross national product. Furthermore, Schiphol creates 80.000 to 120.000 direct and indirect jobs. However, the airport also has negative effects on the environment, such as noise hindrance, emissions and external safety. Next, the airport and related activities put pressure on the, already scarce, space. In 2006, the number of complains on noise increased up to almost 800.000. Besides that, Schiphol Airport generates a lot of road traffic, comparable to a middle large city (Bestuurlijke Regie Schiphol, 2006; Mainport Schiphol, 2005).

Figure 5.1 - Runway layout of Schiphol Airport, The Netherlands (map from NACO, 2008)

Several scenario studies predict that the aviation market will keep growing fast worldwide. From research it is concluded that, on the long-term (2040) capacity problems are foreseen for Schiphol (Centraal Plan Bureau, 2006; SEO Economisch onderzoek, 2006). Therefore, alternatives for extension are investigated by several organizations. The Province of Noord-Holland, started a Schiphol-team several years ago. In February 2007, this team formulated a long-term plan, in which an airport island in the North Sea is one of the possibilities (Provincie Noord-Holland, 2006; Provincie Noord-Holland, 2007). The case study in the multidisciplinary design project of the University of Twente is a continuation of the research by the Province.

5.3.2 Students' assignment: Growth strategy for the extension of Schiphol Airport

The Schiphol-team of the Province of Noord-Holland is the client of the students' assignment. The aim of this assignment is to: "*…design a, feasible and accepted, long-term (2040-2060) growth strategy for the extension of Schiphol Airport on an island in the North Sea…(Hommes et al., 2008b, in Dutch, translated by: S. Hommes)*" To create a feasible plan the project teams should at least focus on the following aspects: landside infrastructure; location, size and shape of the island; the financial feasibility of the extension. Furthermore, to enhance the acceptance of the strategy, the project teams should take into account relevant actors. In Figure 5.2, the elements of the students' assignment for the multidisciplinary design project are shown.

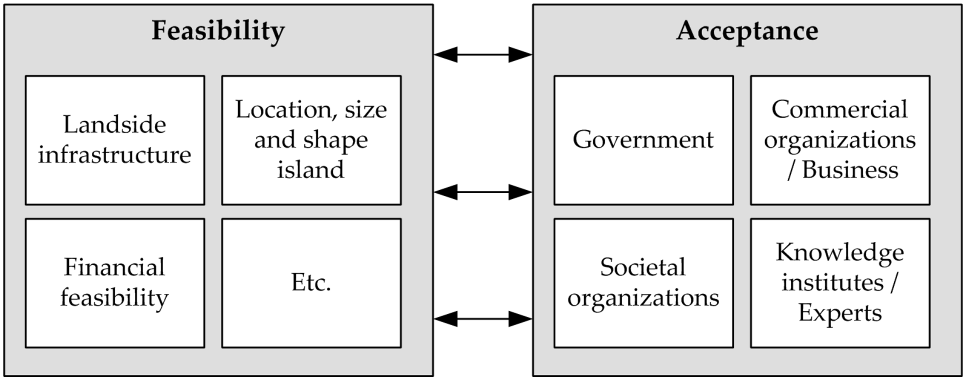

Figure 5.2 – Elements of growth strategy for Schiphol Airport on an island in the North Sea

5.3.3 Kick-off day and study day at Lelystad Airport

The multidisciplinary design project started with a kick-off day and a study day at Lelystad Airport. At the kick-off day the students from both decision-making approaches received the starting document, which included information on Schiphol Airport and on the assignment (Hommes et al., 2008b). During the first meeting, their role as a professional consultancy, executing a project for a specific client, was explained. Furthermore, the assignment itself was introduced. In the first week of the project, both groups (analytical and participatory) attended a study day at Lelystad Airport[42] in the Netherlands.

During this study day, presentations were given by:

- Schiphol Group, the airport operator of Lelystad Airport as well as Schiphol Airport;
- NACO (Netherlands Airport COnsultants), an independent airport consultancy and engineering firm; and
- Boskalis, an international dredging group, with core activities as the construction and maintenance of ports and waterways, land reclamation, coastal defence and riverbank protection.

Finally, Schiphol Group gave the students a tour around Lelystad Airport and a visit was paid to the aviation museum Aviodrome.

5.3.4 Workshop I: Corporate identity and problem definition

At the start of the first workshops (here after referred to as: WSI), the students received their corporate identity. After the students all read their corporate identity individually, they discussed it within their project team and formulated it in their own words. The next step in the workshop was to define the goal of the project, using the corporate identity, and to formulate constraints. The last part of the analytical decision-making workshop was used to define criteria for each constraint. Also an information package, with documents on Schiphol Airport, was handed to each project team. This package was created by the experiment leader.

For the participatory teams, the second step in WSI was to identify actors for the extension of Schiphol. After the project teams identified the actors they placed them in a power-interest grid to classify

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[42] Website Lelystad Airport: www.lelystadairport.nl

them. Next, the grid was overlaid with the participation ladder (Table 2.1) to determine the preferred participation level for each actor. Furthermore, five interviews with actors were planned for the participatory teams. One member of each project team joined in each of the five interviews. The objective of the interviews with these actors was to gain information on their interest and power concerning the extension of Schiphol on an island in the North Sea. The questions that were used in the interviews were prepared during the workshop and checked by the experiment leader. Furthermore, the students received an information package on each actor, created by the experiment leader. The following actors were interviewed:

- Province of Noord-Holland, Schiphol-team; This is the province in which Schiphol Airport is located. They also represent the client of this fictional case study on the extension on an island in the North Sea.
- Schiphol Group, department of Airport Development; Schiphol Group is an airport operator of among others Schiphol Airport. Schiphol Group's shares are held by the State of the Netherlands, the Municipality of Amsterdam and the Municipality of Rotterdam.
- Civil Engineering Division of the Ministry of Public Works and Water Management; This division develops, builds, maintains, advises and co-ordinates infrastructural and hydraulic engineering structures.
- North Sea Division of the Ministry of Public Works and Water Management; This division is responsible for the management of the North Sea; it maintains the shipping trenches, etc.
- North Sea Foundation; The North Sea Foundation is a professional Dutch environmental NGO that stands up for the North Sea.

5.3.5 Product I: Action plan

At the end of the first week the project teams handed in their action plans. These plans consist of: problem formulation, goal formulation, allocation of tasks among the project team members, planning of different activities, etc. We observed that all project teams, except for one (A1), included their corporate identity in their goal formulation.

5.3.6 Workshop II: SWOT-analysis and strategic issues

In the second workshop (here after referred to as: WSII), the project teams worked on a SWOT-analysis. SWOT is the abbreviation for Strengths, Weaknesses, Opportunities and Threats. The first step in a SWOT-analysis was to distinguish between the internal and the external environment. The internal environment consisted of the project organization, in this case Province of Noord-Holland, which could be expanded with cooperation partners if necessary. The internal environment can be influenced, while the external cannot. The external environment consisted of actors and the physical environment in which the extension of Schiphol Airport takes place. Strength and weaknesses are characteristics of the internal environment, opportunities and threats are characteristics determined by the external environment. The strength, weaknesses, opportunities and threats that the different teams came up with were checked and discussed in a plenary way. The second step in WSII was to identify strategic issues. Strategic issues can be formulated by confronting the internal environment from the SWOT-analysis with the external environment. Therefore, the following questions should be asked:

- How can the strengths be utilized in order to take advantage of the opportunities that have been identified?
- How can the strengths be utilized to overcome the threats identified?
- What is needed to overcome the identified weaknesses in order to take advantage of the opportunities?
- How can the weaknesses be minimized to overcome the identified threats? (Doratli et al., 2004)

During the first and the second week, the participatory project teams conducted interviews with five actors. Before WSII, they handed in their reports on these interviews. At the start of WSII the project teams were split up in their interview-teams to analyze the results of the interview. This analysis focussed on the following aspects: what the interest of their actor is (in the frame of the extension of Schiphol Airport in the North Sea), what its power is and what kind of power means the actor possesses. These actor analyses were discussed with all workshop participants. It became clear that not many actors support the idea of an airport island in the North Sea. The project teams were discouraged by these points of view of the actors. In the second part of the workshop, the participatory teams worked on the SWOT-analysis and strategic issues.

5.3.7 Courses on water and morphology, infrastructure and financial feasibility

During the third and fourth week of the project, the students of both groups followed several courses on water and morphology, infrastructure and financial feasibility. The courses of *water* and *morphology* gave an introduction into marine dynamics, i.e. tides, currents, waves, sediment transport and morphology of the coast and the seabed. Furthermore, a morphological model[43] was available to calculate the temporal development of the 'area of influence', i.e. the area around the island in which the morphological effect of the island on the surrounding seabed is significant. Moreover, the model is coupled to the software-program ArcGIS, in which several maps (e.g. user functions, sediment grain size, water depth) of the North Sea are available. This way, the students were able to assess the effects of several alternative island locations, based on for instance the effects on cables and pipelines in the area. Also, the students were taught how to calculate the effects of an island on the coast manually, using a formula.

The courses of *infrastructure* focused on the amount of traffic (passengers and cargo) that will be generated, the importance of distinguishing different types of traffic (hub and non-hub) and how this traffic will be distributed to the landside. The assignment for the aspect infrastructure was to determine an origin-destination matrix for passengers and cargo. Furthermore, a transport system (landside infrastructure) for this traffic should be designed by each project team. The aspect of *financial feasibility* focussed on the calculation of the operational costs, i.e. the initial investments - construction costs for the island and infrastructure - and the costs and benefits during the exploitation of the airport. An excel-sheet was available to calculate these operational costs during the lifespan of the airport island.

5.3.8 Product II: SWOT-analysis and alternative strategies

The second product, to be delivered by the project teams after four weeks (halfway during the project), consisted of the SWOT-analysis and three alternative strategies. One strategy for each scenario: best-, worst- and mid-case. The scenarios were derived from the SWOT-analysis and defined as follows. In the

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[43] The morphological model is based on: Van der Veen, H. H., Hulscher, S. J. M. H., and Peréz Lapeña, B. (2007) "Seabed morphodynamics due to offshore wind farms." 5th I.A.H.R. Symposium on River, Coastal an Estuarine Morphodynamics, RCEM 2007, September 17-21 2007, Enschede, The Netherlands, London: Taylor & Francis Group, pp. 1061-1066.

best-case scenario all opportunities and no threats occur, for the worst-case all threats and no opportunities occur and for the mid-case the most likely opportunities and threats occur. It was observed that the participatory teams (P1 to P3) propose to involve other actors, apart from the province, into the 'internal organization'. They explain that from the SWOT-analysis with the perspective of the province (from WSII), it can be concluded that the biggest threat is formed by the dependence (in authority and knowledge of airports) on the Schiphol Group. They state that this threat cannot be eliminated by strengths of the province. Therefore, the Province of Noord-Holland should cooperate with the Schiphol Group. During the feedback sessions, which were held for project team separately, it was explained to the participatory teams that how this cooperation will be established should also be part of the growth strategy.

5.3.9 Workshops III: Growth strategy, what and how?

During the final workshop (here after referred to as: WSIII), the project teams explored *what* exactly a growth strategy should contain and *how* they were going to achieve that in the three weeks that were left. The experiment leader explained that the growth strategy should consist of a rough design of the airport island, taking into account the different scenarios. This rough design should include a process design (which actors to involve and when) and a technical design. Furthermore, the temporal aspect of the growth strategy should also be encountered, probably in the form of defining different phases and decision moments. In Figure 5.3, an overview of a growth strategy is shown.

In the next step of the analytical decision-making workshop, the project teams worked on the technical design for the island, starting with identifying different functions that the island should facilitate. Functions that were identified are, for example: landing of airplanes, checking-in of passengers, service facilities for passengers. Next, different alternatives for each function were determined in a brainstorm, to enhance creativity. Last, the list of constraints that was determined in the first workshop was re-evaluated and adjusted.

The participatory project teams also worked on the rough technical design, by determining functions of the island and alternatives for each function. Furthermore, they investigated what the process design should look like. The project teams did this by determining: what steps and decision moments should be encountered, which actors should be involved at what participation level and what kind of organizational structure is needed.

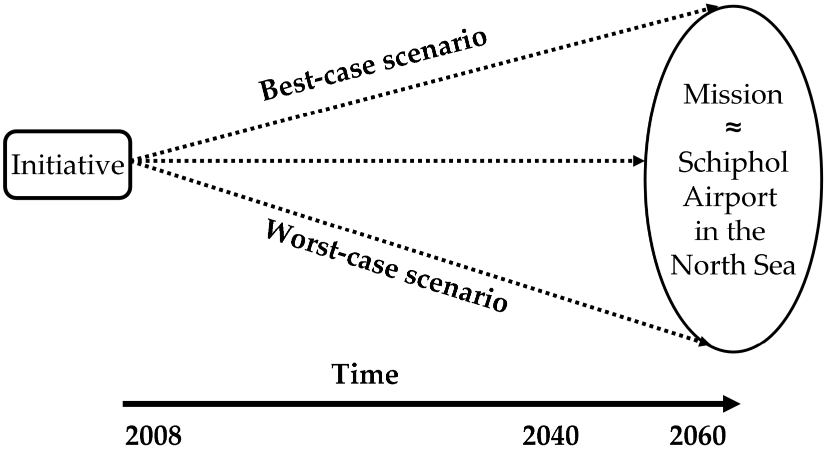

Figure 5.3 – Overview of a growth strategy

5.3.10 Final product: Growth strategy for Schiphol Airport on an island in the North Sea

After eight weeks, the project teams handed in their final reports on the growth strategy for Schiphol Airport on an island in the North Sea. The report was required to be a professional advice, with a fixed maximum number of pages. The growth strategies of all project teams included the following elements: SWOT; scenarios; alternative strategies for each scenario; technical design of the island (location, size, shape, rough outline, landside infrastructure); financial feasibility. Furthermore, the final product of two project teams (P1 and P2) included a process design. In this process design, they described which actors they propose to involve during different phases of the extension, e.g.: initiation, definition, preliminary design, definitive design, licenses and procedures, construction of island and infrastructure. These project teams also gave advice on the level of participation at which each actor should be involved. This was based on the power-interest grid they formulated during WSI.

During a final plenary session, each project team gave a brief presentation of their growth strategy. At these presentations all other project teams and teachers were present. Furthermore, the following actors were present at the presentations: Province of Noord-Holland, NACO and Boskalis bv. After the presentations of all project teams a ‘poster market’ was held. Each project team made a poster explaining their growth strategy for Schiphol Airport in detail. At the poster ‘market’, the project teams answered questions and discussed their strategy with the teachers, actors and members of other project teams.

5.4 Analysis

In this section, we analyze the case study described in the previous section. This is done by reflecting upon the following aspects: decision-making processes; knowledge base; actor perceptions; and substantive outcomes.

5.4.1 Decision-making processes

This case study focused on a comparative experiment between two decision-making processes, i.e. a participatory and an analytical process. These processes were ‘imposed’ on the different project teams by the experiment leader, providing them with a corporate identity, exercises during workshops and interviews with actors (for participatory teams). However, it still depends on the project team itself how and to what degree they followed these directions. Therefore, we analyzed to what extend the different project teams really worked analytically/participatory. In Table 5.1, we ranked the project teams from most analytically (project team A3) to most participatory (project team P2).

The project teams were first ranked based on their ‘scores’ on the first two categories, actor analysis and actor involvement (first four columns in Table 5.1). These categories were part of the experimental setup. These ‘direct’ measurements are used to check if the instructions given in the workshops were followed by the project teams. We observed that project team P3 did not include and project team A1 did include the identification of actors in their growth strategy. So, these teams did not follow the imposed approach entirely and are ranked respectively as less participatory and less analytical then the other project teams (A3, A2, P1 and P2). The involvement of relevant actors, i.e. number of actors and level of participation, differs between the two groups. This participation difference was enhanced by the fact that the P-teams explicitly focused on identifying actors and classifying them using a power-interest grid, during WSI; this was not done in the workshop for A-teams. Furthermore, the difference in participation level was also stimulated by the interviews with five actors that were done by the participatory teams. Although the participatory teams did have contact with actors, the interaction was limited to an interview at the beginning of the project. For the analytical approach there was no direct contact with actors during the project. At the final presentations, they did inform some actors about their growth strategy, as did the participatory project teams. We conclude that the participation level differs for the two decision-making processes. For the participatory teams it was *consulting*, whereas for the analytical teams it was *informing*. Both participation levels are not-interactive (see Table 2.1).

Table 5.1 – Analysis of decision-making processes, project teams ordered from: most analytical (top) to most participatory (bottom) oriented.

	Actor analysis		*Actor involvement*		*Project team characteristics*			*Products*	
	Identification	P/I-grid	# actors	Level of participation	Satisfaction with approach	Similarity	Intellectual level	SWOT perspective	Process design
A3	no	no	4	informing	++	0	7,7	Province	no
A2	no	no	4	informing	0	0	6,4	Province	no
A1	yes	no	4	informing	+	+	6,1	Province	no
P3	no*	no	8	consulting	0	-	6,1	Province + SG	no
P1	yes	yes	8	consulting	+	-	7	Province + SG	yes
P2	yes	yes	8	consulting	+	-	7,5	Province + SG	yes

Identification:	yes = actors were identified; no = no actors were identified; *only included in WSI & III, not in products
P/I-grid:	yes = a power-interest grid was formulated; no = no power-interest grid included
# actors:	Number of actors involved during the process
Level of participation:	Actor involvement, determined by 'ladder of participation' (Table 2.1)
Satisfaction with approach:	-- = very unsatisfied; 0 = it doesn't matter; ++ = very satisfied
Similarity:	-- = completely different to previous used approaches; ++ = exactly the same
Intellectual level:	Group level, determined by grade for final product
SWOT perspective:	Actors involved in the internal environment of the SWOT analysis; SG = Schiphol Group
Process design:	yes = a process design was included in the final product; no = no process design was included

Also the project team characteristics and products were used to analyze the decision-making process that was followed by the project teams. These two categories are used as 'indirect' measurements to check the ranking based on actor analysis and actor involvement and/or to further rank the project teams. The project team characteristics are subdivided into: satisfaction with approach; similarity; and intellectual level. The experiment leader distributed the different project teams over the analytical and the participatory decision-making approach, so the teams did not choose by themselves. The individual questionnaire was used to investigate the satisfaction of the project teams with the decision-making approach in which they were placed by the experiment leader. The similarity describes to what extent the proposed approach is similar to approaches the students used in previous design projects. This was also analyzed using the questionnaire. The intellectual level of the project team was determined by the grade for their final report. We argue that the higher the satisfaction, the more similar the approach and the higher the intellectual level, the more willing a project team was to follow the decision-making approach and the higher the scores for approach conformity. From Table 5.1, we see that the project team characteristics support the ranking based on the 'direct' measurements quite well. The only exception is project team A1, who were quite satisfied with the approach and find it similar to previous approaches, but still included some participatory features (actor identification). Therefore, project team A1 is still ranked as least analytical. Project team A3 was ranked as most analytical (more analytical than A2) as they were most satisfied and had the highest score on intellectual level. Although, project team P1 and P2 had the same score on satisfaction with the approach and similarity, P2 was ranked more participatory than P1 as they had a higher intellectual level.

Last, the products (last two columns in Table 5.1) were used to analyze and rank the decision-making processes of the project teams. In the second product by the project teams a difference in the involvement of actors in the internal organization of the SWOT-analysis was found. The A-teams did not involve other actors than the Province of Noord-Holland in their organization, whereas the P-teams proposed to involve other actors, i.e. Schiphol Group. For the involvement of the Schiphol Group the P-teams referred to the interview with this actor[44]. In this interview, they discovered that the Schiphol Group is not necessary a supporter of the extension of Schiphol on an island in the North Sea. Therefore,

[44] Interview Schiphol Group, Department Airport Development, 11 February 2008

the P-teams conclude that it is important to cooperate with this actor; otherwise the project might not succeed. Furthermore, we observed that in the final product of the A-teams no explicit process design is included; whereas two of the P-teams project teams (P1 and P2) did include such a design. Project team A3 claims that for them it is important to focus mainly on the feasibility of the grow-strategy and not on the acceptance by actors. Also project team A2 describes in their logbooks that actors are one 'piece' of information for them and that they should find out what actors want through documents, etc. On the other hand, the participatory project teams proposed to create acceptance by determining the wishes and desires of relevant actors. From these observations we conclude that the P-teams focused on a cooperative strategy, which fits the participatory approach, whereas the A-teams focused on central steering actor strategy, which matches the analytical approach.

All together, we conclude that there is indeed a difference in the way the A-teams and the P-teams approach the problem. It was observed that two project teams (A1 and P3) did not entirely follow the approach that was given to them. Therefore, the results of these teams will be omitted from the further analysis.

5.4.2 Knowledge base

In Table 5.2, an overview of the knowledge base of each project team, which consisted of the documents referred to by each project team in their final report, is given. At the start of the project, the two groups received two different information packages. The A-teams received an information package with technical information on Schiphol Airport (document 1-5, Table 5.2). The P-teams received an information package for each actor that they had to interview (documents 1, 2, 4, 5 and 18). During the process several other knowledge sources were added. There were several documents available online at the project website (documents 6, 10, 11, 12 and 14-16) and in hardcopy (document 7 and 9). There were two models available: a morphological model (document 8) and a financial model (document 13). Furthermore, the P-teams received practical knowledge from the actor interviews (document 19-23). One of the actors also sent a document to the P-teams (document 17). In addition to the documents that were handed to the students, the project teams searched for additional information. Project team A2 found 5 extra documents on strategies for the 'Randstad' (urban area in which Schiphol Airport is located), economic analysis and environmental information for Schiphol Airport. Project team A3 added one document on wave calculations. Project team P1 found extra information (5 documents) on finances for large projects and on air quality. Project team P2 added a lot of extra information (8 documents) on morphology and ecology and on finances of Schiphol Airport.

From Table 5.2, we observe several differences between the knowledge bases of the A-teams and the P-teams. Firstly, the participatory teams did not use all documents from the information package they received, i.e. they did not use document 4 and 5. Instead, it was observed that they used the actor interviews, i.e. practical knowledge sources on this topic (document 19 and 20). Furthermore, the A-teams did not use the available excel-sheet for financial feasibility (13), they calculated costs themselves. The P-teams did use the financial model that was handed to them. Also, for the Flyland document (17) a difference is observed. This document was sent to the participatory teams by one of the actors; however it is also available online. The information from this document was only used by the P-teams and not by any of the A-teams. From the above, it can be concluded that the knowledge bases of the analytical teams existed of expert knowledge sources, whereas for the participatory teams combined expert and practical knowledge sources.

Table 5.2 – Knowledge base of each project team (in gray)

		A2	A3	P1	P2
	Development of Schiphol Airport				
1)	Schiphol Group (2004)	■	■	■	■
2)	Schiphol Group (2007)	■		■	■
3)	Mainport Schiphol (2005)	■	■		
4)	Provincie Noord-Holland (2006; 2007)	■	■		
5)	Schiphol Group "Belang van vracht"		■		
6)	BRS (2006)		■	■	
	Information on water and morphology				
7)	Van der Kleij et al. (2003)	■			
8)	Morphological model, based on: Van der Veen et al. (2007)	■	■	■	■
	Technical information on airports and infrastructure				
9)	Neufville & Odoni (2002)	■			
10)	IATA (2004)			■	■
11)	Prorail (2005)	■		■	
	Financial information				
12)	CPB (1998)	■			■
13)	Financial model (excel-sheet)			■	■
	Scenario information				
14)	RPB (2007)		■	■	
15)	Min V & W (2006)			■	■
16)	CPB (2006)	■	■	■	■
	North Sea information				
17)	Flyland (2003)*			■	■
18)	Integral Management Plan North Sea (2005)				■
	Actor information				
19)	Interview Province of Noord-Holland			■	■
20)	Interview Schiphol Group			■	■
21)	Interview Civil Engineering Division (Min. V&W)			■	■
22)	Interview North Sea Division (Min. V&W)			■	■
23)	Interview North Sea Foundation			■	■

* This document was sent to the participatory groups by the actor of the North Sea Division (Min. V&W).

5.4.3 Actors' perceptions

In the comparative experiment, the participatory project teams investigated the problem perception (interest, demands and wishes) of different actors by interviewing them. In WSII the interview reports were analyzed. It became clear that not many actors supported the idea of the extension of Schiphol on an island in the North Sea. The P-teams found that the two most important actors, who have the highest interest and are most powerful, were the Province Noord-Holland (the client) and the Schiphol Group. From the interviews with these two actors[45], it is concluded that they both find it very important to displace Schiphol Airport entirely to the island. However, their perceptions were different. The perception of the province is that by moving Schiphol entirely to the island, the noise and environmental pressure on the current location will decrease enormously. Thereby, the living environment within the Province Noord-Holland will improve significantly, i.e. *social problem perception*. On the other hand, Schiphol Groups' perception is that the airport must be competitive and have the possibility to expand, i.e. *economic problem perception*. Furthermore, the P-teams found that the North Sea foundation is a strong opponent of an airport island. Their perception is that such an island will damage the unique ecological environment of the North Sea, i.e. *ecological problem perception*. From this analysis, it can be concluded that the actors' perceptions for the extension of Schiphol on an island in the North Sea are divergent.

The actors' perceptions could not develop during the comparative experiment. There was too little interaction, between the project teams and the actors, and it is a fictional project. Also, the different actors did not interact with each other, only with the project teams (students).

5.4.4 Problem-solution combination

The outcomes of the comparative experiment were the final products of the project teams, which consisted of a growth strategy for Schiphol Airport on an island in the North Sea. The final products included a technical design of the airport island, i.e. location, size, shape, rough outline, landside infrastructure. In the technical designs of all participatory teams it is observed that a solid seawall is

[45] Interview Schiphol Group, Department Airport Development, 11 February 2008; Interview Province of Noord-Holland, Schiphol team, 11 February 2008

recommended for the island, to prevent nuisance from birds on the island. On the other hand, the analytical teams did not focus on nuisance of birds. The P-teams focused on this issue as it was named by several actors in their interviews[46] and it was described in the Flyland-document (document 17, Table 5.2). Thus, they include actors' perceptions in their technical design and use arguments from practical knowledge sources.

We analyzed the island size in the technical designs proposed by the project teams. For the A-teams the size of the island is between 25 and 63 km^2. The islands by the P-teams are between 50 and 82 km^2. Thus, the islands by the participatory teams are somewhat bigger, which led to larger landside infrastructure compared to the A-teams' worst case scenario and higher construction costs (see Table 5.3). This difference is caused by the fact that all participatory teams advised to move Schiphol Airport entirely to the island in the North Sea. This choice was motivated by the perception of two important actors, i.e. Province Noord-Holland and Schiphol Group. Project team P1 explains that there are two important conditions for the Schiphol Group to participate in the project: *"…the airport has to be competent; and all activities have to be moved to the island…"* On the other hand, the analytical teams all advised to preserve Schiphol Airport on the current, inland location and create a step-by-step extension of runways on the island. The analytical teams give financial and technical reasons for this choice. However, they did not take into account the problem perceptions of the province and the Schiphol Group. This caused that there is no agreement on the designs the A-teams proposed, as one of the actors explained *"…if the island is this little, there is no use for Schiphol to move…"*[47]

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[46] Interview Schiphol Group, Department Airport Development, 11 February 2008; Interview Province of Noord-Holland, Schiphol team, 11 February 2008; Interview North Sea Foundation, 13 February 2008

[47] Interview Schiphol Group, Department Airport Development, 22 April 2008, by S. Hommes.

Table 5.3 - Landside infrastructure and construction costs per scenario

	Best case scenario	*Mid case scenario*	*Worst case scenario*
Project team A3	Light rail train through two tunnels 26,5 billion €	-	Light rail train through one tunnel -
Project team A2	Train through four tunnels 49,8 billion €	Train through three tunnels 37,4 billion €	Bridge from island to coast -
Project team P1	Train through tunnel		
	82,5 billion €	78,2 billion €	73,4 billion €
Project team P2	Train through two tunnels		
	Not calculated	50,3 billion €	Not calculated

We conclude that the designs by the P-teams are (more likely to be) an example of *joint problem-solution combination*, whereas the designs by A-teams are not agreed upon by the actors involved. We claim that this difference is caused by the fact that the participatory teams learned about the mutual dependency between relevant actors (Province Noord-Holland and Schiphol Group), i.e. *strategic learning* took place, while the analytical teams did not learn this.

5.5 Discussion

In this section, we will discuss the external validity of the comparative experiment described and analyzed in this Chapter. External validity is defined as *"…establishing the domain to which a study's findings can be generalized…(Yin, 2003)"* In our case, this domain is formed by complex water projects, i.e. decision-making for human interventions in large-scale water systems. There are several factors that might influence the external validity of our comparative experiment. One of these factors is the composition of the participants in the experiment; all participants are Civil Engineering Bachelor students in their third or fourth year. This is not a composition that one would find in practice. Nevertheless, these students are trained to become practitioners in the domain that is the focus of the research. Also students are quite 'mouldable', whereas practitioners are experienced and have their own approaches, which would probably make them less flexible in following our proposed approaches. Thus, the composition of the participants does influence the external validity of our experiment. However, an experimental setup with other participants, e.g. practitioners, will probably cause at least as big impacts on the validity.

Another factor that influences the external validity is the limited interaction with actors, in the participatory decision-making approach. In the case study, the interaction is limited to an interview at the beginning of the project and a presentation of the growth strategy at the end of the project. Therefore, it is not possible for the actors to continuously interact with each other and to co-produce in the technical design. Furthermore, in practice, the process design that is formulated by the participatory teams would have been 'executed' to create the technical design. In our experiment, the participatory project teams had to come up with the technical design without interaction with actors, which does not match the participatory decision-making approach. Thus, the limited interaction does influence the external validity of the experiment.

The case study is also influenced by the limited resources (time, people, money etc.) available. In practice such resources are also limited. Therefore, we argue that this does not influence the external validity of the observations significantly. Finally, the external validity could have been influenced by the 'openness' of the goal formulation in the assignment. The project teams were required to focus on an extension of Schiphol Airport on an island in the North Sea, so no other alternative extension (location) could be taken into account. This means that the formulation of the objective is not as flexible as assumed in the participatory approach. Also, it was compulsory to investigate several technical elements, morphological effects, landside infrastructure and financial feasibility, and hand in certain products according to a 'linear' schedule. These aspects do not entirely match the participatory approach. On the other hand, through the design methodology of the SWOT-analysis and strategic issues the project teams were compelled to focus on actors, as this is part of the methodology. This does not fit the analytical decision-making approach. From these remarks we can conclude that the decision-making approaches that were followed during the experiment are not purely analytical or participatory; they are a mix of both. However, we argue that it would not have been possible to execute the experiment more purely than was done. Moreover, the question arises whether it is possible to make such a 'black-and-white' distinction between the analytical and the participatory decision-making approach in practice. We argue that also in the 'real' world of integrated water management decision-making processes are a mix of both approaches. It is always a matter of balancing between process and contents, navigating between superfluous knowledge and negotiated nonsense or synchronizing the policy analytical approach and the process management approach by using a double helix approach (Edelenbos et al., 2003; Van de Riet, 2003). Also Woltjer (2000) describes that the rational and participatory approach are not mutually exclusive, but complementary. Both approaches have valuable ideals that are worth striving for. Thus, we conclude that it is more realistic to have a mixed decision-making approach, like in the comparative experiment, than a purely analytical or participatory approach.

5.6 Conclusions

In this Chapter, we presented a case study on a comparative experiment between two decision-making processes. This comparative experiment was executed within a multidisciplinary design project for Civil Engineering Bachelor students of the University of Twente. The aim of this case study is to determine how a decision-making approach influences the creation of a knowledge base, the development of actors' perceptions and the substantive outcomes.

In the analysis of the two decision-making processes it was found that the project teams did indeed follow two different approaches, i.e. participatory and analytical. The results of two project teams were omitted from the analysis, as they did not follow the approach that was given to them. From our case study, it can be concluded that the analytical approach leads to a knowledge base which mainly exists of expert knowledge, whereas the participatory approach leads to a combination of expert and practical knowledge sources. Furthermore, it was found that actors' perceptions were divergent in the case study. However, they did not develop during the process as there was too little interaction for this to happen. It was found that the substantive outcomes, which consisted of the growth strategies, by the analytical project teams were not agreed upon by the relevant actors. On the other hand, the substantive outcomes of the participatory approach are an example of a *joint problem-solution combination*, as they represented the relevant actors' perceptions. We conclude that this resulted from *strategic learning* between the participatory project teams and the actors involved.

6 Comparison of case studies & Discussion

6.1 Introduction

In this Chapter, we present the comparison between two analytical and two participatory decision-making processes from our three case studies. This is done by reflecting upon the main elements in our conceptual model from Section 2.6. In Section 6.2, the following elements are compared: creation of a knowledge base, development of actors' perceptions and problem-solution combination. Also, we place the research in a broader perspective by discussing the international value, institutional uncertainty and power issues and the effect of participatory processes on formal decision-making in Section 6.3.

6.2 Comparison of case study results

6.2.1 Decision-making processes

The first case study, described in Chapter 3, focused on the decision-making process for the impact assessment of the extension of Mainport Rotterdam. During this process several actors were involved. Several experts were *consulted* and stakeholders were *informed* in separately organized stakeholder meetings. Therefore, the decision-making process was not-interactive (see Table 2.1). Furthermore, the analysis of the decision-making process showed that the solution of the problem is sought in acquiring more knowledge, indicating that the problem is handled as a purely technical problem, which can be solved by rational analysis. There is no discussion on, for example, the underlying model-assumptions. These assumptions are based on values rather than on facts. By not discussing the values, the model outcomes are presented as facts. This is a typical characteristic of analytical decision-making. In addition, the two standard responses – information gathering and counter-expertise – to deal with substantive uncertainty in analytical decision-making were observed. Also, the process was divided in all sequential phases with a clear beginning and end. Furthermore, the government defined and solved the problem; a central steering actor. This is similar to the phase model (Figure 2.5). From the above, we conclude that this process is a typical example of an *analytical decision-making process*.

The second case study, described in Chapter 4, focuses on the sustainable development of ecology, economy and society in the Delta region, in the southwest of the Netherlands. In a fundamental discussion about freshwater supply for agriculture, national, regional and local government partners directly interact with stakeholders. In the case study, participants contribute to the development of policy and politicians use their advice in the follow-up process. Whether this advice will also be part of the final decision is still unknown. Depending on the course of the remaining process, the level of participation is a form of *advising* or *co-producing*. Therefore this case study is an example of an interactive decision-making process (see Table 2.1). Furthermore, the process was open to divergent perceptions of all relevant actors. The process managers paid special attention to this aspect in the process design. The framework for discussion overlaps with all existing problem formulations, i.e. actors' perceptions on opportunities and bottlenecks. In addition, stakeholder participation also included a representation of relevant individual stakeholders; it was not limited to interest groups or organizations. Moreover, the process design of the fundamental discussion is similar to the rounds model (Figure 2.6). In each round of interaction, i.e. workshops and small-scale meetings, participating actors determine the outcome and this forms the starting point of the next round. This leads to the conclusion that the Delta case study is a typical example of a *participatory decision-making process*.

In third case study, described in Chapter 5, two decision-making processes were compared using an experimental setup. This comparative experiment was carried out within the framework of a Civil Engineering design project at the University of Twente. In this project, the project teams, consisting of Bachelor-students, focused on the extension of Schiphol Airport on an island in the North Sea. The project teams were divided into two types of groups, analytical and participatory. At the start of the project both groups received a different corporate identity explaining their role as a professional (analytical or participatory) consultancy. Furthermore, three parallel workshops took place; separate for each group. Also, the participation level of actors differed for both approaches. For the analytical approach there was no direct contact with actors during the project, they were only informed afterwards. For the participatory approach, on the other hand, a few actors were consulted during an interview at the beginning of the project. So, for the participatory teams the level of participation was *consulting*, whereas for the analytical teams it was *informing*. Both decision-making approaches were not-interactive (see

Table 2.1). In the analysis of the two decision-making processes it was found that the project teams did indeed follow two different approaches, i.e. *participatory* and *analytical*, though not perfectly.

Comparing the decision-making processes of our case studies, we conclude that two analytical decision-making processes and two participatory decision-making processes were presented in this thesis.

6.2.2 Knowledge base

In the impact assessment for Mainport Rotterdam, it was observed that many investigations were carried out and much information was gathered. The used methods were model calculations, expert judgment, historical analyses and audit meetings. These investigations focused on single-actor complexity and reducing uncertainty in the knowledge base, which resulted in a valid, context-specific knowledge base. The communication with the stakeholders was organized separately from the research investigations, in three stakeholder meetings. The aim of these meetings was to inform the stakeholders. Knowledge sources brought up in the actor meetings were not included in the investigations. Furthermore, the diverging actors' perceptions (multi-actor complexity) were not addressed in the investigations. Thus, the knowledge base that was produced is an example of *superfluous knowledge*, as it was not relevant for the policy debate.

At the start of the Delta case study, a knowledge base was created, consisting 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. Therefore, stakeholders contributed to the process with their own knowledge and experiences (practical knowledge) during small-scale meetings in sector-related actor groups; the knowledge base soup is boiling. Also, 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. Finally, the process managers connected the practical knowledge, from the small-scale meetings, with insights from research reports. The case study findings showed that it is possible to create a mix of agreed upon knowledge from: research reports, practical knowledge, assumptions, estimates, objectives and restrictions. And use this as a basis for the formulation of a problem-solution combination which is supported by all actors, i.e. *negotiated knowledge* was created.

In the comparative experiment, both groups received an information package at the start of the project and several knowledge sources were added during the project. It was observed that the participatory teams used practical knowledge, from actor interviews, on topics where the analytical teams used expert knowledge. Furthermore, the participatory teams received a document by one of the actors. The information from this document was only used by the participatory teams and not by any of the analytical teams; although it is also available online. From this case study, it can be concluded that the knowledge base from an analytical decision-making process exists mainly of expert knowledge sources, whereas in a participatory decision-making process expert and practical knowledge sources are combined.

From the comparison of the influence of a decision-making process on the creation of a knowledge base in the three case studies, we found the following. The first and third case study showed that the analytical decision-making approach leads to knowledge that is (scientifically) valid, but does not take into account diverging actor perceptions' and therefore results in knowledge that is not useful in the policy debate, i.e. superfluous knowledge. The second and the third case study, on the other hand, showed that the participatory approach enhances the development of agreed upon and valid knowledge about the problem-solution combination, i.e. negotiated knowledge.

6.2.3 Actors' perceptions

In the first case study, the Dutch Fish Product Board objected to the extension of Mainport Rotterdam. This was their explicit (formal) problem perception, which is based on ecological and procedural grounds. However, their implicit problem perception is wider. The Dutch Fish Product Board was not satisfied with the decision-making process. And they were concerned about income losses, due to the loss of fishing area. Furthermore, no (financial) compensation was arranged for the fishing industry until their objection to the decision for the extension in 2005. We conclude that the implicit problem perception of the Dutch Fish Product Board is *socio-economic.* The problem perception by the government and of the Port of Rotterdam is that, by the invalidation of the decision, the extension of Mainport Rotterdam is no longer ensured by legal means. Thus, they perceive it as a *procedural* problem. Furthermore, according to the experts involved in the investigations for the Appropriate Assessment Wadden Sea the problem was that there was not sufficient knowledge on the effects; they perceived the problem as a *technical* problem. So, in this case study actors' perceptions were divergent. However, the investigations were done from the procedural and technical problem perceptions and did not take into account the implicit socio-economical problem of the objector. The perception of the objector did not develop, because this actor did not interact with the actors involved in the impact assessment and/or contribute their knowledge. Also, the perception of the experts did not change significantly, because they only interacted with actors that had a similar perception of the problem. Therefore, we conclude that the diverging actors' perceptions did not converge during the process.

In the second case study, we observed that basically two extremes in problem formulations exist: the *economy-oriented,* i.e. agriculture on the islands is important for socio-economic reasons and the *ecology-oriented,* i.e. the Delta Works negatively affect the ecological system. It becomes clear that the actors' perceptions diverge. The agricultural sector adheres to the economy-oriented problem formulation and the nature sector to the ecology-oriented problem formulation. Thus, our observations showed that actors in the same social group or sector adhere to similar problem perceptions, although they have individual differences. 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. Although perceptions converged as a result of cognitive learning, we also observe that actors' perceptions did not become identical.

In the comparative experiment, the participatory teams found that several diverging actors' perceptions existed on the extension of Schiphol Airport. The perception of the province is that by moving Schiphol entirely to the island, the noise and environmental pressure on the current location will decrease enormously. Thereby, the living environment within the Province Noord-Holland will improve significantly, i.e. *social problem perception*. On the other hand, Schiphol Groups' perception is that the airport must be competitive and have the possibility to expand, i.e. *economic problem perception*. Furthermore, the North Sea foundation is a strong opponent of an airport island. Their perception is that such an island will damage the unique ecological environment of the North Sea, i.e. *ecological problem* *perception*. These diverging actors' perceptions could not develop during the comparative experiment. There was too little interaction, between the project teams and the actors, and it is a fictional project. Also, the different actors did not interact with each other, only with the students.

Comparing the influence of a decision-making process on the development of actors' perceptions in the three case studies gives us the following results. In the comparative experiment, actors' perceptions did diverge, but could not develop. The case study on the impact assessment for Mainport Rotterdam showed that an analytical decision-making approach does not enhance the convergence of actors' perceptions. In the Delta case it was found that a participatory approach stimulates actors to reflect upon and contribution to the knowledge base, i.e. cognitive learning, which enhances convergence of perceptions.

6.2.4 Problem-solution combination

In the first case study, it was observed that the diverging actors' perceptions did not develop during the process. The process was not approached as an unstructured problem, i.e. it is not a problem structuring approach. Although knowledge is uncertain, 'formally' consensus on values and norms is high, as the extension will be built anyway. This part of the decision was not declared invalid by the Council of State. It was observed that the ecological experts, involved in the investigations, treated the problem as a well-structured problem (type 1), whereas the government treated it as a moderately structured problem (type 2, Figure 2.1). Because the government approached the project as a moderately structured problem, they used the knowledge that was generated in the research tracks in a *strategic* way. This resulted in a lack of consensus, among the parties involved in the investigations, on the use of knowledge in the final assessment. Thus, we concluded that the substantive outcome of this process is not agreed upon by the actors involved.

In the second case study, we found that 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.

In the comparative experiment, it was found that the substantive outcomes, i.e. the growth strategies, by the analytical project teams were not agreed upon by the relevant actors. On the other hand, the substantive outcomes of the participatory approach are an example of a joint problem-solution combination, as they represented the relevant actors' perceptions. We conclude that this resulted from strategic learning between the participatory project teams and the actors involved.

Comparing the substantive outcomes of the three case studies brings us to the following conclusion. The first and third case study showed that an analytical decision-making process leads to substantive outcomes, which are not agreed upon by the relevant actors. The Delta case and the comparative experiment illustrated that a participatory decision-making process does lead to a joint formulation of a problem and its solution. This results from both *cognitive and strategic learning processes*.

6.3 Discussion

In this Section, the results of this research are placed in a broader context. First, we will discuss the international value of our findings. Then, the issues of capacity and power, which were not explicitly taken into account, are investigated. Last, the effects of a participatory process on 'formal' decision-making are discussed.

6.3.1 International value of the research

In this thesis, we presented three case studies of complex water management issues. All three case studies are located in the Netherlands. We argue that differences in cultural context, in relation to water management, will influence the applicability of our findings in other countries than the Netherlands. The Dutch water management policy developed from a technical approach, focussing on technical solutions, to integrated and participatory management, where different aspects, values and actors are extensively taken into account. This change towards integrated water management and participation is further enhanced by the implementation of the European Union Water Framework Directive (2000/60/EC). The Water Framework Directive (WFD) has been put forward as a legislative framework to guarantee the 'good quality of all waters in Europe'. It introduced two important new aspects: the river basin approach and public participation. Thereby the Directive is a strong impetus for integration and cooperation in European water management. However, individual nations have considerably different public participation problems and approaches (Enserink et al., 2007; Van der Brugge and Rotmans, 2007).

Public participation and culture are intertwined; national, local, and professional cultures and their formal institutions co-determine the level and methods of public participation. Relatively little systematic research has been done to examine the relation between culture and public participation in water resources management. Enserink et al. (2007) highlight the importance of national cultures, and report a comparative analysis of the influence of national cultures in different European Countries in relation to public participation and water management. In this study, they used the cultural dimensions by Hofstede (2001) to classify countries and make cultural differences tangible. These are the following five dimensions; power distance; individualism; masculinity; uncertainty avoidance; and long-term orientation. A general finding is that cultures that are characterized by high power distance and high masculinity (for example: China, Ecuador, Mexico and Philippines) are unlikely to embrace participation. Furthermore, high power distance and high uncertainty avoidance inhibit public participation because they support centralized and control-oriented systems of water management (Enserink et al., 2007).

The study by Enserink et al. (2007) showed that culture cannot explain difference between countries in absolute terms. Other factors like experiences with public participation, political and institutional settings and national history play an important role as well and may lead to different conclusions. However, the cultural dimensions by Hofstede (2001) could be used to give an indication of countries that are similar in cultural context to the Netherlands. For instance, Hofstede observes that the dimensions for the Netherlands are very similar to that of Scandinavian countries. Furthermore, the highest dimension for the Netherlands is individualism. There are only seven countries in the research by Hofstede that have individualism as their highest dimension: USA, Australia, United Kingdom, Netherlands, Canada, and Italy.[48] Thus, our research findings might be applicable there. In the remainder of this Section, we will compare our results to empirical studies executed in several other countries.

Collins et al. (2007) present three case studies on managing multiple perspectives and stakeholding in water catchments in the United Kingdom (Scotland, England and Wales). Their case study results demonstrate the limits of catchment management that is based on a narrow evidence base in which science is used to inform policy principally through modeling of catchment functioning. They argue that "…*many issues cannot be understood or defined from one particular perspective alone, nor resolved by unilateral action on the part of a single stakeholder*..." Furthermore, it is concluded that "…*systemic exploration of the multiple perspectives of stakeholders offers significant opportunities for enabling a process of social learning…(Collins et al., 2007)*" These findings correspond with our findings, in the Delta case, that the development of actors' perceptions results from (cognitive and strategic) learning processes.

Mostert et al. (2007) present and analyze 10 case studies of participatory river-basin management that were conducted as part of the European HarmoniCOP project. The case studies were conducted in the following countries: Belgium, England and Wales, France, Germany, Hungary, Italy, The Netherlands, Scotland and Spain. They found eight general themes from the analysis of factors fostering or hindering social learning. One of these themes is framing and reframing, which is comparable to the

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[48] Website Geert Hofstede Cultural Dimensions: www.geert-hofstede.com

development of actors' perceptions studied in our case studies. Mostert et al. (2007) describe that "*…Social learning does not occur if the organizers or technical experts impose their problem perception on the process* […] *Moreover, some processes took technical models as their starting point instead of the issues as seen by the stakeholders. This limited the engagement of the stakeholders…(Mostert et al., 2007)*" These findings correspond well to our conclusions on the impact assessment for Mainport Rotterdam. In this case study, the investigations were executed from a technical perspective, which lead to the fact that there was no consensus on the final assessment among the actors involved.

Moreover, similar examples on participatory processes can be found in North America and Australia. Leach and Pelkey (2001) analyzed 37 case studies of watershed partnerships in the USA, Canada and Australia. Watershed partnerships are defined as assemblies of stakeholders who periodically convene to discuss or negotiate the management of streams, rivers or watersheds. In this study, empirical literature was reviewed to identify primary factors that promote successful partnership outcomes. Two alternative definitions of partnership success were used. One type of success is the adoption and/or implementation of watershed plans, projects or policies and their eventual impacts on environmental or socioeconomic indicators. Another type of success includes trust building, conflict resolution, satisfying the stakeholders and strengthening the long-term organizational capacity. The most frequently recurring themes are the necessity of adequate funding, effective leadership and management, interpersonal trust and committed participants (Leach and Pelkey, 2001). Also, in the Delta case we found the importance of effective leadership, i.e. a neutral and skilled facilitator. The theme of 'interpersonal trust' relates to the process of strategic learning, which was found to contribute to the formulation of a joint problem-solution combination in the comparative experiment and the Delta case.

In sum, we conclude that the research findings presented in this thesis can provide insight in complex water management issues in other countries, which are similar in cultural context. Furthermore, this would be an interesting topic for further research (see Section 7.2).

6.3.2 Institutional uncertainty and power issues

Our conceptual model does not explicitly include institutional uncertainty. Institutional elements are 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. This assumption is justified by our case study observations, as the conceptual model was able to explain the creation of a knowledge base, the development of actors' perceptions and the substantive outcomes. Consequently, we argue that our findings on the process of problem structuring will not change significantly by taking institutional elements into account. However, it would be interesting to link our findings to this topic, for instance to get more insight into the course of decision-making process and the role of certain institutions in (the change of) such a process.

Related with institutional elements are power issues. Koppenjan & Klijn (2004) explain that it is important to distinguish between 'realization power' and 'hindrance power'. If parties control an important and irreplaceable resource, they can block the creation of a solution strived for by others. They can do this if their interests threaten to be harmed by a certain solution or because they think that they will acquire a better negotiation position by creating barriers. On the other hand, if parties want to realize a solution, they must possess realization power: this is rarely concentrated within one party but usually requires the willingness of various parties to invest their resources in a joint process of problem solving (Koppenjan and Klijn, 2004). Although, we did not focus explicitly on power issues our case study results were influenced by them. For example, in the case of Mainport Rotterdam the Dutch Fish Product Board used their lawful right to object to the decision on the extension. Thus, they used their hindrance power. In this thesis, we are interested in the actors' motivation to use this hindrance power, i.e. the actors' perception, and not so much in the power means themselves.

6.3.3 Effects of participatory processes

Experiences in the Netherlands and in other European countries show that the linkage between participatory processes and 'formal' decision-making procedures is often difficult. The risk is that two separate arenas emerge: an 'interactive arena' and an 'administrative-political arena' (Klijn and Koppenjan, 2000). Abels (2007) explains that "*…participatory procedures are still in an experimental stage; their linkages to the institutions of representative democracy vary from case to case and from country to country – and are, by and large, weak...(Abels, 2007)*". Moreover, they do not per se improve the democratic legitimacy and accountability of policy-making and have, at best, a limited impact on solving complex societal problems. Actually, solving complex societal problems "*…does not* [seem to] *work any longer without citizen*[49] *participation. It is hitherto empirically as well as conceptually not clear, if it works with citizen participation – or more precisely: with which kind of citizen participation, in which fields, for what purpose and with what effects…(Abels, 2007)*" The question arises: How to create an adequate link between problem structuring in participatory processes and the formal decision-making process?

One of the barriers that stands in the way of successful participatory policy processes is the attitude of elected politicians. They often fear that participation threatens their political primacy and find it therefore hard to play a constructive role in these processes. This lack of political commitment may lead to the emergence of two separate arenas and may cause that outcomes of an participatory process are not used in the formal political procedures that follow (Klijn and Koppenjan, 2000). Edelenbos and Klijn (2005b) propose two indicators to determine political involvement: *initiation*, whether the political officeholders have been involved in the initiative of starting an participatory process; and *ratification*, if they have confirmed the process design.

In the impact assessment for the extension of Mainport Rotterdam, the political arena was involved in the initiation of the process. However, the process design was not ratified, e.g. the model calculations immediately started after the judgment of the Council of State, also as this research was already planned as part of the EIA (Hommes, 2006). In the case study of the Delta-region, the participatory case study process resulted from a letter from the Minister of LNV and the State Secretary

[49] Although the case studies in this thesis did not focus explicitly on citizen participation, we argue that this statement holds as well for actor participation.

of the Ministry of V&W to the Delta Council. In this letter, they asked the Delta Council (a formal institution with delegates from three Provinces and public servants from national government departments) to start a fundamental discussion, with different actors, about the connection of a more natural Delta and a more natural, sustainable freshwater situation for agriculture. Subsequently, the Delta Council started a fundamental discussion with different actors at local level; on the islands of Tholen and St. Philipsland. Thus, the initiation reveals political commitment at national level. Furthermore, the process was also ratified at this government level.

An important issue is organizing feedback to the democratic institutions involved. This enhances so-called soft coupling, i.e. politicians forming their own judgment making use of the results from the participatory process (Edelenbos and Klijn, 2005b). Klijn and Koppenjan (2000) suggest that if politicians are serious about participatory decision-making, they should reflect on their own role in it. In the case of Mainport Rotterdam, no politicians were actively involved in Appropriate Assessment investigations. However, they were informed by the project leader on the progress of the investigations. In the second case study, civil servants and elected politicians from provincial and regional government bodies were involved in the participatory process. However, problems may still arise with respect to the formal decision to follow. First of all, the outcomes of the pilot-project have to be integrated with the outcomes from other forthcoming local discussions, because the positioning of the preferred solution asks for the cooperation of neighbouring areas. Second, not all institutional bodies that will be involved in the formal decision that has to follow (on national level) and the implementation of solutions were involved in the participatory process. For example, the solution described in the covenant requires investments from parties at national, regional and local level. Moreover, the case study reveals that difficulties arise because discussions take place at the local and regional level, although the formal decision needs to be made at multi-levels. In the case study, attempts have been made to connect these fragmented decision-making levels. Unfortunately, the process managers did not succeed in doing so. One of the reasons was the lack of willingness, among civil servants at provincial and national level, to be involved.

Fragmentation influences the effectiveness and legitimacy of participatory policies. Meijerink (2004) explains that the fragmentation of decision-making in the Netherlands often complicates the learning capacity of actors from the public sector. Still, deliberation on practical solutions to 'locally' defined issues is consistent with the idea of network governance. A suggestion to handle the fragmented nature of decision-making processes is the development of inclusive networks. Inclusive networks open to include other subjects and groups, other contexts, other problem definitions and other concerns, even though they are positioned at the local level. To realize this, awareness needs to be created that narrow issue-definitions and fragmented approaches are inadequate to address uncertainty and ambiguity. Complex, unstructured problems require openness, flexibility and inclusiveness (Pellizzoni, 2003).

The case study on the sustainable development of the Delta-region showed that actor knowledge can contribute to solving complex, unstructured problems. However, we also observed that various actors value knowledge differently and that the government asks for an additional societal costs-benefits analysis. This is in line with experiences of other researchers that decision-makers are liable to value professional knowledge as 'better knowledge' than actor knowledge and that they ask for additional research (Rinaudo and Garin, 2005). Actually, "*…many experts from governmental organizations still tend to favour a mobilization of scientific and technical expert knowledge to diagnose the problems, identify the remediation measures and formulate coherent water management plans, because of a lack of time, means and know-how. In a Western culture, which has a tendency to stress scientific, technical and economic analysis as the basis for decision-making, science still has the monopoly of knowledge and little regard is given to social, cultural and environmental values…(Rinaudo and Garin, 2005; Vasconcelos et al., 2000)*". Also, in the impact assessment for the extension of Mainport Rotterdam it was observed that the expert judgement, by the ecological experts, was perceived as less valuable by the government then model calculations. This imposes another problem to the linkage between the participatory and the formal decision-making process. Problem structuring can only be effective if all actors start to realize that local, contextualized knowledge is increasingly valuable to solve complex, unstructured problems (Parkins, 2006).

7 CONCLUSIONS & RECOMMENDATIONS

In this thesis, a conceptual model for problem structuring was formulated from literature review and we investigated different decision-making processes through three case studies on complex water management problems. Section 7.1 draws conclusions from the case study observations and the reflection upon our conceptual model. First, every research question, i.e. RQ1 to RQ5 from Section 1.2, is answered separately. Then, we respond to the main research question: how to deal with diverging actors' perceptions and knowledge uncertainty in complex water management problems. In Section 7.2, recommendations for further research on institutional uncertainty, power issues and internationalisation are given.

7.1 Conclusions

7.1.1 Complex water management problems

Our first research question (**RQ1**) was formulated as follows: What are characteristics of complex water management problems? This thesis focused on management of large-scale water systems, like rivers, estuaries and coastal zones. These management issues arise in a natural and social system that is characterized by complexity, uncertainty and disagreement between actors. Consequently, they are often examples of unstructured problems for which the knowledge base is uncertain and no consensus on values and norms exists. 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. At first sight, uncertainty in a knowledge base can be reduced by providing more relevant or more adequate information. However, new information can 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 with the necessary time and means.

Water management problems involve many different actors. Various actors hold, produce and value knowledge that differs in both content and orientation; this contributes to their perception of a problem situation. We distinguish between two types of knowledge: expert (or scientific) knowledge; and practical (lay or non-scientific) knowledge. The involvement of various actors results in ambiguity since actors have diverging and sometimes conflicting perceptions of the problem. Actors' perceptions are based on frames. These frames function as filters through which information or a problematic situation is interpreted. With respect to the first research question, we conclude that *knowledge uncertainty* and *ambiguity of actors' perceptions* are characteristic of complex water management problems.

7.1.2 Policy and decision-making for complex water management problems

The second research question (**RQ2**) reads as follows: What are characteristics of policy and decision-making for these complex water management problems? In general, policy and decision-making is aimed at providing a solution for a certain problem. A policy and decision-making process is usually a multi-actor process. In the Netherlands, policy and decision-making for water management has a long history, starting as early as the 11th century when regional water-boards were established. In the centuries that followed water management developed from a technical approach, e.g. building dikes for protection against flooding, to integrated and participatory management, where different aspects, values and actors are extensively taken into account. So, decision-making for human interventions in water systems is no longer only a technical issue; it is more and more a societal issue too.

There are many different decision-making approaches. In general, we can distinguish two 'extremes': the analytical decision-making approach and the participatory decision-making approach. In the analytical approach, decision-making is based on rationality and objectivity and a problem is assumed to be of a technical nature, problem structuring takes place accordingly. This process can be conceptualized by the phase model and is not-interactive, in fact it assumes one steering actor. On the other hand, participatory decision-making is interactive. This process can be described by the rounds model. During such a participatory process several actors contribute to a process of 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.

In this thesis, we presented results from three case studies of complex water management problems. The first case study focused on the decision-making process for the extension of Mainport Rotterdam, which is one of the largest ports in the world. The Dutch government wants to expand the Mainport by land reclamation in the North Sea. This may affect the Wadden Sea, a unique wetlands area protected by the European Bird and Habitat Directives. To assess the impact of the port extension on the Wadden Sea, an Appropriate Assessment procedure was carried out. This process can be characterized as an *analytical decision-making process*. The second case study focused on the sustainable development of ecology, economy and society in the Delta region, in the southwest of the Netherlands. In several areas in this region the ecological quality has decreased due to engineering works for storm surge 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 functions and users, e.g. farmers. This problem has been addressed in a pilot-project, which was used as a second case study in this thesis. This project is a typical example of a *participatory decision-making process*. Finally, in the third case study two decision-making processes (an *analytical* and a *participatory* process) are compared using an experimental setup.

7.1.3 Creation of a knowledge base

In this thesis, we analyzed how a decision-making approach, for a complex water problem, influences the creation of a knowledge base (**RQ3**). We conclude that a decision-making approach mainly focused on reducing uncertainties in the knowledge base, i.e. analytical approach, runs the risk of producing knowledge that does not answer the questions that arise from a variety actors involved in the problem. From a decision-making point of view, this is superfluous knowledge. This was illustrated by the case study on the impact assessment for the extension of Mainport Rotterdam. In this case study, a lot of new knowledge was produced. However, this knowledge was not necessary to solve the problem of the actors that objected to the extension of the Mainport. Thus, the knowledge production did not match with their interest and their problem perception.

Furthermore, we conclude that a process of problem structuring actively involving a variety of actors and their diverging problem perceptions, i.e. a participatory decision-making process, is likely to produce knowledge which (partly) meets the diverging actors' interests. This results in what we call negotiated knowledge. This was observed in the discussion on sustainable development in the Delta region in the southwest of the Netherlands. At the start of this process several actors did not agree at all on what the problem was and what should be done to solve it. However, during the process of problem structuring their perceptions of the problem and its solutions got closer to each other and finally led to an agreement, i.e. negotiated knowledge was created.

7.1.4 Development of actors' perceptions

Parallel to the analysis of the creation of a knowledge base, we investigated how a decision-making approach influences the development of actors' perceptions (**RQ4**). We conclude that the analytical decision-making approach does not enhance the convergence of actors' perceptions. This approach does not sufficiently take diverging actors' perceptions into account, which may lead to knowledge conflicts and 'dialogues of the deaf'. This was observed in the impact assessment for Mainport Rotterdam, where diverging actor perceptions existed. However, as not all relevant actors were involved in the process, these diverging perceptions could not converge.

Furthermore, we conclude that a participatory approach, which stimulates actors to reflect upon and contribute to the knowledge base, enhances convergence of perceptions. In the Delta-region case study, actors' perceptions also diverged. In this case study, we observed that the actors successfully learned about one or more elements of the problem situation. This 'cognitive learning' resulted in convergence of perceptions, although they did not become identical.

7.1.5 Outcome of a decision-making process

In this research, it was analyzed how a decision-making approach influences the formulation of a problem-solution combination (**RQ5**). A problem-solution combination, or the joint formulation of the problem and its solutions, is the substantive outcome of a decision-making process in which various knowledge sources and actors with diverging perceptions are brought together. We conclude that - for complex, unstructured problems - an analytical decision-making process does not lead to an agreed upon problem-solution combination. This was concluded from the case study on the impact assessment for Mainport Rotterdam, as well as from the comparative experiment.

From this research, it can be concluded that a participatory process leads to a joint problem-solution combination, which results from *cognitive and strategic learning*. This was illustrated by the Delta case study and the comparative experiment. In the experiment, the participatory project teams created an agreed upon growth strategy for Schiphol Airport, by taking into account the knowledge and perceptions of relevant actors. In the discussion on sustainable development of the Delta-region, the actors' perceptions did not become identical. However, at the end of the process the actors involved did jointly formulate a solution, which was due to the fact that they learned about their position in the network and their dependency upon other actors in the region.

7.1.6 Dealing with ambiguity and uncertainty through learning processes

In this section, we draw conclusions on the main research question of this thesis, which reads as follows: *How can divergent actors' perceptions and knowledge uncertainty in decision-making processes for complex water management problems be dealt with to reach a valid and agreed upon problem-solution combination?*

The main conclusion of this research is that: to deal with knowledge uncertainty and ambiguity due to diverging actors' perceptions, it is necessary to create and go through a learning process with several actors. We distinguish between cognitive and strategic learning, both of which are essential in creating a joint problem-solution combination. In this research, we found that it is important to involve a variety of actors in the process of problem structuring and stimulate them to reflect upon the problem and their problem perception. Furthermore, it is crucial to let actors add their own (implicit) practical or expert knowledge to the (explicit) knowledge base and interact with other actors.

During a process of problem structuring, the perceptions of actors develop as a result of learning processes. As each actor contributes its knowledge to the knowledge base and reflects upon it, this increases its knowledge on the nature of the problem. This is the result of cognitive learning. Also, by interacting with other actors involved in the problem, negotiation takes place on objectives and solutions and actors learn about their mutual dependences, which results from strategic learning. Thus, a process of 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. Our findings form an argument for practitioners in water management to choose a learning approach in problem structuring. In general, we state that structuring and solving water management problems benefits from learning processes.

7.2 Recommendations for further research

We recommend two directions for further research. Firstly, investigating the process of problem structuring in other countries than the Netherlands, especially countries where Dutch companies and governmental organizations are active, would be very valuable. This is in line with the recently launched Water Vision of the Dutch government (Ministerie van Verkeer en Waterstaat, 2007). One of the spearheads in this vision is the sharing and export of expertise in the field of delta technology. Delta technology concerns the land-water interface including coastal management, river basin management and spatial planning. The Ministry describes that applying this expertise abroad may contribute both to the national economy and to the achievement of the Millennium Development Goals. Although the Netherlands enjoys a worldwide reputation in delta technology, the water sector is having difficulties to retain and expand its share of the global market. To boost the water sector's export position it is important to strengthen the capacity of the Netherlands to innovate. The innovation capacity is encouraged among others through expansion of the domestic market for delta technology and by gaining experiences in solving the world's water problems. Furthermore, the Water Vision stresses that foreign countries do not only have an interest in concrete Dutch products and techniques (e.g. building of new dikes and storm surge dams in New Orleans), but even more so in the way water management is organized in the Netherlands (Ministerie van Verkeer en Waterstaat, 2007). In the Netherlands, we gained a lot of expertise on participatory processes, like for instance the Delta case study presented in this thesis. However, effectively applying this Dutch expertise abroad can be difficult, as it strongly depends on institutional capacity, cultural settings and available technologies and many other factors that differ greatly between countries. Therefore, we recommend investigating the application of Dutch expertise in other countries.

Secondly, further research into the linkage between processes of problem structuring and its institutional context and power issues is also recommended. The Contextual Interaction Theory (CIT) by Bressers (2004) provides a useful theory to include the aspect of power. The basic assumption of CIT is that the course and outcomes of a policy process depend not only on inputs, but more crucially on the characteristics of the actors involved, particularly their motivation, information, and capacity and power resources (Bressers, 2004). The aspects of motivation and information are already included in this research, by focussing on the creation of a knowledge base and the development of actors' perceptions. The element of capacity and power resources is not yet included. The framework for social learning (see e.g.: Mostert et al., 2007; Pahl-Wostl et al., 2007) can also be helpful to study the linkage between problem structuring and the institutional context.

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SUMMARY

Water is of vital importance for human life. Civilization has historically flourished around large-scale water systems, like rivers, estuaries and coastal zones. For centuries, people have altered the natural flows of these water systems, for example by the construction of dikes, seawalls and reservoirs. These interventions are designed to improve the well-being of people, for example by increasing protection against flooding, improving environmental quality or stimulating the national economy. In the Netherlands, policy and decision-making for water management has a long history, starting as early as the 11th century when regional water-boards were established. In the centuries that followed, water management developed from a technical approach, e.g. building dikes for protection against flooding, to integrated and participatory management, where different aspects, values and actors are extensively taken into account. So, making plans for human interventions in water systems is no longer only a technical issue, but has become more and more a societal issue too. Decision-makers involved in these kind of interventions have to make trade-offs to balance different interests, like societal aspects, economic costs and benefits, physical effects, ecological effects. At the same time, they operate within a complicated web of interactions between policy, regulations and social and political processes. So, management of large-scale water systems is embedded in a natural and social system that is characterized by complexity, uncertainty and disagreement between actors. Consequently, water management issues are often examples of unstructured problems for which the knowledge base is uncertain and no consensus on values and norms exists.

In this thesis, we investigate how a decision-making process, for a complex water management issue, influences the creation of a knowledge base, the development of actors' perceptions and the formulation of a problem-solution combination. 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. At first sight, uncertainty in a knowledge base can be reduced by providing more relevant or more adequate information. This is the case for epistemic uncertainty, which is uncertainty due to imperfect knowledge of the system and can in principle be reduced with the necessary time and means. However, new information can 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.

Water management problems involve many different actors. These various actors hold, produce and value knowledge that differs in both content and orientation; this contributes to their perception of a problem situation. We distinguish between two types of knowledge: expert (or scientific) knowledge; and practical (lay or non-scientific) knowledge. The involvement of various actors results in ambiguity since actors have diverging and sometimes conflicting perceptions of the problem. Actors' perceptions are based on frames. These frames function as filters through which information or a problematic situation is interpreted.

A problem-solution combination, or the joint formulation of the problem and its solutions, is the substantive outcome of a decision-making process in which various knowledge sources and actors with diverging perceptions are brought together. It includes the following three elements: description of present and future situation; definition of criteria and objectives; and definition of direction(s) for solutions. There are many different approaches to decision-making processes. We can distinguish two 'extremes': the analytical decision-making approach and the participatory decision-making approach. In the analytical approach, decision-making is based on rationality and objectivity. This process can be conceptualized by the phase model and is not-interactive, i.e. it assumes one steering actor. On the other hand, participatory decision-making is interactive. During the process several actors contribute to problem structuring. This process can be described by the rounds model.

We investigated three case studies, two explorative case studies from practice and a comparative experiment. The first case study focuses on the decision-making process for the extension of Mainport Rotterdam, which is one of the largest ports in the world. The Dutch government wants to expand the Mainport by land reclamation in the North Sea. This may affect the Wadden Sea, a unique wetlands area protected by the European Bird and Habitat Directives. To assess the impact of the port extension on the Wadden Sea, an Appropriate Assessment procedure was carried out. This process can be characterized as an *analytical decision-making process*. The second case study focuses on the sustainable development of ecology, economy and society in the Delta region, in the southwest of the Netherlands. In several areas in this region the ecological quality has decreased due to engineering works for storm surge 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 these dynamics could affect other user functions, like agriculture in the area. This topic has been addressed in a pilot-project, which was used as a second case study in this thesis. This project is a typical example of a *participatory decision-making process*. In our third case study, two decision-making processes are compared using an experimental setup. The comparison between the two decision-making processes was carried out within the framework of a multidisciplinary design project for Civil Engineering Bachelor-students of the University of Twente. In this project, the project teams (consisting of students) focused on the extension of Schiphol Airport on an island in the North Sea. The project teams were divided into two types of groups, which followed a different approach, the *analytical* or the *participatory decision-making approach*.

In this thesis, we found that an analytical decision-making approach runs the risk of producing knowledge that does not answer the questions that arise from a variety actors involved in the problem. From a decision-making point of view, this is superfluous knowledge. This is illustrated by the case study on the impact assessment for the extension of Mainport Rotterdam. In this case study, a lot of new knowledge was produced. However, this knowledge was not necessary to solve the problem of the actors that objected to the extension of the Mainport as it did not match with their interest and their problem perception. Furthermore, we conclude that a participatory decision-making approach is likely to produce knowledge which (partly) meets the diverging actors' interests. This was observed in the discussion on sustainable development in the Delta region in the southwest of the Netherlands. At the start of this process several actors did not agree on what the problem and its solution(s) were. However, during the process of problem structuring their perceptions of the problem and its solutions got closer to each other and finally led to an agreement among different actors, i.e. negotiated knowledge was created.

We conclude that the analytical decision-making approach does not enhance the convergence of actors' perceptions. This approach does not sufficiently take diverging actors' perceptions into account, which may lead to knowledge conflicts and 'dialogues of the deaf'. This was observed in the impact assessment for Mainport Rotterdam, where diverging actors' perceptions existed, but not all relevant actors were involved in the process. Therefore, these diverging perceptions could not converge. Furthermore, we conclude that a participatory approach, which stimulates actors to reflect upon and contribute to the knowledge base, enhances convergence of perceptions. In the Delta-region case study, actors' perceptions also diverged. However, in this case study we observed that the actors successfully learned about one or more elements of the problem situation. This *cognitive learning* resulted in convergence of perceptions, although they did not become identical.

For complex, unstructured problems an analytical decision-making process does not lead to an agreed upon problem-solution combination. This is concluded from the case study on the impact assessment for Mainport Rotterdam, as well as from the comparative experiment. On the other hand, it can be concluded that a participatory process does lead to a joint problem-solution combination, which results from *cognitive* and *strategic learning*. This is illustrated by the Delta case study and the comparative experiment. In the experiment, the participatory project teams created a growth strategy for Schiphol Airport, by taking into account the knowledge and perceptions of relevant actors, which lead to agreement among the different actors. In the discussion on the sustainable development of the Delta-region the actors involved also jointly formulate a solution, although the actors' perceptions did not become identical. This agreement about the solution can be attributed to the fact that they learned about their position in the network and their dependency upon other actors in the region (*strategic learning*).

The main conclusion of this research is that to deal with knowledge uncertainty and ambiguity due to diverging actors' perceptions – for complex water management issues – it is necessary to create and go through a learning process with several actors. We distinguish between cognitive and strategic learning, both of which are essential in creating a joint problem-solution combination. In this research, we found that it is important to involve a variety of actors in the process of problem structuring and stimulate them to reflect upon the problem and their problem perception. Furthermore, it is crucial to let actors add their own (implicit) practical or expert knowledge to the (explicit) knowledge base and interact with other actors. During a process of problem structuring, the actors' perceptions develop as a result of learning processes. As each actor contributes its knowledge to the knowledge base and reflects upon it, this increases its knowledge on the nature of the problem. This is the result of cognitive learning. Also, by interacting with other actors involved in the problem, negotiation takes place on objectives and solutions and actors learn about their mutual dependences, which results from strategic learning. Thus, a process of 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. Our findings form an argument for practitioners in water management to choose a learning approach in problem structuring. In general, we state that structuring and solving water management problems benefits from learning processes.

SAMENVATTING

Water is van levensbelang voor mensen. Sinds jaar en dag leven mensen in de buurt van grootschalige watersystemen, zoals rivieren, estuaria en kustgebieden. Ook worden al eeuwenlang fysieke ingrepen in deze watersystemen gedaan door de mens, zoals de aanleg van dijken, zeeweringen en reservoirs. Deze ingrepen zijn er op gericht om het welzijn van de mens te verbeteren, bijvoorbeeld door onszelf te beschermen tegen overstromingen, door de ecologische kwaliteit van het water te verbeteren of door de economie te stimuleren. In Nederland heeft beleid- en besluitvorming op het gebied van waterbeheer een lange traditie, die begon toen in de 11e eeuw de regionale waterschappen gevormd werden. In de eeuwen die daarop volgden heeft het waterbeheer zich ontwikkeld van een technische aanpak, zoals het bouwen van dijken tegen overstroming, naar integraal en participatief beheer, waarbij waarden en actoren nadrukkelijk in beschouwing worden genomen. Het maken van plannen voor menselijke ingrepen in watersystemen is dus niet langer alleen een technische kwestie, maar is ook steeds meer een sociale kwestie geworden. Voordat een bepaalde ingreep kan worden geïmplementeerd moet er een afweging gemaakt worden tussen verschillende belangen, zoals maatschappelijke aspecten, economische kosten en baten en de fysische en ecologische effecten van de ingreep. Betrokken besluitvormers moeten deze afweging maken. Bovendien bevinden zij zich in een gecompliceerd web van interacties tussen beleid, regelgeving en sociale en politieke processen. Het beheren van grootschalige watersystemen vindt plaats in een complex natuurlijk en sociaal systeem, dat gekenmerkt wordt door onzekerheid, ambiguïteit en onenigheid tussen actoren. Daarom zijn waterbeheervraagstukken meestal voorbeelden van ongestructureerde problemen, waarvoor de kennisbasis onzeker is en er geen consensus over waarden en normen bestaat.

In dit proefschrift onderzoeken wij hoe een besluitvormingsproces – voor een complex waterbeheervraagstuk – het creëren van een kennisbasis, de ontwikkeling van actorenpercepties en het formuleren van een probleem-oplossing combinatie beïnvloedt. Een kennisbasis is een verzameling van kennisbronnen (onderzoeksrapporten, modellen, data, praktijkervaringen, etc.), die expliciet gemaakt zijn voor en gerelateerd zijn aan een bepaalde probleemsituatie. Op het eerste gezicht kan onzekerheid in deze kennisbasis gereduceerd worden door meer adequate of meer relevante informatie te vergaren. Dit is het geval bij epistemologische onzekerheid. Deze onzekerheid wordt veroorzaakt door onvolledige

kennis van het systeem en kan in principe teruggebracht worden wanneer voldoende tijd en middelen voor handen zijn. Maar nieuwe informatie kan de onzekerheid ook doen nemen indien blijkt dat bepaalde onzekerheden nog niet bekend waren of groter blijken dan tot dan toe aangenomen werd. Daarom kan een strategie die gericht is op het reduceren en controleren van onzekerheden soms zelf averechts werken, wanneer onzekerheden niet gereduceerd kunnen worden. Dit is het geval bij zogenaamde ontologische onzekerheid, welke veroorzaakt wordt door de variabiliteit in het systeem.

Bij waterbeheervraagstukken zijn veel verschillende actoren betrokken. Al deze actoren beschikken over kennis. Verder produceren en waarderen zij kennis op verschillende manieren. Dit draagt bij aan hun perceptie van een probleemsituatie. We onderscheiden twee typen kennis: expert (of wetenschappelijke) en praktische (niet-wetenschappelijke) kennis. Het feit dat er veel verschillende actoren betrokken zijn bij watervraagstukken resulteert in ambiguïteit, omdat actoren divergerende en soms conflicterende percepties van het probleem hebben. Percepties van actoren zijn gebaseerd op denkkaders. Deze kaders functioneren als een filter of bril waardoor bepaalde informatie of een bepaalde probleemsituatie geïnterpreteerd wordt.

Een probleem-oplossing combinatie, oftewel een gezamenlijke formulering van het probleem en bijbehorende oplossingen, is de inhoudelijke uitkomst van een besluitvormingsproces waarin verschillende kennisbronnen en actoren met divergerende percepties bij elkaar gebracht zijn. Het bestaat uit de volgende drie elementen: beschrijving van de huidige en toekomstige situatie; definitie van criteria en doelen; en formulering van oplossingsrichting(en). Er bestaan veel verschillende aanpakken voor besluitvormingsprocessen. Hierin kunnen we twee 'extremen' onderscheiden: de analytische besluitvormingsaanpak en de participatieve besluitvormingsaanpak. In de analytische aanpak wordt besluitvorming gebaseerd op rationaliteit en objectiviteit. Dit proces kan weergegeven worden door het fasenmodel en is niet interactief, het gaat namelijk uit van één centrale, sturende actor. Participatieve besluitvorming is echter wel interactief. Hierin dragen verschillende actoren bij aan het proces van probleemstructurering. Dit proces kan beschreven worden aan de hand van het rondenmodel.

We hebben drie casussen onderzocht, twee praktijkcasussen en een vergelijkend experiment. De eerste casus richt zich op het besluitvormingsproces voor de uitbreiding van de Rotterdamse haven, één van de grootste havens ter wereld. De overheid wil de haven uitbreiden door landaanwinning in de Noordzee (tweede Maasvlakte). Deze landaanwinning zou effect kunnen hebben op de Waddenzee, een uniek natuurgebied dat beschermd wordt door de Europese vogel- en habitatrichtlijn. Door middel van een procedure genaamd ‘Passende Beoordeling’ is het effect van de uitbreiding op de Waddenzee onderzocht. Dit proces heeft de karakteristieken van een *analytisch besluitvormingsproces*. De tweede casus heeft als onderwerp de duurzame ontwikkeling van ecologie, economie en maatschappij in de Zeeuwse Delta. De ecologische kwaliteit in dit gebied is sterk achteruitgegaan na de aanleg van de Deltawerken. De overheid beschouwt het terugbrengen van estuariene dynamiek (zoet-zout overgangen) als de belangrijkste oplossing voor dit ecologische probleem. Het terugbrengen van deze estuariene dynamiek kan echter gevolgen hebben voor andere gebruiksfuncties, zoals de landbouw in dit gebied. Dit was het onderwerp van een pilot-project, dat gebruikt is als tweede casus in dit proefschrift en een typisch voorbeeld is van een *participatief besluitvormingsproces*. In de derde casus zijn twee besluitvormingsprocessen met elkaar vergeleken aan de hand van een experimentele opzet. Het multidisciplinaire ontwerpproject voor Bachelor studenten Civiele Techniek van de Universiteit Twente is als raamwerk gebruikt voor de vergelijking van deze besluitvormingsprocessen. In dit project werkten de projectteams (bestaande uit studenten) aan de uitbreiding van Schiphol op een eiland in de Noordzee. De projectteams waren opgedeeld in twee soorten groepen, welke ieder een andere aanpak volgde: de *analytische* of de *participatieve besluitvormingsaanpak*.

In dit proefschrift hebben we gevonden dat een analytische besluitvormingsaanpak het gevaar loopt om kennis te produceren die de vragen van de verschillende betrokken actoren niet kan beantwoorden. Vanuit het perspectief van besluitvorming is deze kennis dus overbodig. Dit wordt geïllustreerd in de casus over de uitbreiding van de Rotterdamse haven. In deze casus werd veel nieuwe kennis vergaard voor de effectbeoordeling. Deze kennis was echter niet bruikbaar om het probleem van de bezwaarmakers op te lossen, doordat het niet overeen kwam met de belangen en de probleemperceptie van deze actoren. Aan de andere kant kunnen we concluderen dat een participatief besluitvormingsproces kennis produceert die wel (gedeeltelijk) voldoet aan de divergerende actoren belangen. Dit resulteert namelijk in zogenaamde onderhandelde kennis. Dit werd waargenomen tijdens de discussie over de duurzame ontwikkeling van de Zeeuwse Delta. Aan het begin van het proces waren de verschillende actoren het niet eens over wat het probleem en de bijbehorende oplossing(en) waren. Echter, gedurende het proces van probleemstructurering kwamen hun percepties over het probleem en de oplossingen nader tot elkaar en dit leidde uiteindelijk zelfs tot een overeenkomst tussen actoren, hetgeen een voorbeeld van onderhandelde kennis is.

We kunnen concluderen dat een analytisch besluitvormingsproces de convergentie van actorenpercepties niet stimuleert. Deze aanpak neemt de verschillende divergerende actorenpercepties niet voldoende mee, waardoor kennisconflicten ontstaan en actoren langs elkaar heen praten. Dit hebben we gezien in de casus van de effectbeoordeling voor de Rotterdamse haven, waar actorenpercepties sterk uiteen liepen, maar niet alle relevante actoren betrokken waren bij het proces. Hierdoor konden de percepties ook niet convergeren. Een participatieve besluitvormingsaanpak, waarin actoren gestimuleerd worden om te reflecteren op en bij te dragen aan de kennisbasis, leidt juist wel tot het convergeren van percepties. In de casus van de Zeeuwse Delta bestonden ook verschillende divergerende actorenpercepties. Tijdens deze casus hebben we echter gezien dat actoren leerden over één of meerdere elementen van het probleem. Dit *cognitieve leren* resulteerde er uiteindelijk in dat hoewel de percepties niet identiek werden ze wel dichter bij elkaar kwamen.

Voor een complex, ongestructureerd probleem leidt een analytische besluitvormingsaanpak niet tot een probleem-oplossing combinatie waarover overeenstemming bestaat bij verschillende actoren. Dit wordt geconcludeerd uit de casus over de effectbeoordeling van de Rotterdamse haven en uit het vergelijkende experiment. Uit het onderzoek blijkt ook dat een participatieve besluitvormingsaanpak wel leidt tot een gezamenlijk geformuleerde probleem-oplossing combinatie, die tot stand komt door *cognitief* en *strategisch leren*. Dit wordt geïllustreerd door de Delta-casus en het vergelijkende experiment. In het experiment formuleerden de participatieve projectteams een groeistrategie voor Schiphol door de kennis en percepties van de relevante actoren mee te nemen. Dit leidde tot overeenstemming, over de groeistrategieën, bij de verschillende actoren. Bij het proces over de duurzame ontwikkeling van de Zeeuwse Delta formuleerden de betrokken actoren, ondanks dat hun percepties niet gelijk waren, een oplossing waar overeenstemming over bestond. Dit wordt toegeschreven aan het feit dat zij geleerd hebben over hun positie in het netwerk en hun afhankelijkheid van andere actoren in het gebied (*strategisch leren*).

De hoofdconclusie van dit onderzoek is dat om bij complexe waterbeheervraagstukken om te kunnen gaan met onzekerheid in kennis en ambiguïteit door divergerende actorenpercepties, het essentieel is om een leerproces te creëren en te doorlopen met verschillende actoren. We maken onderscheid tussen cognitief en strategisch leren, welke beiden van belang zijn voor het verwezenlijken van een gezamenlijk geformuleerde probleem-oplossing combinatie. In dit onderzoek hebben we geconstateerd dat het belangrijk is om diverse actoren te betrekken in het proces van probleemstructurering en hen te stimuleren om te reflecteren op het probleem en hun eigen probleemperceptie. Verder is het cruciaal om actoren hun (impliciete) praktische of expert kennis bij te laten dragen aan de (expliciete) kennisbasis en om hen in contact te laten komen met andere actoren. Wanneer elke actor zijn/haar kennis bijdraagt aan de kennisbasis en er op reflecteert, neemt zijn/haar kennis van de kenmerken van een probleem toe. Dit komt door cognitief leren. Verder zullen actoren, doordat ze in contact komen met elkaar en leren over hun onderlinge afhankelijkheden, gaan onderhandelen over de doelen en oplossingen voor hun probleem. Dit wordt veroorzaakt door strategisch leren. Dus, een proces van probleem structurering is gebaseerd op de volgende ideeën: 1) interactie en communicatie tussen actoren met verschillende percepties tot stand brengen; 2) verschillende percepties verbinden met de onzekere kennisbasis. Onze bevindingen vormen een argument voor praktijkmensen in het waterbeheer om een lerende aanpak voor probleemstructurering te kiezen. Wij zijn er van overtuigd dat leerprocessen het structureren en oplossen van waterbeheervraagstukken ten goede komt.

List of abbreviations

CPD+	Core Planning Decision-plus (Dutch: Planologische Kernbeslissing-plus, PKB+)
DPSIR	Driver-Pressure-State-Impact-Response
EIA	Environmental Impact Assessment
LNV	Dutch Ministry of Agriculture, Nature and Food Quality
NACO	Netherlands Airport COnsultants
OECD	Organisation for Economic Co-operation and Development
RQ	Research Question
SWOT	Strengths, Weaknesses, Opportunities and Threats
VOC	United East India Company
VROM	Dutch Ministry of Spatial planning, Housing and the Environment
V&W	Dutch Ministry of Transport, Public Works and Water Management
VZ-lake	Volkerak-Zoom lake
WS	Workshop

ABOUT THE AUTHOR

Saskia Hommes was born on 15 January 1980 in the city of Roermond, The Netherlands. In 1985, her family moved to the Flevopolder, where she finished her pre-university education (VWO), at the Scholen Gemeenschap Lelystad in 1998. In the period from 1998 till 2004 she studied Civil Engineering & Management at the University of Twente. She did a Master in Water Engineering & Management. From April to July 2002, Saskia conducted an internship at the Universitat Politècnica de Catalunya (UPC) in Barcelona, Spain. The objective of this internship was to investigate the influence of different wave conditions on the migration of long shore ridges. From July 2003 till February 2004, Saskia carried out her Master thesis at the National Institute of Coastal and Marine Sciences (RIKZ[50]) in The Hague. The objective of this Master thesis was to make an inventory of instruments that can be used to predict the long-term physical effects of large-scale offshore sand extraction, in order to support the Dutch decision-making process. This research has been published in the Journal of Coastal Research (Hommes et al., 2007). From June 2004 until October 2008, Saskia has been employed at the department of Water Engineering & Management as a PhD-researcher. During this period she gave several presentations at international conferences: Physics of Estuaries and Coastal Seas (Mexico, 2004), European Forum for Integrated Environmental Assessment (Germany, 2005), International Symposium on Integrated Coastal Zone Management (Norway, 2007), The Coastal Society's 21st Biennial Conference (USA, 2008). Saskia was also involved in teaching courses (Water, Multidisciplinary design project) and supervising Master students. Besides that she organized several activities: PhD theme day for Dutch Centre of River Studies (2005), Batavierenrace for the Civil Engineering team (2005), department's yearly activity (2005), Bachelor information days for Civil Engineering (2005 – 2007) and lunch presentations (2005 – 2007). Saskia will stay employed at the University of Twente as a Post-doc researcher/Assistant professor until September 2009.

[50] From January 2008 RIKZ has transferred into Deltares and Waterdienst.

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