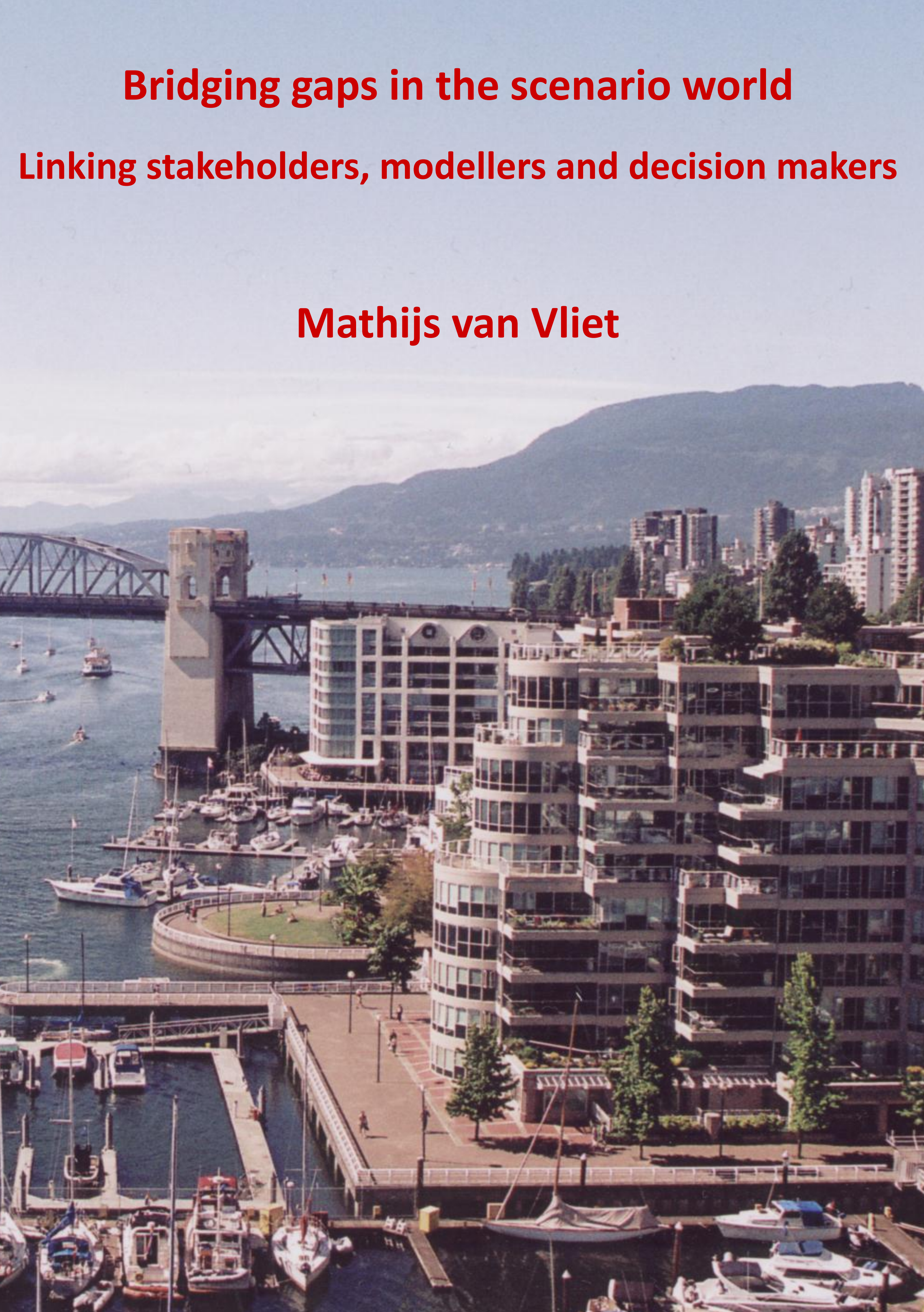
Bridging gaps in the scenario world

Linking stakeholders, modellers and decision makers

Mathijs van Vliet



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Thesis

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Prelude

The title of this thesis is "Bridging gaps in the scenario world". Before starting, it would be good to reflect a bit on the function of bridges; why would someone want to build a bridge? Bridges are built to connect two parts of the world. In general, they are only build when the bridge will have an added value. These added values are, for instance, that people from both sides can get together and exchange goods, knowledge, and ideas.

The same holds for the bridges we have build in the scenario world, we build them because we saw an added value in connecting parts of the scenario world. Furthermore, by connecting different parts in the scenario world these bridges also link to people outside the scenario world. Although it is not 'rocket science' in the sense that rockets are build, it does help to link different worlds; the worlds of social scientist, modellers, stakeholders, and decision makers.

The added value of building the bridges described in this thesis is twofold; develop better scenarios and bring different communities in contact with each other. By connecting different parts of the scenario world the quality of the scenario should increase. By bringing different communities together people can learn from each other and discover new solutions to our problems. Hopefully this can help to make our world a little better.

Chapter 1

General Introduction

1. General introduction

In this introduction an overview will be given of the scenario world; what are the concepts and practices of scenarios, why are they used, what are the gaps in the scenario world that need to be bridged, and why should they be linked?
As this thesis is written from a participatory scenario perspective, it is important to introduce stakeholder participation and its added value in scientific projects. The last part of this introduction introduces the European project as part of which the research for this thesis was conducted: SCENES; Water Scenarios for Europe and Neighbouring States.

1.1. Scenario theory

1.1.1. What are scenarios?

There are many definitions of scenarios. According to the Oxford Dictionary a scenario is "*a written outline of a film, novel, or stage work giving details of the plot and individual scenes*" or "*a postulated sequence or development of events*" or "*a setting, in particular for a work of art or literature*". The second definition best fits the type of scenarios that will be discussed in this thesis. Perhaps the simplest definition of this type of scenarios is: "*scenarios are descriptions of (…) possible futures*" (UNEP, 2002). As the definitions from the Oxford Dictionary show, the word scenario is derived from the dramatic arts in which it is the outline of the play. In the early days of travelling theatre performances, a scenario was the outline of the play that was literally pinned to the back of the scenery. The use of scenarios as descriptions of possible futures started with military projects. During the Manhattan project (1940's) scenarios were developed to explore and analyse the effects of the hydrogen bomb, as some scientists were afraid that the bomb could literally ignite the skies (Schoemaker, 1993; Xiang and Clarke, 2003). A decade later the Rand Corporation developed scenarios for strategic planning of military actions (see Kahn and Wiener, 1967). In the 1970s industries started to use scenarios to plan companies' strategies. A famous example is the use of scenarios by Royal Dutch/Shell that developed scenarios in which an oil shortage was envisioned before the oil crisis (see box 1 and e.g. Schoemaker and Heijden, 1992). During the oil crisis Shell was therefore more prepared than other oil companies, becoming market leader in a short period of time. Another well-known example of successful application of scenarios are the Mont Fleur scenarios that are said to have helped ending apartheid (see Kahane, 1998; Website Mont Fleur, 2011).

One of the first scientific scenarios was the Limits to Growth study in 1972 (Meadows et al., 1972). Currently there are many scenario projects in different fields, such as socio-environmental systems (Millennium Ecosystem Assessment, 2005a), global environmental assessments (UNEP, 2002), European mountain landscapes (Soliva et al., 2008), land degradation and desertification in the Mediterranean (MedAction, e.g. Kok et al., 2006b), environmental policy making (Svenfelt et al., 2010), future land use (EURALIS, e.g. Verburg et al., 2006), rural land use and biodiversity (Rounsevell et al., 2006) and energy use (Giurco et al., 2011; Svenfelt et al., 2011).

Box 1; Shell scenarios

Shell was some of the first companies to use scenarios. Planners at Shell looked for events that might affect the price of oil. During their analysis they found out that the USA was beginning to exhaust its oil reserves while its demand for oil was increasing. At the same time the OPEC was getting stronger. The OPEC resented the Western support of Israel after the 1967 six-day war. It occurred to the planners that the OPEC could increase oil prices to harm the west. The planners developed two scenarios (including storylines and oil price figures). The first one represented the common ideas within Shell; that oil prices would remain relatively stable. It showed that new oil fields were needed, also outside the Arab countries. The other scenario showed an oil price crisis sparked by OPEC. They showed these scenarios to the management, but this did not led to a change in behaviour.
The planners then described the scenarios in more detail, including the consequences of a possible oil price shock. They showed the management how an oil crisis would make the oil industry a low growth industry. They told them how OPEC countries could take over Shell's oil fields. By describing the forces and possible influences of those forces they could convince the management that other futures than the expected stable prices could happen and that the effects could be enormous. Then the management started to think about possible actions they should take if an oil crisis would occur. Not too long after, in 1973, an oil crisis occurred and Shell was the only of the major oil companies that, was prepared for such an event. It could therefore respond more quickly and grew from one of the smallest of the seven large oil companies to the second in size and the number one in profitability. (Mietzner and Reger, 2005)

The origin of scenarios in the arts can still be noticed in the present day and some authors continue to see scenario development more as an art than a science. Schwartz, for instance, named his book on scenarios "*The art of the long view*" (Schwartz, 1996) and Van der Heijden named his book "*Scenarios: the art of strategic conversation*" (van der Heijden, 1996). Even though some consider it an art, many scientific articles have been written on scenarios. A search in Science Direct resulted in 360,736 articles (Website ScienceDirect, 2010) a search in Google scholar to no less than 2,230,000 (Website Google scholar, 2010). These scientific articles, however, do not help unravelling what scenarios are as they contain a large diversity of definitions of scenarios. One of the reasons for the large diversity is the "*fuzziness of the scenario field in terms of 'schools' [and] approaches*" (Mutombo and Bauler, 2009). There is no such thing as *the* scenario, but a whole range of possible scenario types. Each 'school' has their own ideas about what a scenario is. Some groups use scenarios as decision support or planning approach (e.g. Harries, 2003; Shearer, 2005; Eisenack et al., 2006), others as tool to bring different communities together (e.g. Weisbord and Janoff, 1995; Wollenberg et al., 2000; Evans et al., 2006a). Some groups consider different model runs to be scenarios, some develop scenarios in a highly normative manner and mainly look for desired futures while others try to explore all kind of possible futures. This last group states that scenarios are not predictions (best possible estimate of future developments), nor forecasts (best estimate derived with a model or other method) (Rothman et al., 2007). In this thesis I will use their notion of scenarios in which "*scenarios describe futures that could be, rather than futures that will be*"(Peterson et al., 2003).

1.1.2. Reasons for using scenarios

It has been said that the world is changing rapidly; social, natural and physical systems are increasingly connected and societies are getting more complicated (Gallopín, 2002). This results in a high level of complexity and uncertainty which makes it close to impossible to predict. Because uncertainty further increases with time there is a need to describe and analyse multiple possible futures, instead of focusing on predicting one single outcome, in order to capture the uncertainty (Peterson et al., 2003; Biggs et al., 2007). Complex problems cannot be studied outside their context; both socio-economic as well as environmental influences have to be taken into account. An integrated approach is therefore needed. Scenarios can form such an integrated approach and they are good for cases where complexity and uncertainty are high (Schoemaker, 1993).

Again different groups have different ideas about scenarios. Social scientists often see scenarios as tools that facilitate imaginative thinking and stimulate people to think out-of the box; *"to step outside of conventional ways of understanding an issue"* (Soliva et al., 2008). They focus more on the idea that scenarios should be credible, challenging, and relevant to stakeholders and end-users. Natural scientists tend to focus more on the need for scenarios to be based *"on a coherent and internally consistent set of assumptions about key driving forces and relationships"* (Millennium Ecosystem Assessment, 2005a).

Box 2; East Berlin

"What would happen if the Wall were taken down?"
Erhard Krack, Mayor Of East Berlin, thumped his fingers on the polished wood of his desk. "What you are asking," he replied with agitation, "is a philosophic question. Let us get back to reality." (Vesilind, 1982)

Seven years later, the Berlin Wall fell.

Besides capturing uncertainty and complexity, scenarios are used for a variety of reasons: to expand people's thinking by widening the range of alternatives considered, challenge mental models, spur creativity, study one's understanding of the world, test strategies for robustness and stimulate discussion (eg. Schoemaker, 1993; van der Heijden, 2000; Xiang and Clarke, 2003; Jäger et al., 2006). Scenario development is used as much to address current challenges as to study the future as such (Mutombo and Bauler, 2009).
Also from the psychological viewpoint there are good reasons for using scenarios. Xiang and Clarke (2003) state that scenarios can help in the process of 'chunking'; integrating small pieces of information in a larger framework so that the information becomes meaningful. Narratives can incorporated complex elements and forming them to a coherent and comprehensive story that is relatively easy for people to remember (Pennington and Hastie, 1988; Schoemaker, 1993; Mietzner and Reger, 2005). Narratives can help to balance between the need for simplification and complexity (Mutombo and Bauler, 2009).

Last but not least, scenarios have a bridging function as they can be used to bring different communities together (Xiang and Clarke, 2003). This bridging function between communities is one of the reasons why stakeholders are often involved in the development of scenarios (Wollenberg et al., 2000).

1.1.3. *Different types of scenarios*

Given the variety of definitions and reasons to use scenarios it is not surprising that there is also a wide variety of different scenario types. Several authors have developed typologies to provide an overview of the field (e.g. Dammers, 2000; Van Notten et al., 2003; Mietzner and Reger, 2005; Börjeson et al., 2006). Dammers (2000) discerns five characteristics: the width of the scenario topic (sectoral vs. integrated), the level of aggregation (micro, meso or macro), the direction of time (from present to future, or working backwards from the future), the amount of exploration (from only the dominant perspective to highly exploratory), and the focus of action (environmental vs. policy scenarios). Börjeson et al. (2006) base their classification on the questions that users can pose about the future: what will, what can or what should happen? They discern three main types of scenarios; predictive, explorative (or exploratory), and normative (see figure 1.1). Predictive scenarios try to find out what will happen in the future. There are two types of predictive scenarios: what-if scenarios predict what will happen if a specified event happens, while forecasts predict how the future will look like under the most likely developments.
Exploratory scenarios explore what can happen if a certain event occurs. External scenarios respond to external events, while strategic scenarios focus on the consequences of internal developments.
Normative scenarios focus on describing how a normative future objective or endpoint can be reached. They can either be preserving or transforming. In preserving scenarios the target is reached by adjustments to the current situation. In transforming scenarios changes are needed to overcome current structures that block the successful fulfilment of the target.

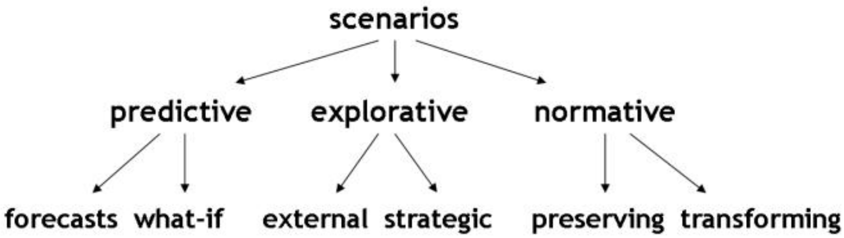

Figure 1.1; Scenario typology of Börjeson et al (based on Börjeson et al., 2006).

For some scenario projects it is hard to classify them within one of these categories, as they are rather broad. Van Notten et al. (2003) therefore developed another typology that is based on three overarching themes: project goal, process design and scenario content. These overarching themes are subdivided in characteristics (see table 1, first column).

Within this study we used three types of scenarios which can be characterised via the method of Van Notten as shown in table 1.1. These three types are: qualitative exploratory scenarios, quantitative exploratory scenarios and decision support scenarios. Both exploratory scenarios combine the external and strategic explorative scenarios in Börjesons typology, while the decision support scenarios best fit within their transforming, normative scenario type.

Qualitative exploratory scenarios are often developed in the form of storylines. Stakeholders are often asked to participate in the development as this can lead to the inclusion of new knowledge, expertise and insights. Quantitative scenarios are used because they can provide the "*numerical information needed by researchers for assessing the future state of (…) resources and by managers for making decisions about (resource) management*" (Kämäri et al., 2008). Transforming, normative scenarios are used to find solutions for long-term problems (Dreborg, 1996; Börjeson et al., 2006).

The three types of scenarios used in this thesis differ in two of the three overarching themes of Van Nottens typology: the project goal and process design (see also table 1.1). There are no differences in the third overarching theme of scenario content, as only complex scenarios have been used because of the complex nature of water related problems.

The project goal can be focussed more on exploration or more on decision support. Exploration includes aspects like awareness raising, creative thinking and increase understanding of the influence of social processes on each other (Van Notten et al., 2003). With exploration as goal the process is often as important as the result. In decision support scenarios the goal is to propose strategic options or pathways to an (often) desired future (Van Notten et al., 2003). The project output is more important, although the process remains important as well. The main target groups that are involved in the two scenario types differ. For exploratory scenarios stakeholder groups, modellers and experts are the main target group and they are often included in the scenario development process. For decision support scenarios decision makers and other stakeholders are the main target group.

The process design can be intuitive or formal. A formal design is mainly model based and leads to quantitative scenarios (Van Notten et al., 2003). Most work is done by the experts (to gather data) and modellers (to calculate scenario impacts) and is often done in the form of a desk study. An intuitive process design often includes participatory, qualitative scenario development (Van Notten et al., 2003). Different groups of stakeholders are asked to participate in the scenario development and share their knowledge and insights in a creative process.

1.1.4. Stakeholder participation

This thesis starts from the perspective of qualitative, participatory scenario development. Therefore a better understanding of what participation entails and why it is done. Stakeholders are involved in scenario development and many other processes, but their influence can differ largely depending on their role.

Stakeholders are involved in scenario development because scenarios deal with complex issues that require both analytical and intuitive understanding. When scenarios are developed and analysed with only mathematical models it can lead to a false sense of

Table 1.1; Scenario typology according to Van Notten et al. (based on Van Notten et al., 2003) including a characterisation of the three scenario types as used in this study

Overarching themes and characteristics	**Exploratory scenarios** qualitative	quantitative	**decision support scenarios**
Project goal *exploration vs decision support*	*exploration*		*decision support*
Inclusion of norms?: descriptive vs normative	descriptive		normative
Vantage point: forecasting vs backcasting	forecasting		backcasting
Subject: issue, area, institution-based	issue, area		issue, area
Time scale: long term vs short term	long term		short to middle term
Spatial scale: global vs national / local	pan-Europe/ region/local	mainly pan-Europe	pan-Europe/ region/local
Process design *intuitive vs formal*	*intuitive*	*formal*	*intuitive*
Data: qualitative vs quantitative	qualitative	quantitative	qualitative
Method of data collection: participatory vs desk research	participatory	mainly desk study	participatory
Resources: extensive vs limited	extensive (2 workshops)	extensive (modelling)	limited (1 workshop)
Institutional conditions: open vs constrained	open		open
Scenario content *complex vs simple*	*complex*		*complex*
Temporal nature: claim vs snapshot	chain		chain
Variables: heterogeneous vs homogenous	heterogeneous		heterogeneous
Dynamics: peripheral vs trend	peripheral		peripheral
Level of deviation: alternative vs conventional	alternative		alternative
Level of integration: high vs low	high		high

certainty and objectivity that is, because of the complexity and uncertainty, not possible (Strauss, 1987; Patel et al., 2007). Stakeholder participation can then lead to a common perspective that has a larger legitimacy. Schwartz even states that "*scenario making is intensively participatory or it fails"* (Schwartz, 1996). Participation encourages discussion and exchange of ideas and perspectives. There is also criticism on participatory processes, for instance that these processes are often limited, hide inequalities, and provide unrepresentative input (Cooke and Kothari, 2002 in Patel et al., 2007).

Participation can have different intensities. Arnstein (1969) developed the 'ladder of citizen participation' that encompasses eight levels of participation. On the one end of the spectrum there is citizen control, on the other manipulation. The lowest two levels are also referred to as degrees of non-participation. With the highest three levels stakeholders can influence the decisions being taken directly. With the middle three there is an exchange of information, but the final decision is taken by decision makers. In case of the two lowest there is no participation, on the contrary citizens are manipulated to change their behaviour. Arnsteins ladder (without the degrees of non-participation) has also been represented as a pyramid form illustrating that with increasing level of participation fewer people can participate (Hendriks et al., 1999). A questionnaire is, for instance, easier to send to many people, while a workshop cannot host more than a couple of dozen people.

While Arnstein mainly focuses on power relations, Mostert (2003) also includes other aspects like social learning. His overview consists of five steps. In the lowest level, called information, stakeholders are only informed on what a project contains or what the main results of a project were. In the case of consultation stakeholders are asked about their ideas which can than be used in the project (or not). With discussion there is a two way exchange of ideas, but the decisions are still made by the project. With co-decision making stakeholders are allowed to participate in the decision making process. The highest level of participation is that stakeholders can make their own decisions for the project.

In scenario development, often different levels of participation are used in different parts of the project. The main findings can, for instance, be disseminated to the public via scientific journals, local news (television and newspapers) and conferences, which is mainly on the level of information. During workshops there is a very high level of participation when participants develop the storylines themselves with no or very little interference from the project (decision making). The influence of stakeholders on quantitative scenarios is often much lower as the possibilities are constraint by the mathematical models (level of discussion).

Reasons for participation

Stakeholders are asked to participate in scenario development (and other) projects for a number of reasons. Stirling (2006) identified three reasons: the normative, substantive and instrumental reasons. Von Korff (2007) added the process of social learning as fourth category. A fifth category is empowerment (e.g. Chambers and Mayoux, 2004; Patel et al., 2007).

- The normative reason states that participation follows democratic principles and should therefore be used often, in order to prevent decisions to be made without reflecting the values of the public (von Korff, 2007).
- The use of participation can better legitimise the decisions taken in the end. It also ensures that scenarios are relevant for and credible to end-users (Kok, 2009). These form the instrumental arguments.
- Substantive arguments follow the line of reasoning that participation can lead to better-informed decisions, due to the inclusion of local knowledge (von Korff, 2007). Participation enriches the knowledge base with contextual knowledge and stakeholders opinions (van Asselt et al., 2001) and heterogeneity in perspectives,

expertise and knowledge (Stirling, 2006). It incorporates and balances the multiple interests of multiple actors, interactions and variables involved (Lynam et al., 2007).

- The fourth category is the process of social learning (von Korff, 2007). Active stakeholder involvement can provide an active learning arena for all who are involved (Kok et al., 2007b; Patel et al., 2007). In this way participation can generate important and surprising insights that contribute to the design of policies that are better suited to serve the needs of those concerned. The study is likely to have a larger impact on policy makers, end-users, and others involved, when their attitudes, beliefs, or preferences are considered in the identification of problems and the development of solutions (Ramirez, 1999; Lynam et al., 2007).
- Some participatory processes also aim to enhance the confidence of stakeholders; to empower them (Evans et al., 2006b). The process can help stakeholders to define, analyse and express their perceptions and ideas (Chambers, 2002). The importance of empowerment highly depends on the context and the project.

1.1.5. Added value of combining different scenario types

There is an added value in combining the different scenario types. Figure 1.2 shows the three different types of scenarios used in this research (qualitative exploratory scenarios, quantitative exploratory scenarios and decision support scenarios), the relations between them and the three communities that are primarily addressed by each scenario type.

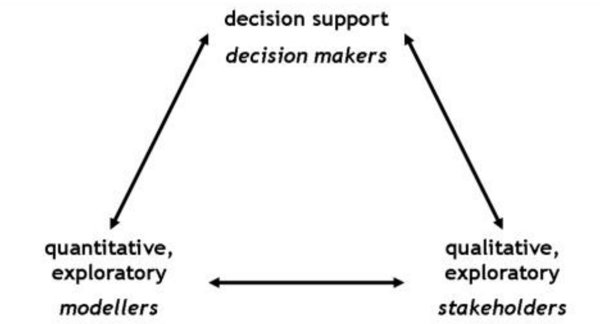

Figure 1.2; Three scenario types and involved communities and possible links between them.

Each of the three scenario types has their own strengths. Qualitative exploratory scenarios have the power to engage stakeholders, to bring creativity and to open up the mind to new alternatives. Quantitative scenarios give clear, numerical, information on changes. Decision support scenarios can aid to decision making processes and create a link back to the present.

The different scenario types also link to different communities, each of which represent a certain type of knowledge (Buizer et al., in press). Modellers base their expertise mainly on scientific knowledge which is based on systematic methods (Nowotny, 2003). Stakeholders bring their practical knowledge to the table. Practical knowledge is based on daily experiences and is context related (Eshuis and Stuiver, 2005). Decision makers

have bureaucratic or administrative knowledge, which includes a deep knowledge on bureaucratic and policy processes (Buizer et al., in press).
Each scenario also contributes to different scenario quality criteria. Alcamo and Heinrichts (2008) propose a list of criteria to assess the quality of scenarios. Others (e.g Clark et al., 2006; Mitchell et al., 2006; Albert, 2008; Vervoort et al., 2010) have worked with related criteria.

- Relevance/Salience; Are the scenarios relevant to the end users, other stakeholders and scientists? Do they address their concerns and needs?
- Credibility; Is the scenario recognisable from the present and how plausible is it? Do the stakeholders and end users believe they are plausible? Are assumptions and causalities compatible with current understanding? Were the models used to calculate the quantitative results credible?
- Legitimacy; Do the scenarios do justice to a wide range of ideas and political perspectives? Are the messages in the scenarios perceived to be fair by the different stakeholders and end users?
- Creativity; Do the scenarios challenge current views of the future, do they show implications of uncertain events? Do they challenge mental models?

These criteria link to several reasons for participation. Legitimacy and relevance link to the instrumental argument. Stakeholder involvement makes sure that also contextual knowledge is included, which increases the credibility. When scenarios are creative and challenge mental models it can lead to social learning.

Although, in principle every scenario type can fulfil all the quality criteria to some extent, each of them is better suited to reach some of the criteria better than the other (see table 1.2).

Table 1.2; Main relations between scenario types and scenario quality indicators.

scenario type	**credibility**	**relevance**	**legitimacy**	**creativity**
quantitative exploratory	X	x		
qualitative exploratory		x	X	X
decision support		X	x	

X: strong relation, x: relation

Quantitative scenarios are especially well suited to increase the credibility as it focuses on internal coherence and needs clear assumptions and causalities. A quantitative underpinning can also make scenarios more relevant for e.g. water managers. Qualitative scenarios (especially if conducted in a participatory manner) are well suited to increase the creativity, legitimacy, and relevance of scenarios. The decision support scenarios can increase the relevance of scenarios even more as they make a link to current concerns and needs much more tangible.

1.2. Problem description

Each scenario type not only offers a different approach, but also uses different types of knowledge, relate to different communities, and focuses on different quality criteria. Each approach therefore leads to a specific result, while complex problems need integrated approaches to tackle the interlinked social, environmental and physical elements. The use of quantitative scenarios will focus on these aspects of the problem that can be quantified and for which data is available. Qualitative scenarios can deal with a lack of data and social aspects that are hard to quantify, but will have more problems to understand the underlying mechanics and cannot provide the quantitative implications. Decision support scenarios can show the effects of policies and the options that are currently possible, but are more focussed on the short term. A combination of these different types can cover a much larger extent of the complex problem and address all scenario criteria. The different scenario types can thus be said to be complementary. It is therefore hypothesised that combining them should lead to higher quality scenarios.
The problem is, however, that the different types of scenarios are not easy to combine. Each type of scenario has its own approaches that need to be linked. The different research, stakeholder and end-user communities involved also need to be able to communicate and understand each other when working together. This is complicated by the different types of knowledge, terminologies and concepts (just think of the different definitions for scenarios) these communities rely on.

These differences form real gaps between the scenario types, which are not easy to bridge. Some attempts have been made, for instance, via the use of the Story And Simulation (SAS) approach (Alcamo, 2008), but the link remains problematic. Modellers have problems to quantify the storylines, which they find too vague and subjective (Alcamo et al., 2006; Verburg et al., 2006). Stakeholders have problems understanding the models used for quantification (Martínez-Santos et al., 2010). Linking long term perspectives to short term actions often proves difficult (Carsjens, 2009).
Bridges thus need to be built, but the right tools and methods to do so seem to be lacking (see Kok and van Delden, 2009). Pahl-Wostl (2008) identified a need for improvement of the methodological link between qualitative and quantitative scenarios. Alcamo (2008) argues for making the quantification of qualitative scenarios more transparent. Kok and van Delden (2009) hypothesised that an increase of structure in the qualitative scenarios can support the quantification, but they did not test such an approach.

In this thesis two bridges will be built, originating from the qualitative exploratory scenarios to the quantitative exploratory scenarios and decision support scenarios. In addition to that, the communication between the different communities involved in the development of these type of scenarios (stakeholders, modellers and decision makers) should be facilitated to enhance the exchange knowledge, expertise and ideas. These bridges should make it possible to increase the qualities of the scenarios by addressing all scenario criteria.

1.3. Research questions

The problem description leads us to the following research questions:

- How can the gaps be bridged between qualitative and quantitative exploratory scenarios, and between exploratory and decision support scenarios?
- How can these bridges be used to contribute to the communication between the different communities?
- What is the effect of the bridges on the quality of the resulting scenarios?

1.4. Setting the stage; the SCENES project

This study has been executed within a specific context. It has been part of a larger research project called SCENES. In this section, the project is described, emphasizing the participatory scenario development.
SCENES stands for Water Scenarios for Europe and Neighbouring States. The project covered the whole European Union and the neighbouring states (dubbed pan-Europe). It was a large EC-FP6 project with 27 partners from 17 countries. SCENES started in November 2006 and ended in March 2011. It developed and analysed a set of comprehensive scenarios of the pan-Europe's freshwater futures up to 2050. The scenarios focused both on water quantity as well as water quality, with the focus changing between case studies depending on local circumstances (SCENES, 2006).

The main objectives of the SCENES project were (SCENES, 2006; Kämäri et al., 2008):

- Evaluate and improve different methodologies for scenario development, including participatory and modelling efforts on different scales.
- Develop and analyse a set of comprehensive scenarios of Europe's fresh waters up to 2050. The scenarios should provide a reference point for long-term strategic planning, alert policymakers and stakeholders to emerging water related problems and allow river basin managers to test their regional and local water plans against uncertainties and surprises.
- Evaluate the socio-economic, environmental and ecological impacts of the different water scenarios. This was accomplished by analysing and assessing the complex relationships between water availability, water demand, water use, and water quality which provided a basis for strategic planning and assessment of technological alternatives.
- Help launch an on-going process in Europe of scenario-development by developing a plan for institutionalising the on-going development of water scenarios in Europe.

SCENES consisted of five Work Packages (WP) and two Integrated Activities (IA) (SCENES, 2006). Figure 1.3 shows the basic organisation of the WPs. IA1 organised the overall coordination and management of the project. IA2 consisted of the Pilot Areas and regions. WP1 was responsible for the drivers and policy measures (part of the quantitative exploratory scenarios). WP2 was responsible for the development of the qualitative exploratory scenarios and decision support scenarios. WP2 developed the participatory scenario methodology that was used by IA2 (see van Vliet et al., 2007) and chapter 2) and conducted the meta-analysis of the workshop results (e.g. van Vliet, 2008; van Vliet, 2009; Kok et al., 2010; van Vliet, 2010). WP3 quantified - in cooperation with

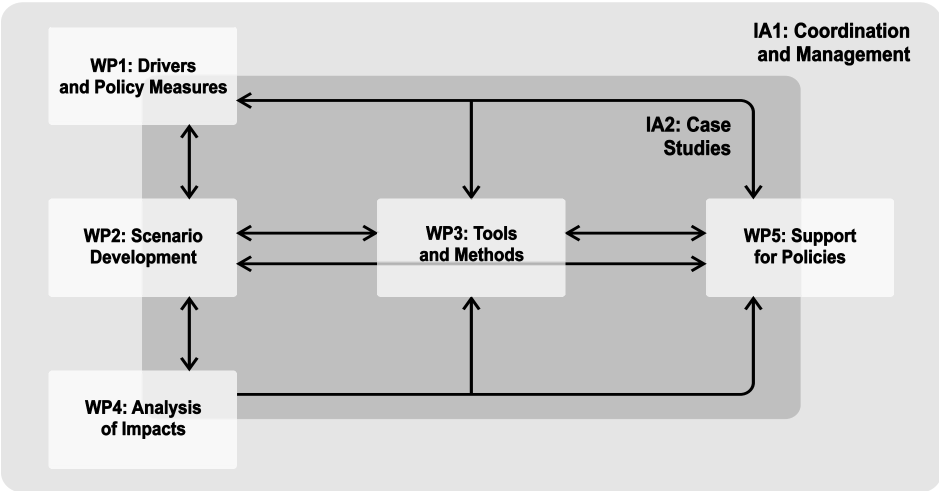

Figure 1.3; Basic organisation of WPs in SCENES project (source: SCENES, 2006).

WP1 and 4 - the exploratory scenarios with the WaterGAP model (Alcamo et al., 2003; Döll et al., 2003; Verzano, 2009) as main model. WP4 identified indicators to analyse the impact of the changes in scenarios. WP5 was responsible for the analysis of the workshop process, the dissemination and the policy relevance of the output.
The research described in this thesis was mainly conducted in WP2, but there was much cooperation with the other work packages, especially with IA2, WP3 and WP5.

SCENES consist of a qualitative part (WP2, WP5 and IA2) within which storylines are developed in a highly participatory way, and a quantitative part within which drivers, models and indicators are developed (WP1, WP3 and part of IA2). The different parts will interact to develop well linked scenarios. The working hypothesis of SCENES is that one dimensional, single sector focussed policies and directives, relying on a limited set of characteristics of the water system, will not lead to a sustainable future of European waters. Hence an integrated approach is needed.
The SCENES scenarios will:
- provide a reference point for long-term strategic planning of European water resource development,
- alert policymakers and stakeholders about emerging problems,
- allow river basin managers to test water plans against uncertainties and surprises,
- be both qualitative and quantitative.

(Kämäri et al., 2008)

Scenarios have been developed on three scales; the pan-European, regional and Pilot Area scale. The Pan-European scale covered the European Union (EU27) and neighbouring countries such as the Baltic states, Ukraine, Turkey and the countries along the South-side of the Mediterranean Sea (see figure 1.4). There were four regions: Eastern Baltic, Lower Danube, Black Sea and Mediterranean. Most of these regions contained two Pilot Areas, while the Mediterranean contained three.

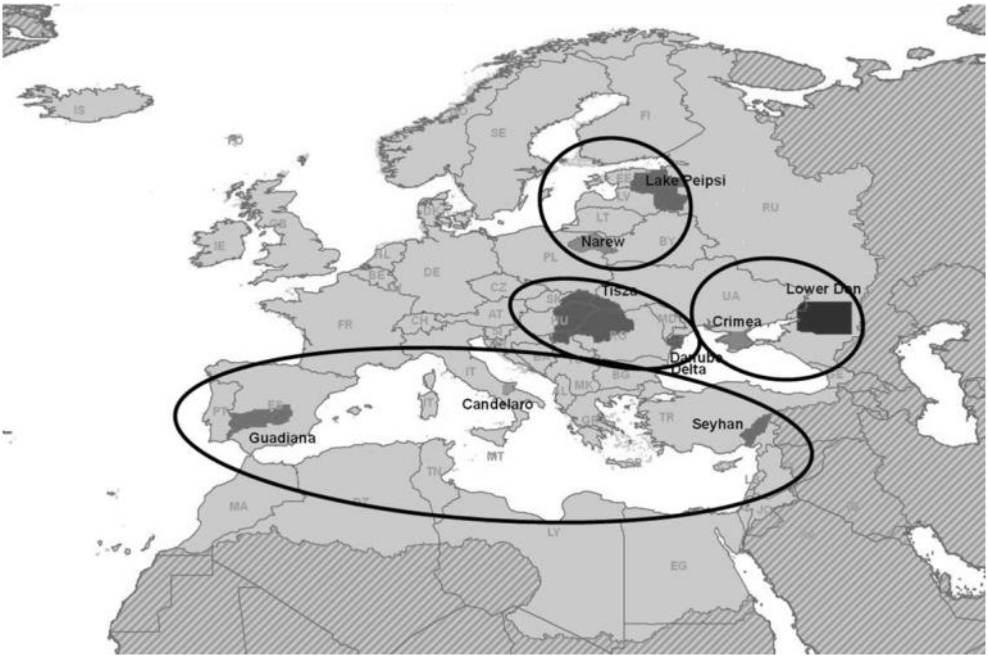

Figure 1.4; Extent of pan-Europe as used within SCENES and the location of the Pilot Areas with indication of the four regions (Eastern Baltic, Lower Danube, Black Sea and Mediterranean) (figure created by Christoff Schneider, CERN, Kassel).

The focus of the workshops was on water but also related aspects like agriculture and nature conservation were addressed. In the northern Pilot Areas the focus was mainly on water quality and in the southern on water quantity issues. See Appendix 1 for the main issues addressed in the different workshops.

1.4.1. Participatory scenario development in SCENES

The participatory scenario development took place on all three scales. On the pan-European scale the pan-European panel (PEP) consisted out of about 30 high level European stakeholders; in each workshop about fifteen of them were present. The Baltic region had a special role as it had the only participatory regional panel. The Baltic regional panel included stakeholders that also participated in the Peipsi and Narew Pilot Area workshops and one stakeholder who also participated in the PEP. The Baltic regional panel workshops were always held after the Peipsi and Narew Pilot Area workshops and before the PEP, so that Pilot Area information could be up-scaled to the PEP. Each Pilot Area also held participatory workshops. See Appendix 2 for more information on the number and type of stakeholders involved in each workshop.

All regional coordinators also participated in the PEP workshops to make sure that regional information was included. Because of a lack of time in the PEP to fulfil this task fully, there was an extra cross-scale enrichment meeting held in April 2009 in which regional storylines have been developed and the PEP2 storylines were refined with

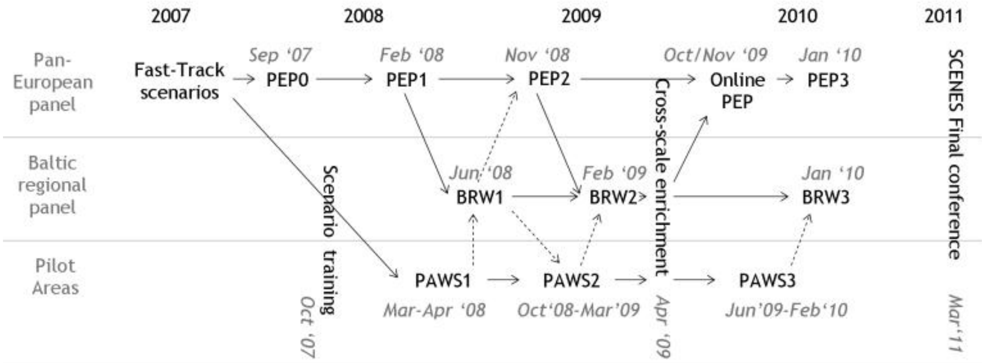

Figure 1.5; Overview of different workshops on the different scales.

regional information (see figure 1.5). This material has been used in an online PEP meeting in which the storylines were finalised.

Three rounds of workshops were held. In the first round qualitative exploratory scenarios were developed. These were enriched in the second round with the use of information from other scales and the quantitative exploratory scenarios, which were developed between these two rounds. The third round of workshops focussed on the development of decision support scenarios. Before the first round of workshop an existing set of exploratory scenarios (from GEO-4; see Kok and Alcamo, 2007) was selected so that a quick start could be made. The so-called 'fast track' scenarios were available as storylines (qualitative) and model results (quantitative scenarios). In the PEP0 this choice was discussed with the stakeholders, who agreed on the chosen set of scenarios. All workshop organisers were instructed on the methodology during an one week training in Wageningen.

The first round of participatory scenario development workshops started with the use of the fast-track scenarios. The pan-European stakeholders used them as basis for the development of SCENES scenario storylines (see Kok et al., 2008). On the other scales the fast-track, pan-European scenarios were used as context for the development of local scenarios. These local scenarios should be plausible futures given that the rest of the world developed as shown in the fast-track scenarios. This made sure that the Pilot Area scenarios were comparable and could therefore be up-scaled more easily.

In the second round of workshops scenarios were refined, with the use of quantitative scenarios, driver and indicator information and information from other scales or other Pilot Areas (see Kok et al., 2009).

These final storylines were used in the third round of workshops which was dedicated to decision support scenarios. A desired objective was chosen by the participants in a plenary meeting. In small groups each group tried to find ways to fulfil the objective within the constraints of one of the exploratory scenarios. This lead to different timelines showing actions needed to make sure that the objective can be reached in 2050 (see van Vliet, 2010) for results). As will be explained in chapter 5 the robustness of the actions against different exploratory scenarios was also checked.

Questionnaires were held among the participants after most workshops. These questionnaires were developed by work package 5 and only a limited number of questions could be included. For several chapters the results of these questionnaires have been used. Often only processed results were available, therefore mainly averages per workshop have been used. The research in this thesis has mainly been based on the Pilot Area and Baltic regional workshops, although sometimes PEP results have been used for comparison as well.

1.5. Reading guide

As said this thesis is about building bridges in a scenario world. Two bridges; between qualitative and quantitative scenarios and between exploratory scenarios and decision support scenarios. Figure 1.6 illustrates which part of these bridges are described in each chapter. Chapter 2 describes the whole participatory scenario development framework. Chapters 3 and 4 study the impact of the toolboxes used in the bridge between qualitative and quantitative exploratory scenarios on the scenario quality indicators. Chapter 5 studies the use of FCMs as common base for linking qualitative and quantitative scenarios. Chapter 6 focuses on the other bridge that between qualitative exploratory scenarios and decision support scenarios.

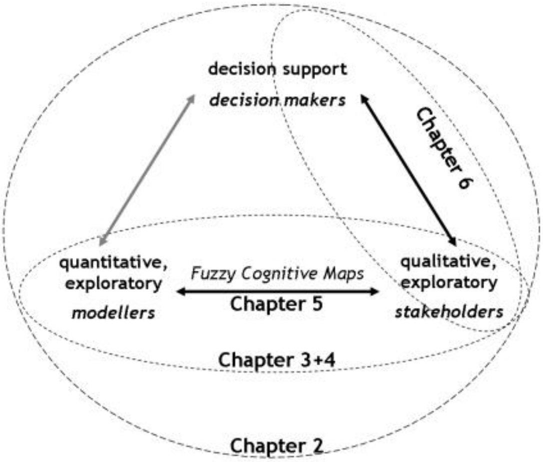

Figure 1.6; Main elements of this thesis and overview of chapters.

The second chapter presents the participatory framework that was used in the Pilot Area and regional workshops. This framework contains the building blocks for the two bridges as it describes the tools that are used to create these bridges. It also describes the main assumption for the bridge between qualitative and quantitative scenarios, and hypothesises how FCMs can be used in the communication between stakeholders and modellers. It describes how the bridge starts from the qualitative scenarios and then builds forward to reach the quantitative scenarios.

The third and fourth chapters also focus on this bridge and the toolbox - consisting of creative tools as well as semi-quantitative structured tools - used to build it. It studies the effects on the quality of scenarios.

The working hypothesis of the third chapter was that adding structure might lower the creativity of scenarios. This would hinder the ability of scenarios to change people's perceptions. The third chapter therefore analyses the effects of adding more structure on the creativity of the scenarios. In other words, the new build bridge should not change the course of the river in such a way that it causes erosion on one of the sides.

A toolbox is used to build the bridges because it is hypothesised that a toolbox has a number of added values compared to using one tool. In the fourth chapter these potential added values have been analysed by evaluating their contribution to the quality

of the resulting scenarios.
As one function of building bridges is to bring people together, people from both sides of the bridge should feel comfortable on the bridge. For the fifth chapter modellers developed a Fuzzy Cognitive Maps of their model, which was compared to a stakeholder based Fuzzy Cognitive Map. They were used to test the hypothesis that Fuzzy Cognitive Maps can be linked to mathematical, quantitative models. It also shed more light on the question if FCMs can be used as tool to facilitate the communication between stakeholders and modellers.

While the previous four chapters mainly discuss the bridge between qualitative and quantitative scenarios, the fifth chapter describes and tests the bridge between exploratory scenarios with decision support scenarios. Also this bridge starts from the qualitative exploratory scenarios. The approach of combining exploratory and decision support scenarios leads to the identification of robust actions, which shows the relevance of exploratory scenarios for decision makers. The effect of the exploratory scenarios on the backcasts is studied and the possibilities for cross scale comparisons and up-scaling are evaluated.

The last chapter, general discussion and synthesis, consists of three parts. In the first part some aspects will be discussed that are closely related to the building of bridges between scenarios and the scenario quality criteria used in this thesis. The second part, the Synthesis, contains a short evaluation of the framework presented in the second chapter and gives recommendations for future work on the framework and the building of bridges between scenario types in general. The chapter ends with a number of conclusions.

Chapter 2

Linking stakeholders and modellers in scenario studies; the use of Fuzzy Cognitive Maps as a communication and learning tool

Based on: van Vliet, M., K. Kok, T. Veldkamp, 2010, Linking stakeholders and modellers in scenario studies; the use of Fuzzy Cognitive Maps as a communication and learning tool, Futures*, 42 (1)*
and: K. Kok and M. van Vliet, in press, Using a participatory scenario development toolbox: added values and impact on quality of scenarios, Journal of Water and Climate Change

2. Linking stakeholders and modellers in scenario studies; the use of Fuzzy Cognitive Maps as a communication and learning tool

2.1. Introduction

In today's world everything is increasingly connected with everything, leading to increasing uncertainties of where things are moving. This causes a growing need for integrated projects that tackle current and future problems. Scenario development is widely considered as a valuable tool within these projects that focus on complex, uncontrollable and uncertain problems (Peterson et al., 2003; Biggs et al., 2007). The Millennium Ecosystem Assessment (2005a) describes scenarios as "*plausible and often simplified descriptions of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces and relationships*". As uncertainty increases the further one explores the future, there is a need for multiple "projections" of possible futures to capture this uncertainty, instead of focussing on predicting one single outcome (Peterson et al., 2003; Biggs et al., 2007).
These definitions indicate that scenarios have to bridge the gap between incorporating large uncertainties and keeping plausibility. Storylines capture uncertainties and integrate social, economical and environmental aspects. They also provide input for quantitative models that in turn provide consistent, spatial explicit projections, which add extra plausibility. Creating a strong link between storylines and models, however, is problematic due to their specific natures.
Scenario development frameworks that combine qualitative and quantitative scenarios have been developed, but in many cases the link between them is weak. This can undermine the model output as stakeholders who created the storylines do not identify with the model outcomes. Kok and van Delden (2009) introduced a different approach that includes the (semi-) quantification of storylines. In this chapter we build further on the idea of using semi-quantitative methods.

2.1.1. State of the art

A large number of scenario studies have worked with a combination of models and storylines, such as the Global Environment Outlook (UNEP, 2002), the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005a) and the IPCC (2000) on the global scale and, among others, MedAction (Kok et al., 2006a; Kok et al., 2006b), PRELUDE (European Environmental Agency, 2006) and VISIONS (Rotmans et al., 2000) on the European scale. Most of these studies involved stakeholders in the scenario development process.

Participation

Stakeholder participation is a major aspect in many integrated scenario studies. Stakeholders are often asked to participate in (parts of) the storylines development. There are multiple ways to conduct (multi-scale) participatory scenario development, see for instance (Rotmans et al., 2000) and (Kok et al., 2007a). Overviews of participatory methods can be found in (Van Asselt and Rijkens-Klomp, 2002; Rao and Velarde, 2005;

Evans et al., 2006b; Lynam et al., 2007) and on the websites (Website SustainabilityA-Test, 2008; Website MSP portal, 2009; Website SAS[2], 2009).
Four categories of reasons for undertaking participation can be discerned: normative, instrumental, substantive and social learning (von Korff, 2007). The substantive and social learning arguments have a larger role in the scientific part of scenario development, whereas the normative and instrumental argument play a larger role in the implementation process that might follow from a successful scenario project. Empowerment often only plays a minor role, except for specific projects.
Alcamo and Henrichs (2008) present four criteria to evaluate the quality of scenarios; relevance, credibility, legitimacy and creativity. All four criteria are related to the need for participation; especially in cases were scenarios aim at non-scientists as end users. When stakeholders participate in the development of scenarios they can make sure they will be relevant for them, which links to the instrumental reason for participation. The same holds for legitimacy; when a wide variety of stakeholders develop the scenarios they are more likely to incorporate a wide array of beliefs and values. Involvement of stakeholders can lead to better informed decisions (substantive argument), which increases credibility. When a good and open atmosphere is created diverse groups can come up with new and creative ideas. This process leads to social learning. It therefore seems likely that participation can help scenario studies to create higher quality scenarios. Furthermore, Van Asselt (2002) argues that participation of non-scientists is especially needed with issues that concern a mix of related problems and cover multiple disciplines, scales and actors. This is also the type of problems for which scenario development is particularly suitable, which further increases the need for participation.

Involvement of stakeholders in most scenario studies has primarily been in the phase of storyline development. Storylines remain close to the every-day language of stakeholders. They are created in a qualitative way, so that quantitative knowledge is not needed. Talking about the future makes it is easier to consider out-of-the-box thinking and create consensus (Evans et al., 2006b). Those aspects make it possible to produce them with a wide array of stakeholders (Millennium Ecosystem Assessment, 2005a). Stakeholder involvement in the modelling part is often regarded as overly complicated, and involving of lay persons as impossible. Progress is made on group model building techniques (e.g. Vennix, 1999) and conceptual modelling (e.g. Pahl-Wostl and Hare, 2004) outside the scenario field. Those methods are used to increase stakeholders' and modellers' understanding of the system (Vennix, 1999; Sterman, 2002). Group model building, however, is not used in large scenario studies where models are data demanding and complex. The relative easiness to involve stakeholders in storylines development compared to model development might be a major reason why stakeholder involvement has mainly been limited to storyline development.

Qualitative vs. quantitative

To use storylines in models they need to be quantified. This is often conducted by approaches like the Story And Simulation (SAS) approach (Alcamo, 2008). The SAS-approach clearly identifies the need for feedback between modellers and storyline developers. Via an iterative procedure (steps 4 to 7 in figure 2.1) storylines are quantified and revised until they are correctly linked.

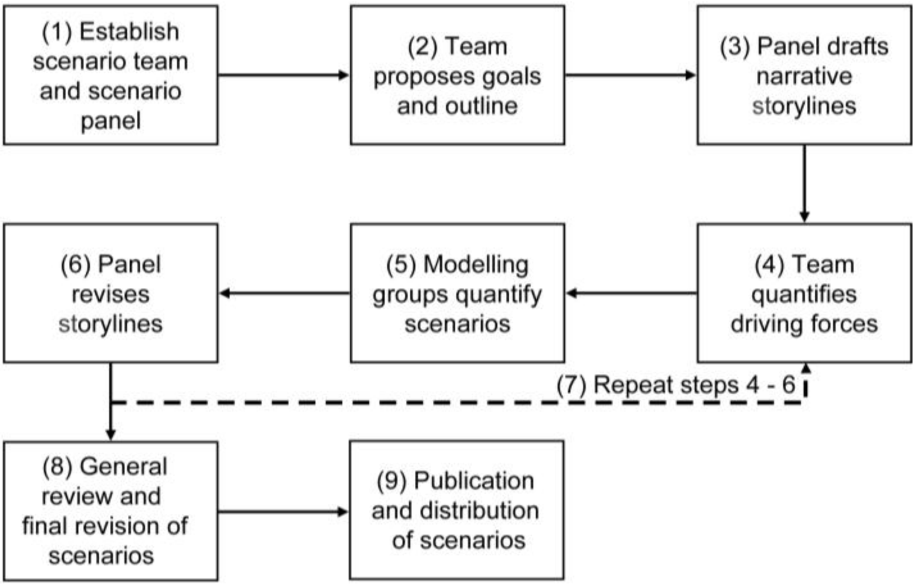

Figure 2.1; Storyline And Simulation approach (based on Alcamo et al., 2001).

In practice this iterative procedure is not executed to its full extent; often due to lack of time and/or budget (Kok and van Delden, 2009). But the problem lies deeper: there is a major gap between qualitative storylines and quantitative models. The gap is partly caused by the different philosophies and underlying assumptions of the two methods (see table 2.1). Particularly the need for data, fixed assumptions, and limited inclusion of social factors results in models that differ substantially from storylines.
Because of these differences, modellers have to interpret storylines while quantifying, which is often "*a rather subjective*" exercise (Verburg et al., 2006). Moreover, modellers also have problems with all the variation in storylines because models are calibrated and

Table 2.1. Characteristics of storylines and quantitative models

Storylines	**Models**
- qualitative	- quantitative
- capture future worlds in stories, ideas and visions	- capture future system in numbers and rules on systems' behaviour
- all aspects important to stakeholders can be included	- inclusion of aspects depend on data availability
- no rules for validation on current system	- validated on current system
- above leads to large flexibility	- above leads to limited flexibility
- social effects included	- hard to include social effects
- no fixed set of assumptions	- fixed set of assumptions
- not always internally coherent	- internally coherent
- no clear system understanding	- system understanding
- no data needed	- need for data

validated on the current system, which limits their flexibility (Kok, 2009). Large social paradigm shifts, for example, are therefore hard to model. To complicate matters further, there are often variables in storylines that are by nature hard to quantify (and therefore to include in models), such as happiness, standard of living and state of the environment. These problems can lead to contradictions between storylines and model assumptions and outcomes.

2.1.2. Problem definition

Stakeholder participation in scenarios development has large potential advantages, but combining qualitative storylines and quantitative models can be problematic. Both methods, however, are essential in an integrated scenario study of which results are accepted and used by the stakeholders. Potentially, the gap could widen far enough for storylines to contradict model outcomes and vice versa, which can cause a lost of trust in the overall project outcomes.

Hypothesis

We will tackle this problem starting from the qualitative, participatory side. We propose an updated scenario development framework that consists of well-known state of the art qualitative methods and tools, and semi-quantitative methods that are novel to the scenario development field.
Our hypothesis is that the use of semi-quantitative methods will:
- structure the participatory scenario development output,
- incorporate system thinking in the participatory process,
- aid a social learning process between stakeholders and modellers,
- facilitate the creation of consensus between stakeholders and modellers,
- show the differences between storylines and models,

and therefore
- increase stakeholders input in the quantification of their products.

2.1.3. Objectives

The objectives of this chapter are to describe an updated framework for participatory scenario development that includes semi-quantitative methods; to describe its practical use in stakeholder workshops; and to demonstrate how resulting participatory workshop outputs are more suitable for a link with quantitative models. Semi-quantitative methods have a central place in the framework, and extra attention will therefore be given to the main semi-quantitative method; Fuzzy Cognitive Maps.

2.2. Research set-up

2.2.1. Background – The SCENES project

This study is part of a larger project, called SCENES. SCENES is a 4-year EC FP6 research project, which started late 2006. It aims at developing and analysing a set of comprehensive scenarios of Europe's freshwater futures up to 2050 (Kämäri et al., 2008). One of the main goals of SCENES is to improve the SAS-methodology. The first step to this improvement is presented in this chapter.

Place of this study within SCENES

Within SCENES the scenario development framework is carried out and analysed in the majority of the Pilot Areas. An elaborate training programme, including a joint, week-long, training workshop at Wageningen University, ensured that all case studies have a similar understanding of the developed framework.

The overall objective is to create scenarios on the Pilot Area level as well as the pan-European level. The scenarios will be compared with model output (WaterGAP (Alcamo et al., 2003; Döll et al., 2003) for the pan-European level). At least one full cycle will have to be made between the two scales and between the storylines and the quantitative model.
The scenario development is kick-started by the use of existing, so called fast-track, scenarios (based on GEO-4, see Kok and Alcamo, 2007). Key to the use of existing (qualitative and quantitative) scenarios is the possibility to increase the number of iterations between stories and models as both are available at the onset of the scenario development process. In the participatory process, the European GEO-4 scenarios were used as a starting point to develop local scenarios.

2.2.2. A four step approach

The participatory scenario development process conceptually consists of four steps in which qualitative and (semi-)quantitative methods are combined. These steps are chosen in order to work towards a set of long-term scenarios and related short-term (policy) actions, rooted in a common understanding of the functioning of the current system.
Step 1: Present and near future.
Step 2: Looking at the future (long-term stories).
Step 3: Critical review of stories.
Step 4: Playing it back (short-term options).

The results of each step are used in subsequent steps; together they make up the final scenarios. The set of products includes a story of the present; long-term exploratory stories; and short-term actions to reach a normative end point. A semi-quantitative conceptual modelling technique (Fuzzy Cognitive Maps) is the backbone of most of the scenario development process. Step 1 and 2 are executed in the same workshop, whereas step 3 and 4 are executed in separate workshops. The steps are thus ideally taken in three workshops of 1-2 days each.

Step 1; Present and near future (short-term obstacles)

A thorough understanding of the stakeholders' perception of the present system and short-term outlook is needed in order to understand how they perceive plausible futures. In the first step Fuzzy Cognitive Mapping (FCM, see next section) is used to describe the present system.
In detail, this step begins with a brainstorming session using post-its. All participants individually note down the most important drivers influencing the water system in their Pilot Area. The post-its are subsequently grouped in clusters of similar issues in a plenary session. Spidergrams are used to map the perceived importance of these issues. The clusters of issues form the starting point for a semi-quantitative conceptual modelling

exercise. Using the FCM technique, the feedbacks between the main issues are identified and discussed. The hypothesis is that this tool will help stakeholders identify key feedbacks and relationships that might otherwise be missed and lead to inconsistencies in later steps, notably the story development.

Step 2; Looking at the future (long-term stories)

In the second step narrative stories are developed, including both an exploratory end situation for 2050 and the main processes leading to it. These long-term visions represent how stakeholders perceive that a set of plausible futures might unfold for their Pilot Area. As said, a set of existing scenarios was used as a starting point. At the start of the storyline development, stakeholders were provided with information on the GEO-4 scenarios for Europe (UNEP, 2006). Specifically, we provided them with short summaries of the four stories and information on developments of the main drivers at European level. We then explained how these drivers should be taken as general information for the whole of Europe, within which local Pilot Area scenarios were to be developed. Examples of important drivers are degree of globalisation, technological development, economic growth, environmental awareness, and population growth. Stakeholders were asked to develop scenarios that should be *coherent* with the fast-track scenarios. We followed the notion of Zurek and Henrichs (2007), who define coherent scenarios are 'scenarios that follow the same scenario logics, which does not preclude substantial differences with regard to how the scenarios play out, both in the selection of important driving forces, their major trends and/or scenario outcomes'. The GEO-4 scenarios thus act as boundary conditions, within which stakeholders were given a large degree of liberty.

In detail, during the joint training workshop of Pilot Area facilitators, it was advised to use a highly creative tool - like collages - as part of the process to develop stories. After the stories are developed, spidergrams can be used to map the stakeholders' perception of changes in the major issues as identified in step 1.

Step 3; Critical review of developed stories

In this step, the stories are enriched. Stakeholders critically review the developed products, both of the present system and of future developments. Participants are confronted with the processed results from the first workshop and with quantitative input from the pan-European scale and local models. This usually leads to changes in the stories.

In detail, stakeholders receive the enriched pan-European scenarios, model output from the WaterGAP model and local models (where available) and results of the FCMs to give them new insights. Fuzzy Cognitive Maps are developed to represent the system under each future scenario, thus enabling a direct comparison of the present and future system conditions.

Step 4; Playing it back

In step 4 the focus moves from exploratory story development to normative desired options. Through a backcasting exercise (e.g. Dreborg, 1996; Robinson, 2003), the necessary (short-term) actions needed to reach a desired end point are identified for each of the exploratory stories.

By spring 2010, All Pilot Areas completed the full cycle of three workshops. This chapter focuses on the results of the first workshop that encompassed step 1 and step 2 of the scenario development process. Results on the backcasting exercise can be found in chapter 6.

2.2.3. Fuzzy Cognitive Mapping and other conceptual models

Fuzzy Cognitive Maps (FCM) are a form of cognitive maps, introduced by Axelrod (1976) to represent social scientific knowledge. He was the first to use cognitive maps to have systems described by stakeholders instead of by scientists. Kosko (1986) extended the idea of cognitive maps by adding fuzzy logic - hence the name Fuzzy Cognitive Map - which makes it possible to incorporate multiple degrees of truth. Fuzzy Cognitive Maps show relations between variables in a graphical and a mathematical way. A Fuzzy Cognitive Map consist of nodes (C), being the concepts or variables, with connections (e) between them. Each connection gets a weight e_{ij} (between 1 and 0) according to the strength of the causal relationship between the concepts C_i and C_j that it is connecting (Kosko, 1986). A relationship can be either positive or negative (see for a detailed description (Kok, 2009). In the graphical map variables are the boxes and the relations the arrows between them. In the mathematical representation the relations are represented in a matrix. Each concept is given a weight representing the current importance, which forms the state vector. The next state of the system can then be calculated via a vector matrix calculation. This calculation can be repeated until an equilibrium is reached. All outcomes should always be compared to other values and should be considered semi-quantitative. Kok (2009) and Özesmi and Özesmi (2003) give a detailed overview of how FCMs can be constructed and interpreted.

The procedure of iterating a FCM can be illustrated with a hypothetical example of a FCM consisting of three concepts C0, C1, and C3. They have a state vector (1, 0, 1) and a matrix in which on the rows shows the arrows going out of an concept.

$$\begin{pmatrix} 1 & 0.5 & 0 \\ 0 & 0 & 0.1 \\ 0 & -0.1 & 0 \end{pmatrix}$$

The new vector than becomes (vector*matrix)
= 1 x (1, 0.5, 0) + 0 x (0, 0, 0.1) + 1 x (0, -0.1, 0)
= (1, 0.5, 0) + (0, 0, 0) + (0, -0.1, 0)
= (1, 0.4, 0)
In the next iteration the vector will become (1, 0.5, 0.04).

FCMs have been used in numerous research projects (e.g. Cole and Persichitte, 2000; Özesmi and Özesmi, 2003; Giordano et al., 2005), but so far barely in the scenario development processes. Moreover, Fuzzy Cognitive Maps have not been produced by stakeholders in a workshop setting. Yet, FCMs can be used to structure the outcomes of the participatory processes by introducing system thinking. FCMs will force participants to make explicit the systems from which they reason explicit, and therefore more transparent. The continued attention on system understanding should also lead to more

internally coherent stories. This in turn should facilitate an objective quantification of the stories. Within SCENES, FCMs are created by stakeholders as a graphical map by small groups of stakeholders. The graphical versions are then represented mathematically as a vector matrix analysis *a posteriori* by SCENES scientists. The iteration results are used as main input in Step 3 to enrich developed stories.
Figure 2.2 provides an example of a graphical map of a Fuzzy Cognitive Map developed for the Candelaro basin, one of the Pilot Areas of SCENES.

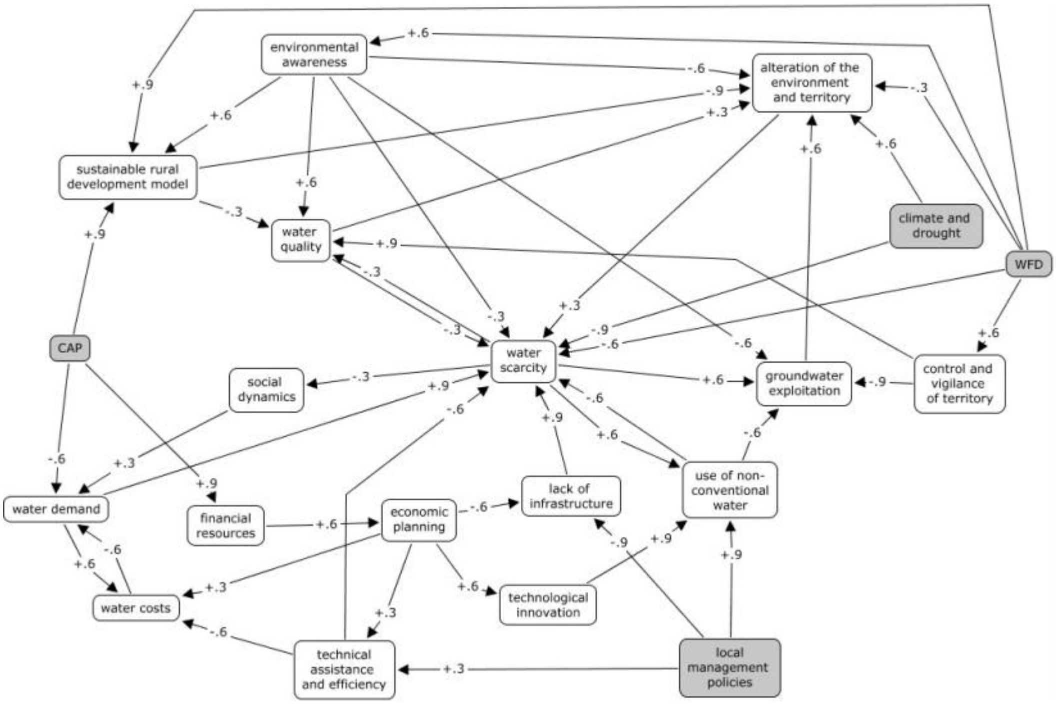

Figure 2.2; Example of the graphical representation of a Fuzzy Cognitive Map, as developed in the Candelaro basin in Italy. Grey boxes indicate outside drivers of the system; numbers indicate strength of the relationships. Adapted from (Khadra et al., in press).

Within SCENES a number of additional conceptual model methods were used. Causal Loop Diagrams (Magnuszewski et al., 2005) are developed for four Pilot Areas and the pan-European level (Dubel et al., 2010). Although stakeholder involvement is limited, Causal Loop Diagrams provide much more and more detailed information. For the Pan-European Panel Cmaps (Website Cmaps, 2009), a conceptual modelling technique has been used to describe the core aspects of the pan-European stories. In other words, the toolbox used within the participatory part of SCENES is itself part of a larger toolbox that consists of all tools used inSCENES. This larger toolbox includes Causal Loop Diagrams and Cmaps, but also quantitative tools like WaterGAP (Alcamo et al., 2003), indicators and drivers.

Reasons for choosing FCM instead of other semi-quantitative methods

There are other semi-quantitative and qualitative modelling methods available besides FCMs. Within SCENES, there was the need for a participatory method that:

- is not too difficult (as all stakeholders should be able to understand the basics),
- is easy to teach (as it needed to be taught to all partners),
- has a high level of integration (needed for the complex issues related to water),
- can be performed in a short time (as funds and time allocated to the workshops are limited), and;
- gives a system description.

Grosskurth and Rotmann (2005) describe the so-called SCENE framework within which a qualitative model can be built. Stakeholders are asked to think about the three capital domains of sustainability, which are further defined in stocks, which are split up into characteristics and finally in indicators. Arriving to a set of indicators is very time consuming, therefore "*the participatory process (…) is usually limited to the stock level of the SCENE model*" (Grosskurth, 2008).

The Syndrome's approach (Petschel-Held et al., 1999; Eisenack et al., 2006) looks at archetypical 'syndromes' within a bigger overarching problem. Qualitative differential equations are used to model different possible states of the aspects that form a syndrome. This is a rather complicated and time consuming method and therefore less suitable in a highly participatory setting.

Kouwen et al. (2008) use qualitative probabilistic networks (QPNs) to link stakeholder input with advanced simulation models. The main disadvantage of these QPNs is that they cannot deal with feedbacks.

In the Spanish Pilot Area of SCENES Bayesian networks (Zorrilla et al., accepted) have been constructed, partly during stakeholder workshops. The identification of probability percentages proved to be difficult for stakeholders to work with. To calculate results of Bayesian networks specific software is needed and feedbacks cannot be taken into account. The results from the Bayesian network exercise might prove a valuable starting point for the development of a FCM.

Causal Loop Diagrams (Magnuszewski et al., 2005), finally, will be used within four of the Pilot Areas of SCENES, but they will be developed with no or limited stakeholder involvement. Again this type of tool is time demanding and therefore not primarily suitable for a participatory process.

FCM fits the requirements stated above better than any of the other conceptual modelling techniques analysed here. Most other methods are either too difficult for the type of stakeholders we are aiming for, or take too much time. Yet, FCMs have their own set of specific disadvantages. Kok (Kok, 2009) gives an overview of the drawbacks of FCMs; time for instance is ill defined and incomparable factors are compared. This may lower the scientific value of the results of an FCM. Trying to fix those problems will however lead to a different type of exercise that does not fit our goals. Besides, the system description obtained after one workshop is expected to be good enough for our goals; to understand from what background the visions are developed, to use it during the backcasting exercise and to be able to compare the stakeholders' system perspective with that of the modellers. A method as fast and simple as FCM will always have disadvantages, but our hypothesis is that the advantages outweigh the disadvantages. The use of other methods and the comparison with quantitative models in the SAS-approach should lower the disadvantages.

2.2.4. Other tools

Below is an overview of all tools besides conceptual models that were employed within SCENES. Tools were selected based on their usefulness in a participatory workshop, their ability to facilitate the development of scenarios, and specific characteristics to enhance either structure or creativity of the resulting scenarios.

Card technique

Card techniques are used to organize, cluster and rank information. This technique is also known as a Delphi technique, metaplanning or post-it session. It is one of the most useful and widely used techniques in workshop settings because of the ease with which many ideas can be quickly collated and organised. Additionally, it allows stakeholders to provide input anonymously, which lowers the barrier put forward information. The card-technique consists of two steps in which first each participant put his/her most important issues on cards; after which similar issues are clustered to reach a workable amount of clusters. These cluster form input for other tools, for instance the Fuzzy Cognitive Maps and spidergrams (see Step 1).

Spidergrams

Spidergrams are used to get a quick visual representation of the importance of the main issues in each Pilot Area. They can be made both for the present and the future. Spidergrams of the different stories facilitate a scenario comparison. Each axis of the spidergram represents one of the main issues, which are the same for all participants. On the outside the value of importance of the issue is very high, at the middle none. Participants indicate the perceived value of importance for each issue. The dots are connected for a better visual appearance.

Timetrends

Timetrends are used to sketch the expected temporal change of any development. By illustrating these changes, participants are forced to analyse the reasons for the fluctuations during different time intervals (Website MSP portal, 2009). Timetrends were proposed as a tool for the backcasting session. However, in some Pilot Areas timetrends were also used during story development. Timetrends make yet another visual tool with which scenarios can easily be compared with each other.

Collages

Collages are used to develop and present visions. Collages are always combined with a presentation and/or written text that explains it. Participants start with discussing how the future might look like, based on the developments in the rest of Europe as described in the fast-track scenarios. At the same time they visualize that future in the collage. Everybody can give input to the collage by choosing pictures that represent a certain aspect of the vision . The collage is presented at the end of the exercise, which together with notes taken results in a story. See figure 2.3 for an example.

Figure 2.3; example of a collage from the Crimea Pilot Area.

Stories

All Pilot Area coordinators wrote stories directly after the workshops based on the products developed in the workshop. Two Pilot Area developed stories in the workshops. Two different ways of directly creating stories have been used. In one workshop draft stories had been created before the workshop, on which participants commented to make them fit their own ideas about the future. In the other workshop a matrix with three time periods and the main issues in the Pilot Area was used. For each issue the developments in each time period were described, thus forming the basis of the story.

Quantitative models

WaterGAP (Alcamo et al., 2003) has been used within SCENES as the main quantitative model. As this is a global model which is downscaled to the pan-European scale it is only used at that scale. For the Pilot Area scale several local models have been used, ranging from economic and sectoral water models to hydrology models, depending on the main issue at stake.

2.3. Case study results

Because of the central place of FCMs in the proposed new framework and the lack of documented testing of its implementation in a group setting during one workshop, we present the results of two FCM-building exercises that we recently conducted.
We have tested our approach of developing FCMs in groups twice: during a two day training in Bari, Italy (at CIHEAM-IAMB) and during a four day scenario development

training in Wageningen, the Netherlands (at Wageningen University). The program for the test was the same as has been used in the workshops in the SCENES Pilot Areas.

2.3.1. Creation of FCM Bari

During a two day training in Bari, Italy, the framework has been tested with seven young scientists from CIHEAM-IAMB. The training followed the first two steps of the framework and gave extra background information on scenario development theory and FCM theory. FCMs were created during one afternoon session (ca. 4.5 hours).

For the development of the FCM we used the following steps:

1. Define which factors are important
   1a. Write down post-its with issues (individual)
   1b. Cluster individual issues and discuss importance (group)
2. Define which relations exist (two small groups, four people per group)
3. Define sign and strength of relationships
   3a. Define if relationships are positive or negative
   3b. Define relative strength of relationships in four classes (++, +, -, --)

4. Presentation and discussion of FCMs

Step 1; which factors are important

The participants identified nine clusters of factors that they considered important; they can be found in figure 2.4 and 2.5.
Note that some clusters are very specific (e.g. water quality) and others are very general (e.g. institutions/policies). There needs to be a balance between the number of factors considered and the level of detail represented in the FCM. More factors will provide more detail, but will also result in a more complex system representation. The disadvantage of very general factors is that they can often be explained in multiple ways, which decreased the system understanding, which in turn can lead to multiple interpretations of a single FCM. It was decided to provide detail for water-related issues and limit the number of other groups of factors.

Step 2-3; relationships and their strengths

Relationships and their strengths were defined in two separate groups. T hose graphs were subsequently treated as Fuzzy Cognitive Maps. To do this, the values assigned by the groups where transformed in real numbers. The following rule was applied: '++' = 1; '+' = 0.5; '–' = -0.5, and '– –' = -1. In both cases C8, social capital, drives itself (+1) and is the only external driver. For both groups C8 had a state vector of 1 and all others 0.
The resulting flow-charts are given in figure 2.4 and 2.5.

Step 4; presentation and discussion of FCMs

The presentation of the dynamic output of the FCMs (in Excel) showed how the system reacts under the assumptions given by the groups. This provided input for discussion, as the expected outcomes did not always match the output generated by the Fuzzy Cognitive Map, mostly because of the influence of feedbacks. This shows the potential added-value of a Fuzzy Cognitive Map as a discussion tool.

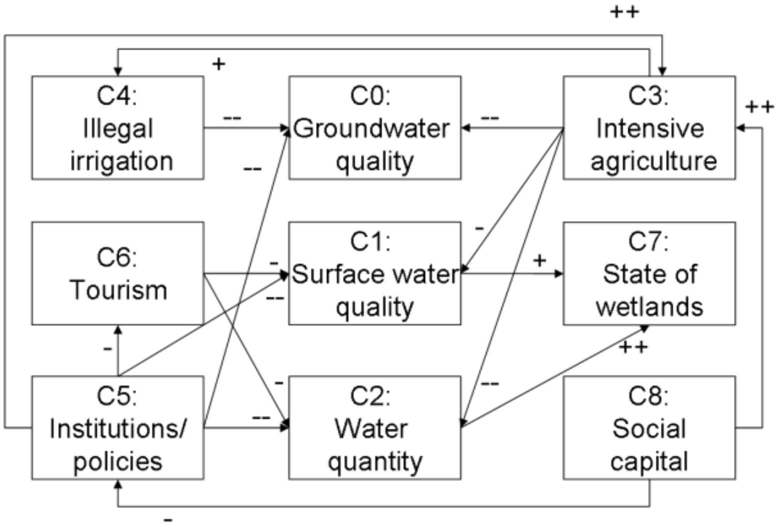

Figure 2.4. Flow-chart created by Group1.

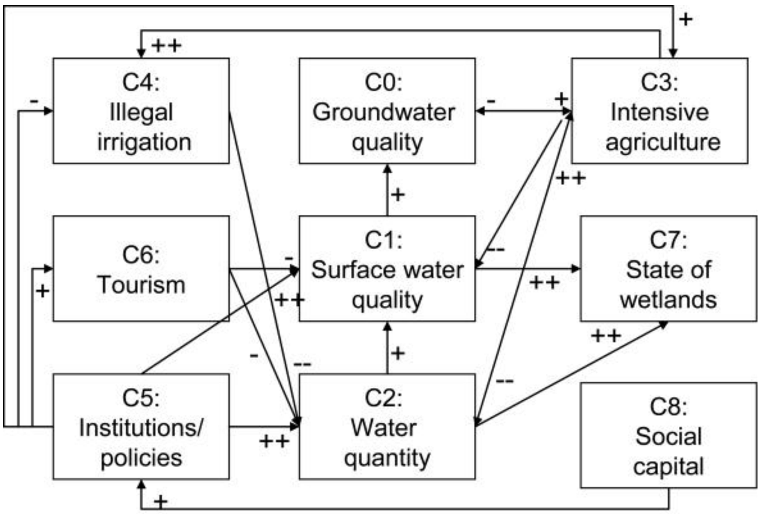

Figure 2.5. Flow-chart created by Group2.

2.3.2. Results Bari training

The results from the iteration of the two FCMs are given in figure 2.6 and 2.7. The results are different, mainly because of the assumption of different policies.

Details of the system description as given by the groups differed substantially. The box institutions/policies was interpreted different by both groups, leading to different connections. There was a surprisingly large number of relationships present in only one of the two FCMs.

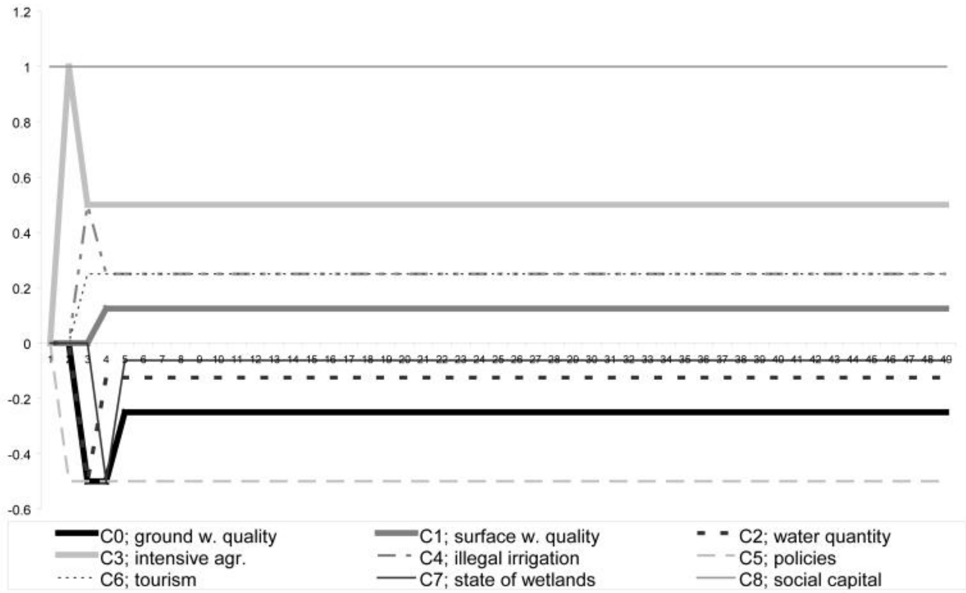

Figure 2.6; FCM results for Group1. Y-axis showing the value of the variables, X-axis number of iterations.

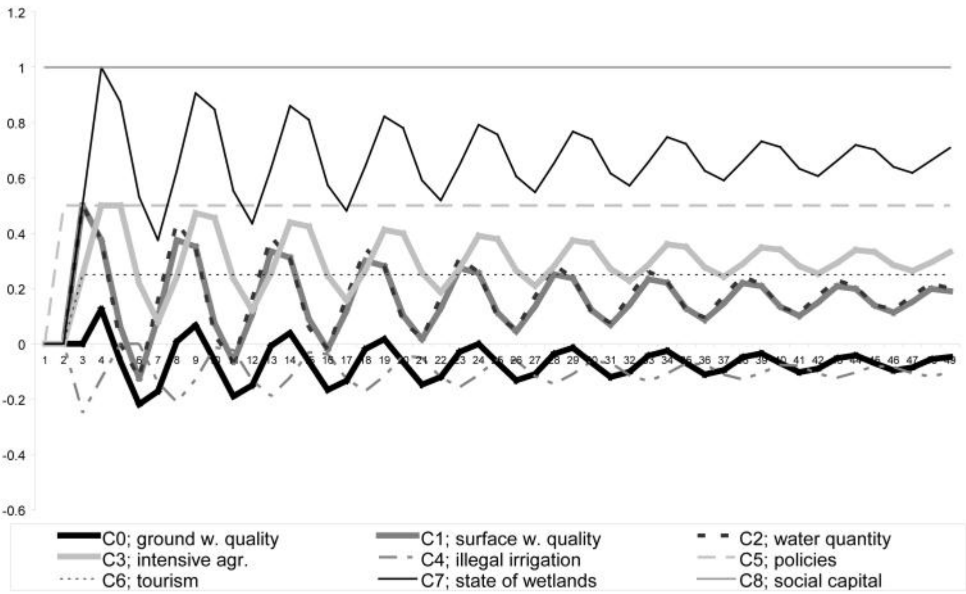

Figure 2.7; FCM results for Group2. Y-axis showing the value of the variables, X-axis number of iterations.

Present in Group1 and absent in Group2:
- Illegal irrigation → Groundwater quality (-1)
- Social capital → Intensive agriculture (+1)

Present in Group2 and absent in Group1:
- Surface water quality → Groundwater quality (+0.5)
- Water quantity → Surface water quality (+0.5)
- Groundwater quality → Intensive agriculture (+0.5)
- Water quantity → Intensive agriculture (+0.5)

Despite these differences, however, most general characteristics are similar. Table 2.2 shows that both groups constructed a flow-chart that has a relatively high number of connections, resulting in a relatively high number for density and hierarchy. Also number of receiving and transmitting variables is similar. Yet, the graphs differ in one important aspect, being the sum of positive and negative arrows.

Table 2.2. Key characteristics of FCMs developed by group1 and group2 in the Bari training.

Characteristic	Group 1	Group 2
Number of variables (N)	9	9
Number of connections (C)	15	20
Sum of all +	8	18
Sum of all -	17	10
Density (C/maxC) (D)	0.21	0.27
Number of receiving variables (r)	3	4
Number of transmitting variables (t)	4	5

2.3.3. Interpretation of Bari training results

Based on the discussions and an analysis of the FCMs it became clear that Group1 assumed a situation with policies that stimulate intensive agriculture and have a negative effect on water quality and quantity. The equilibrium shows a situation where intensive agriculture and illegal irrigation have gone up on the expense of ground water quality and the state of the wetlands. However, note that surface water quality has gone up, as well as tourism. It is a rather optimistic view of a system that is relatively stable, that can absorb shocks, and in which intensive agriculture can be expanded further without strong negative consequences for water quality and wetlands.
Group2 assumed a set of policies with two faces, intensive agriculture is stimulated, and at the same time water quality and quantity are also positively influenced. The equilibrium that is reached here also reflects a positive view of the situation in the Candelaro. The system sketches a situation where more intensive agriculture can be realised without damaging the environment. It is important to realise that policies to

improve the water issues should be interpreted as water transport policies that import clean water from the neighbouring Basilicata basin.
Group1 created a flow-chart that has a very high number of negative relationships, whereas Group2 had much more positive than negative relations. Consequently, the results of the FCM differ considerably (see figures 2.6 and 2.7). Group2 shows a system that reaches equilibrium, but only after large fluctuations. In other words, the system is very instable and small changes in the parameter values could lead to a loss of equilibrium. Contrasting, the results for Group1 show a system that stabilises after 5 iterations. The large number of controlling negative feedbacks results in a very stable system.

To test the reaction of the two systems, we added the relations that were only present in one FCM to the other system and evaluated the effects. For Group1, the system proved to be especially sensitive for the effect of water quality and water quantity on intensive agriculture. Adding these two arrows resulted in an unstable system. For Group2 it could be concluded that the system is insensitive for adding a pressure from social capital, and extremely sensitive for the effect of illegal irrigation on groundwater quality. In other words, for both systems the relationships between water quality and quantity and intensive agriculture are very important. When both a negative effect on water (more agriculture, less water) and a positive effect on agriculture (less water, less agriculture) are incorporated, the system becomes instable in both cases. The main drivers behind this instability are policies. In both cases it is assumed that policies heavily stimulate intensive agriculture, whereas control over water issues is present but less influential. This constant push of increasing agriculture drives the system to a state where water pollution and water resource exhaustion are constant threats.
As shown above, it is relatively straightforward to compare multiple FCMs. It is however always important to look at the stories behind the relationships, as some differences might look bigger then they were intended by the different groups. Illustrative is the strongly negative relation between policies (C5) and water quantity (C2) in the FCM of Group1 and a strong positive relation of Group2 (figures 2.4 and 2.5). Group1 argued that the current policy is very positive towards intensive agriculture has a strongly negative impact on water quantity. They showed this by a direct link. Group2 also said that the current policy is positive towards intensive agriculture, but argued that there are also policies that have a positive impact on water quantity. They therefore gave a positive relation between water quantity and policies. Group2 also recognised that intensive agriculture has a negative impact on water quantity, but put this in their FCM by a direct link from intensive agriculture to water quantity instead of a negative link from policies.

Results show that with FCM a relatively good system description can be obtained within a short time. Within a four and half hour session, two structured system description were obtained. Feedbacks were also incorporated within the system. The resulting system descriptions can be compared to show the differences in system perceptions of the different groups.

2.3.4. Creation of FCM Wageningen

During the Wageningen training, FCMs were created by the participants for the four regions of SCENES: Mediterranean, Black Sea, Lower Danube and Baltic States. A significant part of the participants is involved in one of the ten Pilot Areas within the four regions. A program was followed similar to the Bari training. For lack of space we will not present the FCMs that originated from that meeting. This second case has mainly been included to substantiate the claim that FCM is a good tool to use in a participatory setting, from the perspective of the participants (see next section).

2.4. Results from questionnaires

After both the Bari workshop and the Wageningen training, all participants were asked to complete a questionnaire. Most of the questions related to the opinion of the participants on the different methods presented in the training. Answers could be given on a scale of 1 to 5, with 1 being very negative and 5 very positive. In Bari no backcasting exercise was conducted. A selection of the results is presented in table 2.3.

Table 2.3; Results from questionnaires after the two trainings.

question	**Bari (n≈7)**	**Wageningen (n≈34)**
usability of FCM in first stage of scenario development	4.4[1)]	4.0
was the exercise well structured and clear?		
FCM	4.3	4.1
collage (vision)	4.2	3.8
backcasting	n.a.[2)]	4.0
ability to give input for		
FCM	3.4	3.9
collage (vision)	3.4	3.7
backcasting	n.a.	4.0
input in represented in final product		
FCM	3.7	3.8
collage (vision)	3.1	3.8
backcasting	n.a.	3.9

1) on a scale of 1 to 5, with 5 being very positive and 1 very negative
2) not available

The participants of both trainings found FCMs very useful in the first stage (describing the present) of the scenario development process. Participants indicated that the FCM exercises were clear and more structured than the visioning exercise, which was expected given the different nature of both exercises. Participants felt that they could give more (or the same amount of) input to the FCM development than to vision development, although backcasting scored even higher. Also the contribution to the final product was higher for FCM than for visioning, with backcasting again scoring highest.

2.4.1. *Interpretation of questionnaire results*

Results of both questionnaires show potential for the use of FCMs in participatory scenario development. Participants gave high scores to all the methods used. FCM often scored highest, for instance on the ability to give input. This gives a strong indication that FCM can be used in a highly participatory setting. The outcomes give a strong indication that with the adopted methodology, FCMs were quite easy to teach and execute with the group of participants present. Furthermore, all SCENES Pilot Area coordinators that attended the training were enthusiastic about the methods and plant to use them in their Pilot Area workshops. The participants' appreciation of the backcasting method and the overall high scores further strengthens our confidence in the framework presented here.

2.5. Discussion

The weak link between qualitative and quantitative scenarios is a major problem in the development of integrated scenarios (Kok and van Delden, 2009). The aim of this chapter was to demonstrate the use of the presented scenario development framework to bridge the gap between storylines and models.
Results from two case studies show that FCM appears to be a useful method for a first step in scenario development (to discuss the present). Moreover the local partners of SCENES are enthusiastic about it. However FCM, like all methods, also has it drawbacks. Some of them have to do with the method itself (see Kok, 2009) and will not be discussed here, others are more process based.

2.5.1. *Process based issues*

There are two process related issues that need specific attention when using FCM in scenario development. These are: creativity versus structure, and working to consensus versus mapping out diversity.

Creativity versus structure

Scenario development is an exercise that asks for flexibility and creativity from stakeholders. Creativity of the scenarios is one of the four criteria proposed by (Alcamo and Henrichs, 2008) to assess the quality of scenarios. Creation of FCMs, however, forces stakeholders to be very clear and specific in their description of the system following a number of rules, which might well limit creativity. By using stricter rules in the beginning of the process, there is a chance of hampering free and creative thinking in later stages. There should thus be extra attention on creating a free, creative and open atmosphere during the second step of the framework in order to stimulate the development of creative scenarios, especially when FCMs are also used in that second step. Interaction between creative (qualitative) and more structuring (semi-quantitative) methods should lead to a better structured end product that remains creative.

Consensus versus diversity

Parts of the framework are more focussed on working towards consensus, where other parts are more focussed on mapping out the diversity of ideas of stakeholders. Post-it sessions and spidergrams show the diversity of ideas and perceived importance. Visioning aims on the creation of consensus (Evans et al., 2006b). Creating FCMs in groups does need some level of consensus among the group members, but can also be used to show the diversity of different groups. In workshops where reaching consensus seems very difficult it is possible to split the group so that like minded participants will be together. However, in that situation possibilities for social learning are limited compared to groups that include different perspectives.

2.5.2. Place of FCM in the framework and SAS approach

It is important to remember that FCM is used within a larger framework in which methods are interlinked; outcomes from one are used by others. All methods together cover a wide spectrum of issues. The use of various methods at the same time can improve the quality and adequacy of the results (Rotmans, 1998). In figure 2.8 the tools and methods used within the framework are placed along two axis derived from the above discussion; creativity versus structure and consensus versus diversity.

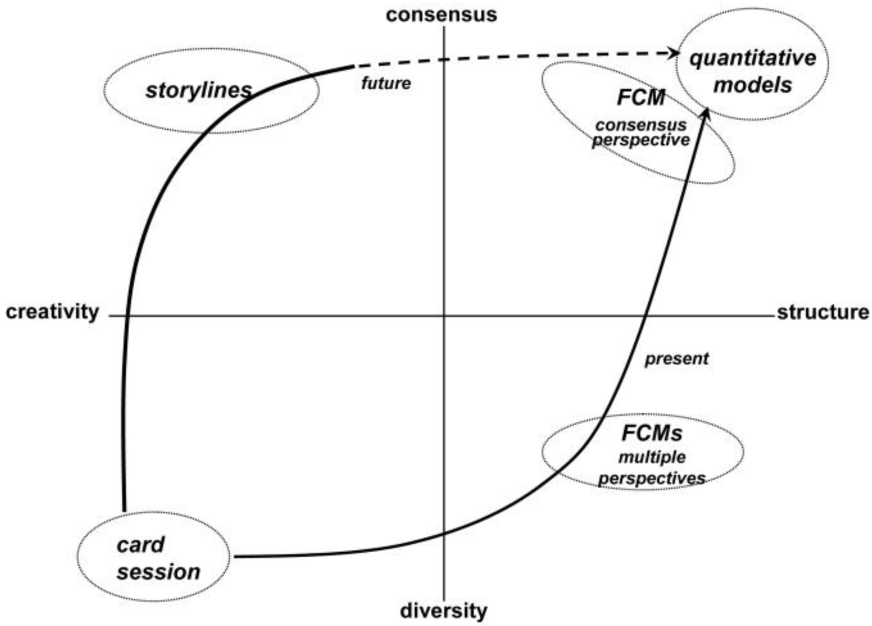

Figure 2.8; Use of FCMs in connecting workshop results with model, for the present and future situation

Traditional qualitative tools can be placed on the left side of the figure; the gap between them and quantitative models is large as they are more focussed on creativity than structure. Semi-quantitative methods are more focused on structure and are thus place more on the right side of the figure. FCM is placed close to quantitative models; the gap between those two methods is smaller.
The participatory process often starts with getting out the diversity of views, after which the group will work towards consensus. In scenario development consensus is reached on the storylines. These storylines are then quantified by experts for use in models. This is illustrated in figure 2.8 by the upper arrow: where the stakeholders' role ends and experts take over the line is dashed. Within the proposed framework a FCM of the future

is created by stakeholders. The input of stakeholders thus becomes closer to the models. The FCM can be used to compare stakeholders' system perspective with that of the modellers. FCMs form a 'language' that both the stakeholders and the modellers can work with, so that they can learn from each other and try to find a consensus.
FCMs of the present are created by several small groups of stakeholders. It is likely that those FCMs will be different from each other, they show multiple perspectives of the current system. In general one final FCM will be created that shows a consensus view of how stakeholders perceive the system. This FCM can then be used to compare stakeholders' system perspective with the modellers' system perspective. This process is represented by the lower arrow.
We can thus discern two possible paths that can be used to link participatory output and expert models, both of which include the use of FCMs. The first is more focussed on creativity and primarily aims at consensus building (upper arrow). The second is more focussed on increasing structure and system thinking, without losing diversity of perspectives. The proposed framework provides possibilities for both approaches, when desired also within a single workshop. As we argued in section 2.5.1 a balanced use of both processes is needed.
In this light there are two other issues we want to discuss in more detail; the relations between modellers and stakeholders, and how to link models and storylines.

Linking stakeholders and modellers

The learning cycle among stakeholders and modellers is important in our approach. If the iteration between models and workshop outputs is given sufficient attention from both sides, a consensus can be found between the ideas of stakeholders and modellers. As long as the assumptions, system descriptions and results are relatively similar this should not be a very difficult exercise. FCMs can then be used to show the differences between storylines and model system perspectives. Interesting is what happens when stakeholders create a FCM that is so radically different from the system description of the modellers that consensus is impossible. Stakeholders might no longer find the model credible or vice versa. Should the model be abandoned and a new model be developed on the basis of the FCM, or should the modellers try to convince the stakeholders of the credibility of their model? In projects where existing, large models are used it might be impossible to change the model in such a way that it better fits the stakeholders' system perception. In cases where it is possible to create a new model fitting the stakeholders' perception, a second round of workshops should be organised in which from the FCM, through a group model building approach, a new model can be created. This exercise will give both the stakeholders and the modellers new insights and new ideas, which they can use in other cases as well. Stakeholders can then check their ideas with a model, of which they know what the limitations and assumptions are.

Linking storylines and models

FCMs can be used to increase the link between storylines and models. Figure 2.9 shows an overview of how this can be done. FCMs of the future are derived from the storylines, which serves as a check for the storylines' internal consistency (arrow 1 in figure 2.9). FCMs can be used in the quantification process (2); semi-quantitative output can be used as guidelines for variables change. FCMs can also be used directly by modellers (3) as a description of the stakeholders' system perception. This perception can be compared with the model's system description. Feedback from models to storylines (4) can be either direct, by showing stakeholders model output, or via FCMs by showing the differences between the stakeholders FCM and a (F)CM derived from the model. Although this does not necessarily directly facilitate the quantification process, semi-quantitative methods do strengthen the possibilities to show the contradictions between models and storylines. With FCMs the qualitative aspects of the system can be shown that can not be represented in the model. In our opinion this will do more justice to both the storylines and the models.

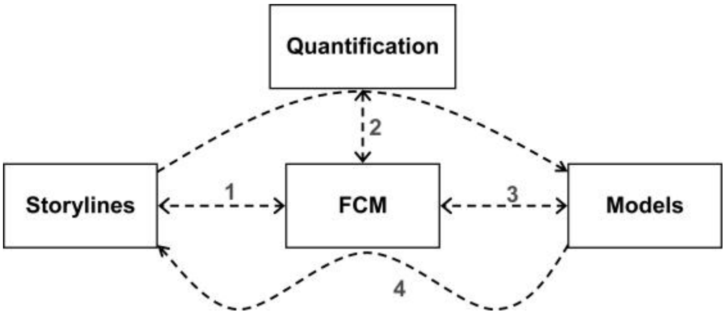

Figure 2.9; Quantification of storylines with the use of FCM.

2.6. Conclusion

The aim of this chapter was to show the possible use of the updated scenario development framework to bridge the gap between storylines and models. The semi-qualitative outputs of FCM can be used in the quantification of the storylines and other communications between stakeholders and modellers. FCMs:

- add system understanding
- are able to work with qualitative variables
- do not need hard data
- shows effects of changes in feedbacks
- can include social effects included
- are flexible

The characteristics of FCMs show that they form a stepping stone between storylines and models (for characteristics of the storylines and models see table 2.1).

The first tests with FCM development in a participatory workshop showed that Fuzzy Cognitive Maps are a useful, easy to teach, and easy to use tool that can play an important role in bridging the gap between scenario storylines and models. A relative good system description can be obtained in a short time. Outputs of groups can be compared to facilitate up-scaling. The FCMs give a clear idea of the system the stakeholders' reasons from when they describe the future, showing some of the assumption behind their visions.
FCMs can be used in the communication between stakeholders and modellers. This in turn can lead to a better representation of stakeholders input in models. FCMs can thus

be used as a communication tool to work towards consensus, but they can also be used to show the diversity among stakeholder groups and between stakeholders and modellers.

Concluding we can say that the use of FCM and other semi-quantitative methods in participatory scenario development can help the overall scenario development. The framework described structures workshop outputs, but still keeps attention on the creative aspects of scenario development. The better structured output facilitates a stronger link between storylines and models, and the communication between stakeholders and modellers.

Chapter 3

Structure in creativity; effects of structuring tools used to combine qualitative and quantitative scenarios on the resulting storylines

Based on: van Vliet, M., K. Kok, T. Veldkamp, S. Sarkki, submitted, STRUCTURE IN CREATIVITY; Effects of structuring tools used to combine qualitative and quantitative scenarios on the resulting storylines, Regional Environmental Change

3. Structure in creativity; effects of structuring tools used to combine qualitative and quantitative scenarios on the resulting storylines

3.1. Introduction

In today's world social systems are increasingly tightly connected to biophysical processes. The resulting fundamental unpredictability and uncertainty of social-ecological systems gives rise to a growing need for research that attempts to unravel the complexity of current and future issues. Also climate change is driven by - and impacts on - combined social and environmental systems. Scenarios are frequently used to increase understanding of such complex systems in which uncertainties are high (Peterson et al., 2003; Biggs et al., 2007; Valkering et al., 2010). They capture a range of uncertainties by describing and analyzing a set of possible futures in which social and ecological systems are linked, instead of trying to predict one single outcome (Peterson et al., 2003; Valkering et al., 2010). Commonly, qualitative stories are developed – often in a participatory manner – to explore the future uncertainties in the socio-economic, cultural, political and institutional aspects as linked to environmental factors. Models are developed to enhance this information and are especially well suited to study the linkages between environmental factors and demonstrate their impacts (Ridder and Pahl -Wostl, 2005). Both types of scenarios have their advantages and disadvantages (van Vliet et al., 2010). In order to create scenarios that incorporate the best of both types they are often developed together (e.g. IPCC, 2000; UNEP, 2002; Millennium Ecosystem Assessment, 2003; Kok et al., 2006b).

As the input from policy makers and other stakeholders is mainly in the storylines and the input from scientists and experts mainly in models it is important that these products are linked (Xiang and Clarke, 2003; Alcamo, 2008). Discrepancies between the products may lower the trust of stakeholders in models and lower the credibility and scientific status of the overall results. Limited exchange between stakeholders and experts also leads to a loss of 'negotiated science' (Giller et al., 2008) and social learning (e.g. Pahl-Wostl, 2006). One way of combining qualitative and quantitative scenarios is using the Story And Simulation (SAS) approach (Alcamo, 2008). In this iterative process, storylines and model results are compared and revised until both products are consistent. A range of potential problems inhibit a complete link between models and storylines, among others related to time and resource limitations and differences in system description (Kok and van Delden, 2009; van Vliet et al., 2010). Quantification of the storylines remains difficult, due to the vague and unstructured output of many participatory workshops. One problem, which will be highlighted in this chapter, is related to the low level of structure of the qualitative output.

Structure

A number of studies have defined quality criteria for scenarios (e.g. Albert, 2008; Alcamo and Henrichs, 2008; Hulme and Dessai, 2008; Girod et al., 2009), most of them mention credibility. Alcamo and Henrichs (2008) state that: "*the SAS approach produces credible results because it can incorporate state-of the art computer models for generating numerical information about environmental changes and their driving forces and for checking the consistency of qualitative scenarios*." In other words, the credibility of scenarios increases if the storylines and models are linked better. We hypothesize that a structured output from the participatory process enhances the link between qualitative and quantitative scenarios in the SAS approach. Structuring qualitative output therefore increases the credibility, and consequently the quality, of scenarios.

Structure is hard to grasp but links to aspects like the number of rules, internal consistency and explicitness. Vervoort et al. (2010) also added aspects that link to structure in their criteria for capturing Complex Adaptive Systems, such as showing systems' connectedness and feedbacks and transferability of methods to other scenario exercises and contexts. Structure can be linked to credibility, internal consistency, explicitness and whether or not there are clear underlying rules and assumptions. In this study different tools have been used; collages, storylines, timetrends and a semi-quantitative form of conceptual models, called Fuzzy Cognitive Maps (FCMs). Collages are developed by groups of participants by pasting images on a large paper to illustrate the scenario. It is an unstructured tool, as there are no rules, and from the collage alone it does not become clear how the different parts are related. Storylines often show the sequence of events and some relations, but they are not clearly defined. In one workshop a matrix was used with important issues and time periods, to structure the development a bit more. Timelines clearly show the sequence of events, but assumptions and relations remain largely hidden. Conceptual models clearly show relations, which forces participants to be more explicit on underlying assumptions (van Vliet et al., 2010).

Creativity

Another key quality criterion is creativity. A creative process can lead to more innovative, non-linear thinking that can challenge current perceptions about the future (Alcamo and Henrichs, 2008; Bohunovsky et al., 2010). Involvement of stakeholders can increase creativity; in an open atmosphere diverse groups can learn from each other, compliment arguments and thus come up with new and creative concepts for future developments. Involvement of a wide range of stakeholders leads to a wide range of ideas. It is therefore preferable to involve diverse stakeholders and to ensure that there is room for creative and non-linear thinking, which increases creativity, and consequently the quality, of scenarios.

Although there is quite a lot of literature on how creativity in people can be measured (e.g. Amabile, 1982; Kaufman et al., 2007; Karwowski and Soszynski, 2008; Silvia et al., 2009), there is hardly any to be found on measuring the creativity of products (Couger and Dengate, 1996). There is not one definition for creativity; according to Bruner (1968) "effective surprise" is the main criterion for creativity, while Keil (1987) sees creativity as the ability to look at things differently. Amabile (1982) argues that creativity is exhibited when a product or service is generated that is both novel and useful. Although there is no single definition, many authors agree that divergent-thinking is an important skill relevant to creativity (e.g. Guilford, 1956; Baer, 1997; Silvia et al., 2009), although it does

not represent creativity fully (Kaufman et al., 2007).
In the search for finding techniques to test the creativity of scenario storylines we found one technique, used to study creativity of people, that involves the writing of stories. The consensual assessment technique (CAT, e.g. Amabile, 1982) asks participants to write a story, which is than assessed on its creativity by experts, such as authors. It does, however, not included an objective measurement for creativity, experts have to give a score based on their perceptions.
A test that includes divergent thinking is the Test of Creative Imagination, that uses three indicators to test the creativity of people (Karwowski and Soszynski, 2008). These people are asked to create drawings based on a limited number of given elements (straight and curvy lines, semi-circles and dots). The indicators are (Karwowski and Soszynski, 2008):

- fluency – measured by a number of created drawings
- elaboration, transformativeness and visualization – measuring transformative capabilities as well as elaboration and an extent of drawing visualization
- originality – measuring the originality

Other test also include novelty and transformation capability (e.g. Jackson and Messick, 1965). However, most tests include many subjective elements, which are hard to measure in scenarios.

Structure versus creativity

There seems to be a tension between the need for structure and the need for creativity, but both are important for the quality of scenarios. Our hypothesis is that overly focusing on structure will decrease the level of creativity, as a more structured approach lowers the freedom of action and thinking by forcing more rules. Van Vliet et al. (2010) presented a participatory scenario development framework (see also section 3.2.2) that aims to balance between creative and structuring tools. This is hypothesized to increase the quality of the developed scenarios as they gain more credibility (by including structure), while maintaining creativity.

The main ideas behind this framework are:

- Introducing more structured methods will lead to more structured output, which can lead to a better link between the participatory output and the models.
- Incorporating creative tools is necessary to ensure the creativity of scenarios.
- A consensus view output is needed in order to link the participatory output and the models.
- A toolbox of methods is required to reach a wide range of stakeholders (which can increase learning, relevance and credibility of the results).

Stakeholder processes can be said to make use of certain inputs and lead to both outputs (the products, in this case storylines) and outcomes (learning processes, development of trust, etc.) and are executed within a certain context (Burgess and Chilvers, 2006; Hermans et al., 2011). Often these four aspects are related to each other (Hermans et al., 2011).

3.1.1. Objectives

The objective of this chapter is to analyze the effects of structuring tools on the creativity of workshop results. In order to reach this objective the following questions are addressed:

- What is the effect of structuring tools on the creativity of the workshop outcomes, as perceived by the workshop participants?
- What is the effect of structuring tools on the creativity of the storylines (outputs) resulting from the workshop?
- Are there relations between the effect of structuring tools on the creativity perceived by the participants and the level of creativity in the output?

These questions enable to address the overall research question:

- Is it possible to introduce more structure (in order to increase the credibility of the scenarios), while maintaining creativity?

3.2. Research set-up

Use of framework in the workshops

Data has been used from eight Pilot Areas workshops and one regional panel workshop. Each workshop used the participatory scenario development framework described in the previous chapter. They started with mapping the main issues concerning the basin, mainly using a card session. These issues were then clustered and used as input for the creation of Fuzzy Cognitive Maps, which normally contained around 15 boxes. Collages were suggested as tool to develop visions, but in practice also timetrends, FCMs and storylines were used (see table 3.1). Directly after the workshop all Pilot Area organizers produced storylines based on the workshop material. The fact that all Pilot Areas worked towards the same output (storylines) enabled a comparison of the creativity of the results from the different Pilot Areas.

The tools proposed for using in the workshops were intended to have a specific effect. Card sessions and collages were aiming at creativity, where FCMs and timetrends were aiming at bringing more structure in the workshop output. Timetrends were originally intended to be used during a backcasting exercise (in the third workshop) as means to illustrate changes due to (policy) actions. Being very specific on the when and how much questions, timetrends can also be considered a structuring tool. In one Pilot Area pre-developed draft storylines were discussed, in one other a matrix of main issues and time periods was filled in, which formed a kind of storyline. Due to the structured way in which storylines were created it is here considered to be a structuring tool as well.

3.2.1. Main characteristics of the stakeholder workshops

The Pilot Areas were asked to follow the framework, but were allowed to deviate if local circumstances made that necessary. An extensive training program made sure that Pilot Areas had a similar understanding of the developed framework. Overall all workshops were a success. All desired results were produced. Table 3.1 (see next page) shows the main characteristics of the workshops as they were executed.

Table 3.1; Typology of workshops per Pilot Area for process.

	type of tool used for visioning exercise	**tool used in visioning exercise**	**length of workshop**	**size of toolbox**	**tools used in the workshop**	**data available for**
Baltic region	structuring	timetrends	2 days	4	card session, spidergrams, Fuzzy Cognitive Map, timetrends	both [a]
Narew	not-structuring	collage	2 days	4	card session, spidergrams, Fuzzy Cognitive Map, collages	both
Peipsi	structuring	timetrends	2 days	4	card session, spidergrams, Fuzzy Cognitive Map, timetrends	outputs
Crimea	not-structuring	collage	2 days	4	card session, spidergrams, Fuzzy Cognitive Map, collages	both
Lower Don	not-structuring	collage	1 day	4	card session, spidergrams, Fuzzy Cognitive Map, collages	both
Danube Delta [b]	structuring	storylines	2 days	3	spidergrams, Fuzzy Cognitive Map, storyline	both
Guadiana	structuring	FCM	1 day	2	card session, Fuzzy Cognitive Map, (present and future)	both
Seyhan [c]	structuring	storyline	1 day	3	spidergrams, Fuzzy Cognitive Map, storyline (matrix)	outcomes
Candelaro	not-structuring	collage	2 days	3	card session, Fuzzy Cognitive Map, collages	both

a: data available for both outcomes (participants' perception) and outputs (storylines)
b: issues predefined by organisers, changes were possible
c: issues predefined via a questionnaire

3.3. Methods and techniques used in analysis

To study the creativity we needed to develop a tool to analyse the creativity of the output and outcomes. As there were no test found to analyse the objectively test the creativity of storylines, we had to develop our own. We wanted a relatively simple and straightforward test, which is described in section 3.2. For the outcomes questionnaires have been used, this is described in section 3.3. In the next section we discuss the context of the workshops.

3.3.1. Context of the workshops

To study the effects of structuring tools on the creativity of the output, we selected three context characteristics that are assumed to have an impact and were readily available for analysis.
These were first of all the type of tool used; Use of structuring tools (Fuzzy Cognitive Maps, timetrends or storyline) versus collages. It is hypothesized that more structured tools will hinder creativity.
It is further hypothesized that in a two-day workshop there are more opportunities to be creative than in a one-day workshop. Therefore the influence of the length of the workshop on the creativity was also studied.
It is expected that by using more tools more and different types of stakeholders can be engaged in the process. More and different ideas are likely to spur creativity. Therefore the third context characteristic that is taken into account is the number of tools used.

3.3.2. Participants' perception on creativity (outcomes)

At the end of the workshop participants were asked to fill out a questionnaire. Participants were asked, among others, to indicate their level of agreement with three statements. These statements, although not specifically designed for this study, can be linked to creativity and structure. Answers were given on a scale of one to five, in which one represents 'totally disagree' and five 'totally agree'.
The statements were as follows:

1. Participating in the workshop helped me to build a more comprehensive understanding of the river basin area.
2. Other participants brought fresh ideas into discussion.
3. The fact that we worked together with different participants raised fresh ideas that were new to all participants.

The first statement can be linked to structure, as without structure it is hard to get a comprehensive understanding. A more comprehensive understanding of the river basin area might originate from a good FCM exercise and lead to a more structured output.
The second and third statement are linked to creativity, as creativity is often linked to novelty in creativity literature (e.g. Jackson and Messick, 1965; Amabile, 1982).

3.3.3. Creativity in the storylines (outputs)

For the analysis of the creativity in the storylines, the FCMs of the present and the storylines were used. First the number of boxes in the FCM of the present was used as an indication of how many issues were considered relevant. Then the storylines were read carefully and all issues mentioned were noted. The issues in the storylines were compared to the issues mentioned in the FCMs of the present, resulting in a count of the

number of new issues. This links to the aspect of novelty, which is recognized as an indicator of creativity of products (Jackson and Messick, 1965). The higher the percentage of new issues, the higher the novelty of the scenario. The length of the storylines - in number of lines - was also measured after they were all put in the same format. These two aspects are relatively easy to measure and directly links to divergent thinking which is an important aspect of creativity (see e.g. Guilford, 1956; Baer, 1997; Karwowski and Soszynski, 2008).
The creativity of a storyline is linked to both the percentage of new issues as well as the length of the storylines. A creativity index was calculated by taking the length of the storyline times the percentage of new issues (Equation 1).

Creativity index = number of lines of storyline X percentage of new issues (Equation 1)

Storylines should not only be creative, but also relevant for today. The percentage of issues from the FCM of the present used in the storyline can be seen as an indication for their relevance.
For three Pilot Areas only data from either the participants' perception or the storylines was available (see table 3.1).

3.3.4. Method of analyzing

We compared the scores for the statements and the creativity of the storylines per context characteristic. Furthermore we checked whether or not the differences were statistically significant. We used PASW Statistics 17.0 to conduct a nonparametric Mann-Whitney test, a test developed for small data sets. Given the small data size, we considered significance up to the 0.1 level. The results of creativity of storylines and the participants' perception have also been cross checked for correlation and statistical significance (bivariate correlation analysis, for Pearson correlation, two-tailed significance).

3.4. Results

3.4.1. Results of participants' perception of creativity (outcomes)

Participants graded the workshops with an average of 4.0 on a scale of 1 to 5. Overall the participants agreed with the three statements, with an average of 3.85 on a 1 to 5 scale. Scores per Pilot Area ranged between 3.35 and 4.36 (see Appendix 3). Results per characteristic (see table 3.2) were derived by calculating the average of the Pilot Areas' results that fitted that characteristic. There were no significant differences between one and two day workshops or between toolboxes with four or fewer tools. There was a large, significant, difference between structured and unstructured tools. There were also large differences between the separate structuring tools and collages.

Interpretation of participants' perception results

Type of tool used

The type of tool used influenced the participants' perception the most. Participants of workshops that used collages agreed significantly more with statement three than participants of workshops that used structuring tools. This shows that participants of

Table 3.2; Comparison of average agreement with the three statements for different types of workshops.

		statement		
category		**1**	**2**	**3**
type of tool				
collages	*n=4*	3.83	4.08	3.94
structured	*n=4*	3.81	3.84	3.45*
timetrends	*n=1*	3.74	3.94	3.37
FCM	*n=1*	4.13	3.41	3.35
storyline	*n=2*	3.68	3.99	3.55**
workshop length				
2 days	*n=6*	3.79	4.05	3.66
1 day	*n=2*	3.88	3.81	3.76
toolbox size				
4	*n=4*	3.80	3.99	3.83
3 and 2	*n=4*	3.85	3.92	3.57

n: number of Pilot Areas
Significance of the differences (between that row and the first row of each category) is shown as follows:
** difference is significant at the 0.05 level*
*** difference is significant at the 0.10 level*
Statement 1: Participating in the workshop helped me to build a more comprehensive understanding of the river basin area.
Statement 2: Other participants brought fresh ideas into discussion.
Statement 3: The fact that we worked together with different participants raised fresh ideas that were new to all participants.

workshops that used collages perceived more creativity (in the form of fresh ideas new to all participants).

There are also differences between the different structuring tools. Participants in the workshop that used FCMs of the future agreed much more with the first statement, which is linked to structure. Participants of this workshop agreed less on statement two and three, but timetrends got a similar score on statement three. It seems therefore reasonable to conclude that FCM is the most structuring tool, but that it is less creative. Timetrends do not add much structure and lead to less creativity. Storylines give even less structure, but are more creative than the other two structuring tools. FCM is the only structuring tool that seems to bring extra structure; participants found it helped them to create a more comprehensive understanding of the basin than other tools did.

Workshop length
There were only minor differences between one and two day workshops, none of which were significant. This does not support our hypothesis that with more time there would be a larger possibility to get more creativity.
Size of toolbox
Participants in workshops that used four tools agreed more with statement 3, however, the differences were small (up to 0.25) and not significant. From the perception of the participants there is no clear indication that the size of the toolbox affects the creativity.

3.4.2. Results of creativity of storylines

Overall the storylines included a relatively high percentage of new issues (around 50%, see also Appendix 3). In most Pilot Areas also relatively many of the issues mentioned in the FCMs were also mentioned in the storyline (on average 57%). The length of the storylines differed from more than one page to a small number of lines, with an average of 24 lines.
Results per category (see table 3.3) were derived by calculating the average of Pilot Areas' results in that category. Differences between collages and the other tools used to discuss the future were studied in more detail.

Interpretation of storyline results

Type of tools used
The use of structuring tools in the workshops led to less creative storylines compared to the use of collages, as they include fewer new issues and are significantly shorter. There is a significant difference in the creativity index between the type of tool (structured vs. not-structured) used.

Table 3.3; Comparison of storylines for different types of workshops

category		number FCM used in storyline	percentage FCM used in storyline	number new issues in storyline	percentage new issues in storyline	average length of storyline	creativity index
type of tool							
collages	*n=4*	7.6	54%	9.3	55%	30.1	16.7
structured	*n=4*	9.0	61%	7.4	44%	18.3*	7.9*
timetrends	*n=2*	*10.5*	*86%***	5.4**	*34%***	*19.3***	*6.5***
storyline	*n=1*	*6.5*	*28%*	6.3	*50%*	*19.0*	*9.5*
FCM	*n=1*	*8.5*	*43%*	12.5	*58%*	*15.5*	*9.1*
workshop length							
1 Day	*n=2*	7.6	55%	10.1	56%	25.4	13.9
2 Days	*n=6*	8.5	58%	7.8	48%	23.8	11.8
toolbox size							
4 tools	*n=5*	8.1	67%	7.2	47%	27.7	13.8
3 and 2	*n=3*	8.7	40%**	10.3	54%	18.3	9.8

n: the number of Pilot Areas
** difference is significant at the 0.05 level*
*** difference is significant at the 0.10 level*

Timetrends in specific resulted in shorter storylines with a lower percentage of new issues and a higher percentage of FCM used. An important reason might be that the key issues represented in timetrends were often the boxes of the FCM of the present. Storylines and FCMs both gave a percentage of new issues that is comparable with that of the collages. All three structuring tools lead to a lower creativity index, but only for timetrends the difference is significant.
The storylines developed from the FCM of the future contain a high percentage of new issues; apparently structure does not necessarily lead to less creativity. In fact, the percentage of new issues in the storylines of FCM is the second highest (see Appendix 3). A reason for this might be that new boxes are relatively easily added to a FCM. The low creativity index of the storyline of the FCM workshop is completely caused by the short length of the storylines.

Workshop length

Differences between one and two-day workshops were relatively small and not significant. This reinforces the perception of the participants.

Size of toolbox

Storylines of workshops that used four tools contain a significant higher 'percentage of FCM used' then storylines of workshop that used fewer tools. These storylines are also longer and have a lower percentage of new issues, resulting in a lower creativity index. These differences, however, are less strong and not significant. This corresponds with the perception of the participants, out of which also no clear differences became apparent. A further analysis of the workshops that used four tools showed that two out of five used timetrends. Timetrends lead to a low percentage of new issues and a high inclusion of issues from the FCM, similar to the differences noted above. Therefore, the analysis was repeated without these two workshops. With the timetrends taken out, workshops with four tools have significantly longer storylines that include a slightly higher percentage of new issues and a higher percentage of 'FCM used' than workshops with fewer tool (see table 3.4). The creativity index is with nine points significantly higher. It therefore seems that the type of tools influences the results most and that the size of toolbox might affect the level of creativity as well.

Table 3.4; Comparison of storylines for toolbox size, without timetrends.

category		number	percentage	number	percentage	average length of storyline	creativity index
		FCM used in storyline		new issues in storyline			
toolbox size							
4 tools	*n=3*	6.5	55%	8.4	56%	33.4	18.7
3 and 2	*n=3*	8.7	40%	10.3	54%	18.3*	9.8*

n: the number of Pilot Areas difference is significant at the 0.05 level*

3.4.3. Relations between outputs and outcomes

There is a high degree of consistency between the participants' perception on creativity and the analysis of the creativity of the storylines. In both cases the main differences are caused by the type of tool that is used. In general, structuring tools lower creativity. A comparison between the two data sets shows that the creativity index is strongly positively correlated (Pearson correlation) with the results of statement 3 ($r=0.736$, significant $p \leq 0.1$). The perception of participants thus matches the analysis of the storylines.

There are, however, some differences. In the analysis of the storylines timetrends score lowest on creativity of the three structuring tools. In the perception of participants timetrends score slightly better on creativity as FCMs. Participants do agree that FCMs bring more structure.

3.5. Discussion and conclusions

In order to increase the overall credibility of scenarios, qualitative and quantitative scenarios should be linked. Increasing the structure is important to strengthen this link. It was, however, hypothesized that increasing structure would lower another key scenario criterion; the creativity of scenarios.

Both the results for outcomes (participants' perception) and output (storylines) showed that the type of tool used has the largest influence on the creativity, while other context related factors like the length of the workshop and the size of the toolbox used had less impact. Results for both output and outcomes show that structuring tools significantly negatively affect the creativity of a workshop. Timetrends score lowest in this respect, while FCMs score best.

These results were, however, derived from a relatively small number of workshop and a novel method was used to measure the creativity. Below we reflect on the methods and analysis used, after which we will use the results of the analysis to critically reflect on the relation between structure and creativity that was hypothesized. The discussion leads to a set of recommendations for participatory scenario workshops and overall conclusions.

3.5.1. Reflection on analysis and methods used

Questionnaires were used as the only input for the stakeholders' perception analysis. Some results might therefore be biased, as participants might give socially wanted answers, or might want to give themselves the idea that their time was well spent. According to some studies, individuals are only partly aware of their own perspective and how it changes over time (Beratan, 2007; Raadgever, 2009). It is, however, likely that the deviance will be more or less the same in all workshops. Furthermore, the questionnaires were not specifically developed for this study. The differences in reaction on statements 2 and 3 are interesting in this case. It seems to show that creativity mainly came from the whole group working together, in stead of individual participants.

The creativity index uses a combination of the length of the storyline and the percentage of new issues. This strongly links to an important aspect of creativity; divergent thinking. However, other aspects like novelty (e.g. Amabile, 1982), and originality (e.g. Karwowski and Soszynski, 2008) are not taken into account. The length of the storylines and the percentage of new issues can both also be influenced by other aspects than creativity. The length of the storylines for instance is also influenced by the time available to the writer. The percentage of new issues might also be influenced by aspects such as facilitation and presentations given in between the FCM and visioning exercise. Another option could be to combine the creativity index with a more subjective approach like the consensual assessment technique (Amabile, 1982) in which the creativity of stories is assessed by experts like professional writers. Overall, It seems that the creativity index can provide a good indication of creativity, especially in combination with other sources.

There was data available from many different Pilot Areas, which made it possible to study the effect of the different methods. However, as Pilot Areas were spread all over Europe, it is likely that it also introduced differences in context that have not been taken into account, such as culture and differences in experience with participatory techniques of the organizers. At the same time might also make it more likely that conclusions will hold for other workshops elsewhere in Europe. Even with all the variation between Pilot Areas, results showed significant differences and high correlations. However, to get a better understanding of other factors that influence workshop results more research is needed.
Another aspect that was not studied is the fact that all workshops started with creating a FCM of the present. This structuring tool in the beginning of the workshop might have affected the creativity of the rest of the workshop. Given the creativity of much of the results, we do have the feeling that participants managed to switch to a more creative mindset in the second part of the workshop. This should, however, be studied in more detail. First getting a clear understanding of how participants perceive the current system of the basin was valuable to better understand their ideas about the future. It does however lead to a loss of time to discuss that future in more detail. Giving the small differences in creativity between one and two day workshops this loss of time will most likely not lead to less creative storylines.

3.5.2. Relation between structure and creativity

This chapter started with the hypothesis that structure is opposed to creativity; the more structure, the less creativity. Although results partly confirm this hypothesis, there are strong indications that structure can be introduced (particularly through FCMs) without hampering creativity. This has important consequences for the diagram that was introduced in the previous chapter to characterize the workshop tools and that formed the basis for the central hypothesis of this chapter. This diagram has two axes; consensus versus diversity and creativity versus structure.
To illustrate the results of this chapter better, the structure versus creativity axis needs to be divided into two axes, separately indicating the degree of structure and creativity. Figure 3.1 shows these two axes; for clarity the third axis of consensus versus diversity has not been included. The degree of creativity has been based on the results of our analysis. The degree of structure has mainly been based on our experiences and the - results of the statement related to structure in the questionnaire(statement 1). Although no significant results were found for statement 1, FCMs seemed to score best. FCMs also seem to bring most structure as their development follows a number of rules, forces participants to be explicit and it gives a system description. Collages give the least structured output, as there are no rules for development and they can often be interpreted in several ways. Timetrends seem to be a bit more structured as storylines. It was not expected that timetrends hamper creativity so severely. The ostensible success of FCMs to maintain creativity was likewise surprising.

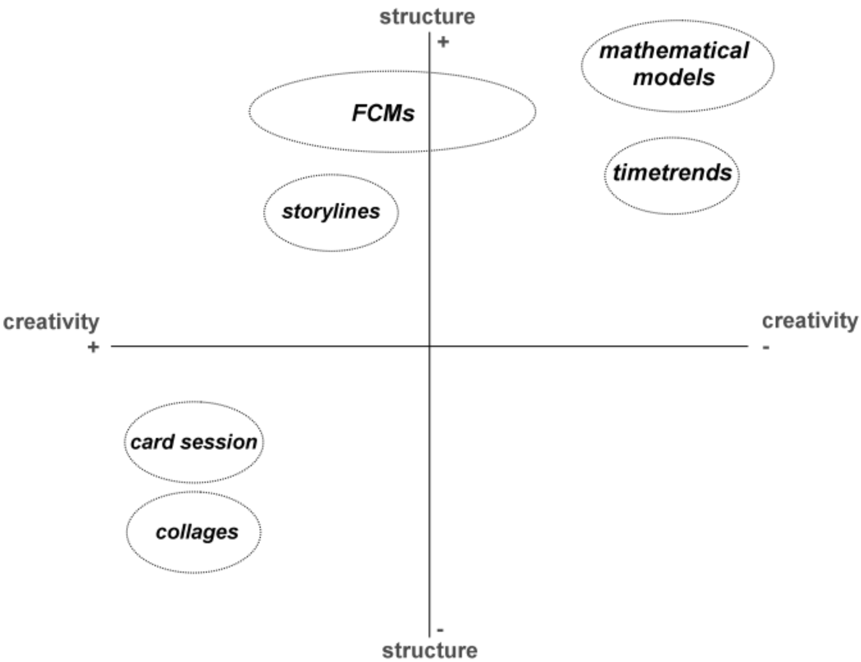

Figure 3.1; The degree of structure and creativity of tools.

In two sequential workshops (as described in the participatory framework from Chapter 2) more and more structure can be achieved, while maintaining a large part of the creativity. In the end the step towards highly structured mathematical models has to be made (SAS approach). This process starts in the lower left quadrant of figure 3.1, with very creative thinking. There remains a large gap in structure between the storylines developed after the first workshop and the mathematical models. This is where the more structured tools of the upper left quadrant come back into play, which can structure the results of the first workshop (note that in the diagram of Chapter 2 these tools could not be placed properly).

In the second workshop all Pilot Areas developed FCMs of the future (based on the storylines) to describe the future in a more structured way. The storylines can be seen as an easy to communicate method to the outside world. For the communication with the modelers FCMs of the present and future can be used (going from upper left to upper right quadrant, see previous chapter). FCMs are closer to the level of structure of mathematical models, but can still incorporate a high level of creativity. They show the "*set of assumptions about key driving forces and relationships*" (Millennium Ecosystem Assessment, 2005a) that exist in the participatory scenarios. This makes FCMs very interesting for communicating participatory workshop results, as they can add to the credibility of scenarios (directly and via the SAS approach) while maintaining the creativity.

3.5.3. Recommendations

Structure and creativity

If more structured output is needed to facilitate a better link between qualitative and quantitative scenarios one should be careful in the choice of structuring tools in order not to harm creativity. Not all structuring tools provide the same level of structure (only FCMs scored higher than collages on the statement linked to structure), and some hamper creativity more than others. Results indicate that timetrends especially hamper creativity a lot. Moreover timetrends tend to lead to linear thinking, which hampers creativity further. Therefore we recommend that timetrends are not used for the creation of storylines. They should only be used in the latest phases of scenario development project to illustrate changes in (creative and non-linear) storylines. Instead we recommend the use of structuring tools that leave room for creativity and stimulate non-linear and system thinking. like FCMs.
To maintain creativity, a good balance between structuring and leaving room for creativity should be found. Especially in longer workshop, or in sequences of workshops, one could start with more creative tools and then use structuring tools to structure these creative results. Therefore a flexible, yet structured tool is needed. FCMs are promising for such a role as they incorporated a high (second highest of all Pilot Areas) percentage of new issues in the storyline. So while being highly structured, they also left room for creativity.

Workshop length

Results did not show clear differences between one and two day workshops. When faced with this choice, a one-day workshop seems to suffice, particularly as they are less resource demanding. Bear in mind, however, that there might be other aspects than creativity that play a role in choosing for a two day workshop such as social contacts, social learning, group building, building commitment, etc. It also depends on the ease that participants will have in getting used to the tools used, as this determines the actual time available for discussion and scenario development.
Note that organizing workshops longer than two days might have strong effects on the findings of this paper.

Size of toolbox

Results suggest that a larger toolbox has a positive effect on the creativity of the workshop, but results were not very strong. In one day workshops it might be more practical to focus on a low number of tools, provided good facilitation is in place to ensure that all voices are heard. With more tools more time is needed for explanation of the tools. However, having only one main tool increases the risk that certain types of participants will be easier involved than other types. If possible, it is therefore recommendable to incorporate additional tools. Combining tools can take advantage of the different types of knowledge and expertise of the participants and can more effectively combine creativity and structure (see Kok and Van Vliet, in press). One option would be to include a very short session in which the creativity of participants is stimulated, for instance via a short mind mapping or rich pictures session (e.g. Lynam et al., 2007; Website MSP portal, 2009). If only one tool can be used in a workshop, we

recommend using another type of tool in the next workshop, bearing in mind potential disadvantages of tools focusing solely on high creativity or structure. Creative output from the first workshop can for instance be used as input for more structuring tools in the second workshop.
The toolbox offered in the participatory scenario development framework worked well; it offered sufficient flexibility to the variety of Pilot Areas, while the mix of tools selected in all cases lead to a successful workshop in terms of stakeholder satisfaction and results produced. In projects with multiple case studies I therefore recommend to always offer a toolbox and, if time permits, to use multiple tools in each workshop (see also the next chapter).

3.5.4. Conclusions

Concluding we can state that it is possible to introduce more structure (in order to increase the credibility of the scenarios) while maintaining creativity, even in one day workshops. As the type of tool used has the largest influence on the creativity of the workshop, great care should be taken when selecting tools for scenario development. Contrary to our hypothesis, the length of the workshops (one or two days) did not affect the creativity. To further illustrate this, both the best and lowest graded workshops were one day workshops.
Results on the size of the toolbox seem to show that with a larger toolbox more creativity is possible, most likely because it makes it easier to incorporate different types of knowledge and expertise of the participants.
Of the structuring tools timetrends led to the largest loss in creativity and should therefore not be used during the development of scenarios. FCMs bring most structure and seem best capable of maintaining part of the creativity. It is therefore the most promising structuring tool, but still underutilized in scenario development.
As a minimum recommendation for a one day scenario we therefore recommend FCMs to be used to develop storylines. When time permits, we recommend to also use creative tools to further ensure the creativity of scenarios.

Chapter 4

Using a participatory scenario development toolbox: added values and impact on quality of scenarios

Based on: K. Kok and M. van Vliet, in press, Using a participatory scenario development toolbox: added values and impact on quality of scenarios, Journal of Water and Climate Change
and: van Vliet, M., K. Kok, T. Veldkamp, 2010, Linking stakeholders and modellers in scenario studies; the use of Fuzzy Cognitive Maps as a communication and learning tool, Futures, *42 (1)*

4. Using a participatory scenario development toolbox: added values and impact on quality of scenarios

4.1. Introduction

4.1.1. Scenarios and participation

The world is growing increasingly complex with social systems being tightly connected to biophysical processes acting over a large range of scales. The resulting fundamental unpredictability and uncertainty of social ecological systems gives rise to a growing need for research that attempts to unravel the complexity of current and future issues. Scenario development is widely considered as a valuable tool to deal with complex, uncontrollable and uncertain problems (Peterson et al., 2003; Biggs et al., 2007). Key to the state-of-the-art scenario development methodology is the notion that the further one explores the future the more uncertainty increases. Hence, there is a need for multiple projections of plausible futures to capture this uncertainty, instead of focusing on predicting one single outcome (Peterson et al., 2003; Biggs et al., 2007). Commonly, qualitative stories are developed – often in a participatory manner – to explore the future uncertainties in the socio-economic, cultural, political and institutional aspects as linked to environmental factors. These stories are then combined with quantitative models that provide detailed information on particularly environmental processes. Models can also be used as a consistency check of narrative stories.

The working hypothesis of most scenario projects is that one dimensional, single sector focused scenarios, relying on a limited set of characteristics, will not lead to sustainable solutions. Hence an integrated, participatory approach is needed, which gave rise to a multitude of recent scenario projects in which stakeholder participation was important. Good examples are the Global Environment Outlook (UNEP, 2002) and the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005a) on the global scale, and MedAction (Kok et al., 2006a; Kok et al., 2006b), PRELUDE (European Environmental Agency, 2006) and VISIONS (Rotmans et al., 2000) on the European scale.

With the increased level of stakeholder participation and the increased number of tools that are consequently needed, two separate but related questions urgently need to be addressed. First, what is the effect of increasing the number of tools within a scenario development process? What are the added values, and importantly, what are the pitfalls? Secondly, in order to correctly assess these added values, what are the criteria to evaluate the quality of the (participatory) process and of the scenarios that are produced? In this chapter we will address both questions. The focus will be on the added values of employing a scenario development toolbox by critically using a set of existing scenario quality indicators. Both are introduced below.

4.1.2. A scenario development toolbox: Story-And-Simulation

The Story-And-Simulation-approach (Alcamo, 2008) is a state-of-the-art approach, in which qualitative and quantitative scenarios are linked in an iterative procedure.

Originally devised to link stories and mathematical models, more recently it has been expanded to include a variety of additional techniques to facilitate the link between both types of scenarios (see for instance van Vliet et al., 2010). Worth mentioning are semi-quantitative tools such as Fuzzy Cognitive Maps (Kosko, 1986) and Fuzzy Sets (Alcamo, 2008; Onigkeit et al., 2009), and qualitative tools such as Causal Loop Diagrams (Sterman, 2000; Magnuszewski et al., 2005; Sendzimir et al., 2007). In other words, from a two-product (stories and models) approach, it has evolved into a multi-product approach that includes multiple tools that together offer more flexibility to combine stakeholder-led and model-based scenarios. This chapter will focus on the participatory tools; for details on how these qualitative products were linked to mathematical models, I refer to Kok et al. (2008) and other chapters.

4.1.3. Added values

The Story-And-Simulation approach is evolving to an approach that includes a large number of potential tools, which all together bridge the gap between the original two tools. Besides the aforementioned advantage of facilitating the link between qualitative and quantitative scenarios, there are a number of additional added values to such a participatory toolbox. A toolbox helps scenarios to:

1. Be adaptable to specific case study conditions. Main differences between cases can include: different phase of participatory process; different background of stakeholders; different issues that are of importance; different acceptance of tools; or different culture and traditions.
2. Be adaptable to a broad range of stakeholders during a workshop. Different stakeholders might be more comfortable with different tools.
3. Be comparable across case studies and across scales, which calls for a comparable set of tools.
4. Contain creative elements, yet within a structured and consistent overall scenario.

4.1.4. Scenarios quality criteria

The main underlying reason for using a collection of tools rather than a single one is the aim to develop high-quality scenarios. A number of studies have defined quality criteria for scenarios (e.g. Albert, 2008; Alcamo and Henrichs, 2008; Hulme and Dessai, 2008; Girod et al., 2009); most of them include relevance, credibility, legitimacy and creativity (see chapter 1 for more detail). In the previous chapter structure was proposed as fifth criterion in the light of the Story-And-Simulation approach; Are resulting scenarios internally consistent and coherent? What kind of methods did the participatory process follow and up to what level were the steps prescribed? Structure in both the process and the resulting qualitative scenarios needs to be guaranteed in order to facilitate a link of qualitative and quantitative scenarios. Failure to structure qualitative scenarios might weaken the link and endanger the development of consistent products, which in turn will endanger credibility.

It is important to realise that none of these criteria have exhaustively been tested. To date, it remains a proposed list of relevant criteria on the importance of which there seems to be consensus. An important additional goal of this chapter is to evaluate the usefulness of these criteria.

4.1.5. Objectives

Our hypothesis is that using a toolbox to develop participatory scenarios in a large number of case studies simultaneously has at least four added values, as mentioned above. The main objective of this chapter is to analyse these potential added values by evaluating the contribution to the quality of the resulting scenarios. The focus is on the selection criteria legitimacy, relevance and credibility. Results from chapter 3 are used to illustrate the implications for creativity and structure. In doing so, we will also evaluate the usefulness of the various criteria.

The chapter, however, serves a number of other purposes that precede this analysis. First a short overview will be given of the toolbox and the role of FCMs in it.. Secondly, the chapter offers a meta-analysis of the results across all Pilot Areas, which facilitates placing of individual cases in the larger whole of SCENES. As said, this will be followed by an analysis of the success of the added value of the toolbox employed in SCENES (see chapter 2). The chapter ends with a set of recommendations on the use of toolboxes.

4.2. Added values of using a scenario development toolbox

In Section 4.1.3 we identified four added values of using a set of tools when developing participatory scenarios, all of which merit discussion. We will subsequently analyse the adaptability to (local) circumstances; the flexibility to appeal to different types of stakeholders; increasing the comparability across scales and across case studies; and the usability of the results in terms of links to mathematical models.

4.2.1. Adaptable to circumstances

General info on the workshops

In all Pilot Areas a similar stakeholder-selection procedure was followed. In general, we advised workshop organisers to aim for a group of stakeholders that should include representatives from the private sector, policy, scientists, and non-governmental organisations, thus covering a broad range of expertise on water-related issues. We furthermore advised to aim for a total group of stakeholders of around 35 persons out of which 15-25 should participate in any of the scenario workshops. In practice, the balance between the various types of stakeholders differed strongly, depending on local circumstances and importance of local actors. In general, however, all types of stakeholders were represented everywhere and any workshop was attended by at least 15 stakeholders.

In table 4.1 an overview is given of the actual tools used in each Pilot Area in the first round of workshops. We expected all Pilot Areas to largely follow the approach described in Chapter 2 which includes a toolbox with tools like card sessions, collages, FCMs, timetrends and storylines. The Pilot Areas were, however, allowed to deviate if local circumstances made that necessary. Indeed, most Pilot Areas adopted the suggested tools in the framework to a large extent. All Pilot Areas used a mix of at least three tools, with a minimum set of Fuzzy Cognitive Maps, spidergrams and stories. Some organisers felt the need for slight changes in the set-up and/or methodology in order to fit better to the local culture, customs, or previous experience of working with stakeholders. Stories based on at least two different GEO-4 scenarios were developed everywhere, except in Seyhan where scenarios were not connected to GEO-4. The largest differences were found in the choice for the main tool used to provide information for the stories. Four Pilot Areas used collages; while other Pilot Areas used time trends, Fuzzy Cognitive Maps and/or stories. All Pilot Area coordinators created stories from the mix of products used during the workshop. A number of Pilot Areas also used local quantitative models to quantify the scenarios and deliver quantitative input for the second workshop. In the original set-up we recommended a 2-3 day workshop. To attract high-level stakeholders, a shorter program of 1-2 days was decided on in all Pilot Areas. Three Pilot Areas had a one-day workshop. Of all adaptations this was the largest one. Goal of the workshops were to develop scenarios on the freshwater future of their Pilot Area. The focus lay on the main issues shown in Appendix 1.

Table 4.1. Overview of tools used and some selected additional workshop characteristics in each Pilot Area in the first round of scenario development workshops

Pilot Area	**length WS (days)**	**card session**	**FCM**	**spider grams**	**storyline development method ***	**number of tools used**	**previous experience**	**local models**
Baltic region	2	yes	yes	yes	timetrends	4	no	
Narew	2	yes	yes	yes	collages	4	no	yes
Peipsi	2	yes	yes	yes	timetrends	4	no	
Danube Delta	2	no	yes	yes	storylines	3	yes	
Tisza	2	yes	yes	yes	FCMs	4	no	yes
Crimea	2	yes	yes	yes	collages	4	no	yes
Lower Don	1	yes	yes	yes	collages	4	no	
Candelaro	2	yes	yes	yes **	collages	3	no	yes
Guadiana	1	yes	yes	yes **	FCMs	2	yes	yes
Seyhan	1	no***	yes	yes	storylines	3	no	

** All Pilot Areas developed storylines, but mostly after the workshop was completed. Collages are regarded to be a creative tool, the others to be structuring tools.*
*** as part of the FCM exercise*
**** clusters developed before the workshop through a questionnaire*

In general, we can conclude that the suggested toolbox was sufficiently flexible with a number of tools that appealed to all local organisers. The main tools were used in all Pilot Areas, which indicates that the mix of (qualitative and semi-quantitative) tools that was recommended covered the main aspects that local organisers deemed necessary. Moreover, all Pilot Areas saw added value in using multiple tools. Note that the use of Fuzzy Cognitive Maps and construction of stories was strongly recommended.
There are large differences when looking at the usefulness of individual tools. Although

strongly suggested as visioning tool, collages were only used in 40% of the Pilot Areas. Three possible reasons stand out: Firstly, the phase in the participatory process; a creative open discussion was deemed less necessary in the Tisza and Guadiana where stakeholder-driven processes have been common. Secondly, the time available; one-day workshops can accommodate fewer tools, which could explain the choice in the Guadiana and Seyhan. And finally, above all collages were used in some Pilot Areas *in addition to* more structuring tools (e.g. spidergrams for the future, in the Crimea and Lower Don), indicating that most Pilot Areas were less comfortable with using such a creative tool.

All Pilot Areas saw added value in using structuring tools. Even though Fuzzy Cognitive Mapping is not a standard tool and it takes effort to understand, both for local organisers and for stakeholders, all saw the potential in structuring information. Finally, it is important to note that stories were normally constructed after the workshop. This might indicate a lack confidence or experience with this – again – more creative tool. Summarising, in the view of the local partners and local organisers Fuzzy Cognitive Maps, spidergrams, and to a lesser extent collages were regarded valuable tools to use, with stories mainly being developed afterwards. The toolbox was thus highly adaptable to the range of local circumstances present in the various Pilot Areas.

Impact on scenario quality indicators

The use of a toolbox with at least three different tools influences various scenario quality indicators. Creativity was stimulated by collages; structure was stimulated by Fuzzy Cognitive Maps, timetrends, and spidergrams. The preference for Fuzzy Cognitive Maps timetrends and spidergrams thus seems to indicate a tendency to select structuring tools rather than creative tools. The effect on the creativity of the resulting stories is discussed in detail in the previous chapter (van Vliet et al., subm.-b).

To some extent legitimacy was ensured by using multiple tools, which offer different angles at developing scenarios. This makes it easier for different types of stakeholders to provide input.
Credibility was enhanced in the second workshop by linking FCMs of the future system to FCMs of the present. The use of more structured tools might also have increased the link between the qualitative scenarios and local model output, which further enhances the credibility. Aspects of relevance were addressed by using a mix of participatory tools. The relevance for end users will strongly depend on the selection of stakeholders that participated.

In short, offering a broad toolbox has enhanced structure while maintaining a large part of the creativity, while scenarios are potentially credible, relevant, and legitimate to those that participated in the process. This potential is further assessed in the subsequent session.

4.2.2. Added value: Adaptable to stakeholders

In order to study the stakeholders' perception of the workshops a questionnaire was distributed directly after the first workshop. We assessed the overall appreciation of the workshop and the scenario development framework used in SCENES, as well as differences between different types of tools. Furthermore, we analysed the influence of the following characteristics: toolbox size, use of structuring or more creative tools, workshop length and previous experience of participants (see table 4.1, see Appendix 4 for results per Pilot Area) on the perceived legitimacy, relevance and credibility of the results and process.

Questions were mostly posed using a 5-point Likert scale. For the satisfaction participants could either choose for 'yes', 'no' or leave it blank. The scores on four selected statements from the questionnaire and their satisfaction with the created scenarios were used to assess the appreciation with the workshop and resulting scenarios. Questions and hypothesised links with quality indicators of legitimacy, relevance and credibility are listed in table 4.2.
First the overall results for all workshops will be presented after which the results are analysed per characteristic.

Overall scenario development framework

As shown in table 4.2, overall the workshops scored high with an average score of 4.1 and grades of at least 4 for any of the separate tools, while 86% of the stakeholders indicated their satisfaction with the process. The same holds for most of the individual Pilot Areas. This reinforces the findings from the previous section: the toolbox offered was sufficiently flexible to accommodate the variety of circumstances. Additionally, it shows that on average all of the separate tools selected by local organisers appealed to

Table 4.2. Overview of the questions and statements that were analysed from the stakeholder questionnaire distributed after the first workshop, together with the hypothesised links to scenario quality indicators, and average scores per question.

Questions and statements	**Indicator for**	**Average score**
grade for whole workshop	quality of toolbox	4.05
satisfaction with scenario development process	quality of toolbox	86% yes
grade for post-it / spidergram FCM / scenario-building exercise	quality of tools	4.02 / 4.21 4.01 / 4.12
statement 1: The participatory process succeeded in taking advantage of the different types of knowledge and expertise of the participants	legitimacy	4.32
statement 2: My ideas were included in the scenario outcomes	legitimacy	4.11
satisfaction with created scenarios	relevance/credibility	88% yes
statement 3: scenario-making process is useful for river basin management planning	relevance	4.20
statement 4: produced scenarios are usable for river basin management planning	relevance /credibility	3.97

scores on a 1-5 point Likert scale, percentages are percentage of participants that were satisfied the stakeholders. Grades for individual tools differed considerably between Pilot Areas. Interestingly, all tools received both the highest and the lowest score in at least one Pilot Area. Fuzzy Cognitive Maps, for example, scored lowest in three out of seven Pilot Areas, but scored highest in three other cases. The average scores for the individual tools differed little, with scores mostly above 3.7 which is generally regarded as satisfactory.

Results per workshop characteristic

When we calculate scores by characteristic, significant differences surface, despite the low variation in average scores (see table 4.3).

Size of toolbox

The differences between using four tools as opposed to using three or two tools were substantial. On the one hand, the overall workshop grade was significantly higher in Pilot Areas that used more tools, as was the grade for the story development exercise. The grade for the Fuzzy Cognitive Map exercise was also higher. Surprisingly, however, the satisfaction with the resulting scenarios was lower, and with the process leading to them significantly lower.

It seems counterintuitive that although the tools and the workshop were graded higher, the participants were less satisfied with the process and resulting scenarios. One possible explanation is that offering more tools will ensure more participants to be attracted to at least one of them. Simultaneously, however, understanding the process and keeping track of the products that are being constructed might be clouded by the amount of tasks and tools that need to be understood (see Beers et al., 2010). Additionally, time available for each tool is limited, which might lead to less satisfaction with the final results. An alternative explanation is that by using more tools, shortcomings of other tools might become more apparent to stakeholders, which might in turn lead to a lower confidence in the overall process and result.

Length of workshop

There were no significant differences between one and two day workshops. This corresponds with the findings of Van Vliet (subm.-b), but is in contrast with our initial hypothesis that longer workshops will provide better results and a better process. Overall the one day workshops scored slightly higher, especially on the card session and the story development exercise. The satisfaction with the produced scenarios and the process were higher as well. Explanations are speculative, but in any case there is no reason to assume that a 2-day workshop will improve results, even if a similar amount of tools is used.

Type of tool

There were large and partly significant differences between workshops that used collages and those that used more structuring tools for the story development exercise, with higher scores where collages were used. Significant differences were in the overall grade of the workshop, as well as the grade for the FCM exercise.

The overall higher score seems to be mostly related to the feeling of participants to be influential in the process (4.5 on statement 1 and 4.2 on statement 2). The fact that particularly Fuzzy Cognitive Maps were more appreciated most likely shows the added value of combining creative and structuring tools, thus increasing the appreciation for either type of tool. Both findings seem to support the use of a diverse toolbox.

Table 4.3. Average scores (on a 5-point Likert scale) provided by stakeholders on a selection of questions and statements; and total percentage satisfied with two statements. See Table 4.2 for details on statements and questions. Scores are grouped by workshop characteristic.

	statement					card			story	satisfied with	satisfied with
	1	**2**	**3**	**4**	**workshop**	**session**	**spidergram**	**FCM**	**development**	**scenarios**	**process**
toolbox size											
4 tools	4,43	4,06	4,20	3,96	4,31	4,14	4,25	4,39	4,36	80,3%	80,0%
3 tools	4,21	4,17	4,21	3,98	3,90	3,94	4,14	3,72	3,88	91,0%	94,3%
difference	*0,21*	*-0,10*	*-0,01*	*-0,02*	*0,41***	*0,20*	*0,12*	*0,67*	*0,48***	*-10,7%*	*-14,3%***
workshop length											
2 days	4,28	4,02	4,18	3,91	4,09	3,86	4,11	3,90	4,01	84,8%	86,8%
1 day	4,38	4,27	4,24	4,07	4,06	4,23	4,35	4,15	4,34	90,5%	91,5%
difference	*-0,10*	*-0,24*	*-0,05*	*-0,16*	*0,03*	*-0,37*	*-0,23*	*-0,25*	*-0,33*	*-5,7%*	*-4,7%*
type of tool											
collage	4,48	4,16	4,22	3,96	4,25	4,10	4,25	4,32	4,19	88,0%	87,7%
structuring	4,16	4,07	4,19	3,98	3,84	3,91	4,14	3,59	3,98	85,3%	88,5%
difference	*0,33*	*0,09*	*0,03*	*-0,02*	*0,40***	*0,19*	*0,12*	*0,74**	*0,22*	*2,7%*	*-0,8%*
experience											
experienced	4,14	3,94	4,21	4,07	4,00	4,24	4,05	4,00	3,95	85,5%	83,0%
not experienced	4,37	4,09	4,22	4,00	4,20	4,13	4,20	4,26	4,14	87,0%	85,8%
difference	*-0,23*	*-0,14*	*0,00*	*0,07*	*-0,20**	*0,11*	*-0,15*	*-0,26**	*-0,19*	*-1,5%*	*-2,8%*

Differences are the difference between the first and second row.
** difference significant $p<0.1$*
*** difference significant $p<0.05$*

Previous experience
The grade for the workshop and Fuzzy Cognitive Maps were significantly higher when participants had less previous experience with participatory scenario development. The differences were however smaller than with toolbox size and type of story development tool. It seems that new participants felt they learned more and perhaps therefore more appreciated separate tools.

Overall conclusions for adaptability to stakeholders

Overall grades are high, which indicates that stakeholders appreciated the workshop and the variety of tools that was offered. Grades for individual tools were equally high, indicating that all tools were highly valued. However, variation between Pilot Areas indicates that appreciation differed between Pilot Areas. This is another indication that a flexible toolbox is needed in projects that have case studies with a varied background. In workshops with three tools the process and produced scenarios were graded higher overall, even though single tools were graded lower. This nicely illustrates the balance that needs to be found: adding more tools will increase chances that stakeholders will identify with the method, but increases chances that participants will be overwhelmed at the same time.

Impact on scenario quality indicators

Overall results
The average scores on the questions linked to legitimacy, relevance and credibility were around 4 or higher (see table 4.3). Note that statement 1-3 all had higher scores than the grade for the overall workshop. This might indicate that stakeholders strongly felt that relevance, legitimacy and credibility were guaranteed, despite minor issues they might have with the tools that were used. Particularly statements related to legitimacy and credibility scored high. The relatively low score related to statement 4 might indicate that participants were somewhat doubtful that the resulting scenarios would be useful in their day-to-day life, thus questioning the relevance.

By category
Creativity was guaranteed by either the use of collages, or in a more structured way by Fuzzy Cognitive Maps. The use of creative tools such as collages seems to be related to a higher grade for the workshop and end products. In terms of legitimacy, answers of stakeholders strongly indicate that all participants valued their input. Additionally, by shortening the workshop programme, more (high-level) stakeholders could be convinced to participate in the workshop, which was the main reason for a number of Pilot Areas to opt for a one-day programme. Note however, that the actual number of participants was relatively low (15 participants) in some places. By developing Fuzzy Cognitive Maps for the present and for the future, credibility of scenarios is increased. The fact that existing (higher-level) scenarios were used that facilitated a link to international scenario sets further increased credibility. Finally, the scores for separate tools hint towards a process that was relevant for the stakeholders present. The score for the satisfaction with the resulting scenarios indicates that with three instead of four tools the relevance of the results and the process is more clear to stakeholders.

Importantly, however, none of the differences related to the statements linked to legitimacy, credibility or relevance were significant. Moreover, neither legitimacy nor relevancy can be evaluated in any depth based on the analysis of a single workshop. Thus, the conclusions above are mere indications that need further verification.

4.2.3. Added value: Comparability across scales and across Pilot Areas

Methodological considerations

The added value of working towards comparable results cannot be understated in projects where multi-scale scenarios are being developed. Yet, there are various methods to develop multi-scale scenarios. According to Biggs et al. (2007) two features can be used to categorise and understand multi-scale scenarios: 1. the number of focal scales, i.e., the number of scales at which scenarios are developed, and 2. the connectedness between scales, i.e., the strength of the links between them. Most recent scenario exercises are built around two focal scales that are tightly coupled; good examples are VISIONS (Rotmans et al., 2000), MedAction (Kok et al. 2006a, b and Patel et al. 2007); Millennium Assessment (Lebel et al., 2005). Likewise, SCENES uses two focal scales (with some participatory scenario development activities on the third, regional, scale) and the scales are tightly coupled. Main difference lies in whether a strict downscaling approach is followed, where higher-level scenarios partly determine lower-level developments, or whether independently developed scenarios are linked a posteriori (see Kok et al., 2007a). Problems with tighter coupled scales may include aspects like loss of variety, temporal mismatches and creative translations which in the end might still lead to diverging scenarios. SCENES opted to start from an existing set of European scenarios that were used to bound possible scenarios at lower levels, thus tightly coupling scales to maximise comparability. Cross-scale comparison could only be successful when comparability across Pilot Areas would be maximised. There is no 'best' way to build multi-scale scenarios, but in SCENES with its emphasis on the pan-European scale, it was imperative that scenarios at the lowest level were comparable and thus scalable.

Experiences in SCENES

All Pilot Areas used the same minimum set of three tools (Fuzzy Cognitive Maps, spidergrams, and stories), which at least from a methodological point of view, makes the results highly comparable. In fact, the previous sections are good examples of how comparable methods can lead to directly comparable results. One of the main aims of SCENES is to perform a cross-scale enrichment which should ultimately lead to the upscaling of Pilot Area scenarios to pan-European level. Especially in the second round of Pilot Area workshops the pan-European stories have been downscaled to the Pilot Area level. A cross-scale enrichment workshop took place, during which stories developed at pan-European and local level were compared and enriched. Particularly this cross-scale meeting contributed towards completing a full cycle of iterations between both scales. Fuzzy Cognitive Maps were used in all Pilot Areas, thus providing regional coordinators with a structured tool to compare them. The mathematical properties of Fuzzy Cognitive Maps enable combining of multiple (Pilot Area) Fuzzy Cognitive Maps into one (regional) product, which further enhances comparability (see van Vliet et al., subm.-a).

Concluding, even though local partners were given the liberty to devise their own Pilot Area specific program, all Pilot Areas opted for the same set of three basic tools. This resulted in scenarios that are highly comparable. As scenarios at all levels started working from the same set of fast-track scenarios this further increased comparability within and between scales. Particularly Fuzzy Cognitive Maps are promising when putting its potential comparability into practice. On the downside, some of the tools, particularly the stories as part of the original Story-And-Simulation approach, were strongly recommended. There are indications that in hindsight some Pilot Areas would have slightly changed the program if it would have been stressed more that none of the tools were mandatory. Particularly in the Lower Don – where 4 tools were used during a one-day workshop – this was the case. The relative lack of experience with an open dialogue in the Russian Pilot Area is likely to be of influence. Resulting scenarios might be sub-optimal as a result.

Impact on scenario quality indicators

Strongly recommending a set of tools will in principle lower the potential for creativity and relevance of the scenarios produced in a single Pilot Area. The added value is by and large on the resulting set of scenarios at the regional and pan-European level. However, no indications have been found that either the set of recommended tools or the higher-level scenarios restricted creativity or relevance in any way. If so, other factors (see previous sections) were more important in determining creativity and relevance. By using a large portion of the results of individual Pilot Areas at higher scales, the legitimacy and credibility of the pan-European scenarios is strongly enhanced as compared to scenarios that are developed only at the pan-European level. Results are too preliminary to claim that legitimate scenarios at pan-European level have been produced. However, first signs are that at least products can be compared and integrated. Experiences with the stakeholder panel at the Baltic regional level seem to indicate that Pilot Area scenarios are becoming more legitimate when included in the regional level product. Again, we have weak indications at best to corroborate most of these indications.

4.2.4. Added value: Mix of creative and structuring elements will facilitate link to mathematical models

The analysis below is a summary of the main findings as presented in the previous chapter. A mix of creative and structuring tools can increase the level of structure of the output, while being able to maintain creativity. The previous chapter concluded that with more creative tools both the resulting stories and the process were significantly more creative. Key to that conclusion is the fact that participants agreed significantly more with the statement "*The fact that we worked together with different participants raised fresh ideas that were new to all participants"* when collages were used in the story development exercise than when other more structuring tools (like Fuzzy Cognitive Maps and timetrends) were used. The resulting stories were also significantly more creative in terms of being longer and including more new issues.

Offering a toolbox helps to provide structuring elements that in turn help to translate more creative products to input for a mathematical model. However, although SCENES particularly emphasised the weak link between stories (creative, qualitative scenarios) and models (structured, quantitative scenarios), it remains one of the key issues in the Story-And-Simulation approach that deserves extra attention, also when a toolbox with structuring tools is employed.

Impact on scenario quality indicators

As concluded in the section on added value for stakeholders, the toolbox has successfully employed tools with different purposes, thus maintaining creativity, while increasing the potential for credibility and relevance via structure. It is premature to hypothesise that a stronger link between more creative and structured scenarios will lead to an increase of relevance, legitimacy or credibility. However, if the link between qualitative and quantitative scenarios can be increased, it is likely that this will lead to more credible scenarios. A better representation of the impacts in quantitative numbers (e.g. water use) will also increase the usability of the scenarios for river basin managers, thus increasing the relevance of the scenarios.

4.3. Discussions and conclusion

4.3.1. Advantages of toolbox employed

The experiences in SCENES highlighted a large number of advantages related to all four added values as presented in Section 4.1.3. Summarising, these were the most important advantages:

- Three tools can be used in a 1-2 day workshop without jeopardising the process of stakeholder involvement.
- Differences in culture, phase of stakeholder involvement, or individual level of stakeholder knowledge only played a minor role.
- Stories, Fuzzy Cognitive Maps, and spidergrams proved to be good tools to include, as they were embraced in all Pilot Areas and were highly valued by the stakeholders in the majority of the Pilot Areas.
- The overall focus of SCENES on pan-European scenarios (for example through the relative rigidity of the scenario workshop set-up) did not limit the Pilot Area process of scenario development.
- There are indications that the use of a toolbox has increased the quality of the resulting scenarios on all indicators. Scenarios are creative and structured, while being relevant, credible, and legitimate for most stakeholders present at the workshop.

In short, the toolbox proved to be sufficiently adaptable to Pilot Area specifics; be adaptable to a very broad range of stakeholders; have enabled a cross-scale comparison; have successfully integrated creative and structuring elements in the stakeholder-determined products.

4.3.2. Disadvantages of employed toolbox

Despite the many positive indications that the selected toolbox was successfully employed over a range of Pilot Areas across Europe, a number of important issues remain:

- Using multiple tools can overwhelm stakeholders, and lead to a loss of overview of what has been produced (e.g. Beers et al., 2010). This should be avoided.

- Observers of workshops have reported that Fuzzy Cognitive Mapping can in some cases be overly complex. Particularly the dynamic output of the tool is a black box to some groups of stakeholders. In the Crimea, an observer noted that it might be good to test alternative tools that are less difficult to understand. In other words, in those Pilot Areas with a lack of experience, it is best to focus more on simple, less-structured tools.
- The results are credible, legitimate, and relevant for those people that participated. This is but a fraction of the total pool of stakeholders. Although comparison to other Pilot Areas can increase these aspects, a drawback of a workshop is its low number of participants.
- Although stakeholders labelled the results as creative, local organisers in several Pilot Areas have commented on the low degree of surprising issues in the scenarios. This partly relates to the phase of the process (e.g. Guadiana) but is an issue that needs to be further analysed.

In short, a number of issues deserve to be studied in more detail. Particularly the ease with which Fuzzy Cognitive Maps are understood and used by stakeholders; the differences in perception between stakeholders and local organisers on the creativity of the scenarios; and the optimum number of tools to be employed are in need of further research.

4.3.3. Other methodological reflections

In the analysis of the perception of stakeholders, only questionnaires held directly after the workshop have been used. Some results might be coloured, as participants might give more socially wanted answers, or might want to give themselves the idea that their time was well spent. According to some studies individuals are only partly aware of their own perspectives and how they change over time (Beratan, 2007; Raadgever, 2009). It is, however, likely that the deviance will be similar across all workshops. Furthermore, there was data available of many different Pilot Areas, which made it possible to study the effect of the different tools. Yet, group sizes of the different categories remained small, where larger data sets likely would have given more conclusive results. As it seems very difficult to get larger data sets from one project, the scenario field should find ways to be able to better compare different scenario projects.
As Pilot Areas were spread all over Europe, it is likely that this also introduced differences that have not been taken into account, such as culture or the skills of the facilitator. More comparative research in which more of these factors can be studied, is therefore needed.
Another aspect which was not studied is the effect of all workshops starting with the creation of a Fuzzy Cognitive Map of the present. Using a structuring tool in the beginning of the workshop might have affected the creativity of the rest of the workshop. Given the creativity of much of the results, we do have the feeling that participants managed to switch to a more creative mindset in the second part of the workshop. First getting a clear understanding of how participants perceive the current system of the basin is valuable to better understand their ideas about the future. It does however lead to a loss of time to discuss that future in more detail.

4.3.4. Summary scenario quality indicators

Table 4.4 summarises the effect of aiming for any of the four added values of employing a toolbox of methods discussed in this chapter on the five scenario quality indicators used here.
In general, employing a toolbox can positively influence all scenario quality indicators. It seems fair to conclude that when employing a toolbox, not only a number of added values become apparent but the quality of the resulting scenarios will be higher. Legitimacy, credibility and relevance all seem to be positively influenced. Creativity and structure are increased more specifically and mostly when the aim is at linking qualitative and quantitative scenarios.

Table 4.4. Added values of using a toolbox to develop scenarios linked to possible impact on scenario quality indicators.

	creativity	**structure**	**legitimacy**	**relevance**	**credibility**
adaptable to circumstances	x		x	xx	x
adaptable to stakeholders			xx	x	x
comparable across scales		xx	x		x
link stories and models	xx	xx			x

Particularly aiming at a higher adaptability to circumstances can positively influence all indicators except structure. Thus, providing a toolbox that is flexible to case-study circumstances will lead to higher quality, more creative products, though a higher structure is not guaranteed. Similarly, aiming at a higher adaptability to stakeholders is related to legitimate, credible, and relevant scenarios. It can also increase creativity when it better enables stakeholders to work together. Aiming for comparability across scales will focus mostly on a more highly structured methodology. Comparable products across scale and space can potentially become more credible and legitimate.
Finally, linking stories and models will increase both structure and creativity, but does not necessarily lead to relevant or legitimate products. Yet, as said before, this chapter is merely a first indication that a toolbox leads to higher quality scenarios. The selected set of scenario quality indicators is but a good starting point that deserves to be explored in subsequent studies.

4.3.5. Recommendations

We recommend the use of different combinations of structuring and creative tools. Local organisers should have a large degree of freedom in which tools from the toolbox they use, as stakeholders are bound to be attracted to a variety of tools while local circumstances differ. Depending on the circumstances, the toolbox offered should partly differ from the one described here. Collages could be replaced by a tool that is more appealing to local organisers, while Fuzzy Cognitive Maps could be replaced by a tool that is more transparent, to stakeholders especially when experience with FCMs is lacking. The total number of tools should not be too low, but too many tools can lead to time constraints. Finally, a single questionnaire provides a wealth of information, but information that can be linked to the quality of the scenarios is rather limited. We thus particularly strongly recommend that future studies include more structured tests on the quality of the resulting scenarios.

Chapter 5

FCMs as common base for linking participatory products and models

Based on: Van Vliet, M., Flörke, M., Varela-Ortega, C., Cakmak, E. H., Khadra, R., Esteve, P., D'Agostino, D., Dudu, H., Bärlund, I., Kok, K., submitted, FCMs as common base for linking participatory products and models, Environmental Modelling and Software

5. FCMs as common base for linking participatory products and models

5.1. Introduction

Social, economic and biophysical systems are increasingly intertwined. The analysis of these complex systems necessitate multi-disciplinary approaches, including stakeholder participation (Voinov and Bousquet, 2010; Website Mont Fleur, 2011). Stakeholder involvement can further increase the relevance and legitimacy of the research. In particular, local knowledge should be incorporated when data is lacking, or when actions of stakeholders have large influence on the system (Özesmi and Özesmi, 2003). Furthermore, involvement of stakeholders makes it more likely that research results are used by them and it will contribute to the learning process of both stakeholders and scientists (Vennix, 1999; Sterman, 2004).
Stakeholder involvement has also increased in modelling exercises. There are several approaches to develop models in cooperation with stakeholders (Bousquet and Voinov, 2010), but in many projects existing models are used. Incorporating the output of stakeholder workshops in quantitative models is, however, difficult (Cash et al., 2006; Martínez-Santos et al., 2010) as some aspects are difficult to quantify by nature, others are not well defined, or expected magnitudes of change are not specified. Stakeholders should not only be used to provide input for the model. Because most models are highly technical it is difficult for stakeholders to understand them and correctly use the results. Stakeholders and especially end-users should understand the model, including how and when the model can be used (Refsgaard et al., 2005). Likewise it is often difficult for modellers to interpreting the stakeholder driven results (Verburg et al., 2006). Thus, there is a need for a tool that can form a shared language and common base for comparison of stakeholder and model driven products (van Vliet et al., 2010). This tool should make assumptions explicit, and give a clear system description. Additionally, it should be able to deal with social, economic and biophysical issues. Such a tool can give stakeholders better insight in the model, and modellers a better insight in the stakeholders' perceptions. Conceptual models have been frequently used to elicit knowledge from scientists from different fields (both social and natural sciences e.g. Heemskerk et al., 2003) and they have been used by both experts and stakeholders in participatory workshops (e.g.Hare et al., 2003; Magnuszewski et al., 2005).
Fuzzy Cognitive Mapping (FCMs; Kosko, 1986) is such a conceptual tool that can be used to develop a system description in a workshop and show the dynamic behaviour of a system. FCMs have been used successfully in a wide variety of cases, in which both social and biophysical aspects are often combined (e.g.(Cole and Persichitte, 2000; Özesmi and Özesmi, 2003; Kok, 2009). FCMs have also been proposed as a tool to add structure to scenario development workshops in order to enhance the link between stakeholder based qualitative scenarios and model based quantitative scenarios (van Vliet et al., 2010). In scenario development projects storylines developed by stakeholders need to be quantified. The interpretation of these storylines is, however, often "*a rather subjective*" exercise (Verburg et al., 2006). To link stakeholder based qualitative storylines and model based quantitative storylines the Story And Simulation approach

(Alcamo, 2008) is used. Even though the scenarios are iterated between the models and stakeholders the link often remains weak. A communication tool that adds structure and links stakeholders and modellers can help to bridge this gap. FCMs can function as such a tool (van Vliet et al., 2010).

In earlier chapter I have demonstrated a number of added values of using FCMs in stakeholder workshops:

- developing system dynamics models and discussing feedbacks makes stakeholders aware of the influence of feedbacks
- to aid discussion among stakeholders by forcing them to be more explicit on their system understanding
- to aid scenario development, by structuring the ideas of stakeholders and making their assumptions more explicit

The most important assumed added value of using FCMs is in the potential to link stakeholder derived output to a mathematical model. This potential has earlier been hypothesised for the scenario development field by Kok and van Delden (2009) and van Vliet et al. (2010) but the practical application of the link has been untested so far.
In Chapter 2 I hypothesized that FCMs can be used to linking stakeholders and modellers in several ways, which are represented in figure 1.1, (which is repeated in a slightly different form below). Input from stakeholders is often directly quantified by experts (represented by arrow 1 in figure 5.1). FCMs can aid this process in the following ways. FCMs are developed by stakeholders (arrow 2). The modellers develop a FCM in which they represent the system as depicted by the model (arrow 3). The stakeholders' system description can then be compared with the models system description (arrow 4). This comparison will show the differences in system understanding between the stakeholders and the modellers and, consequently, between the storylines and models. The FCM of the model can be used to inform stakeholders on the model, and get a stronger link between the model and other stakeholder output (arrow 5). The FCMs of the stakeholders can further be used in the quantification phase (arrow 6). In this chapter we will study to what extend this can be done; can FCM output be used as input for the model, or make the interpret stakeholder products less subjective?

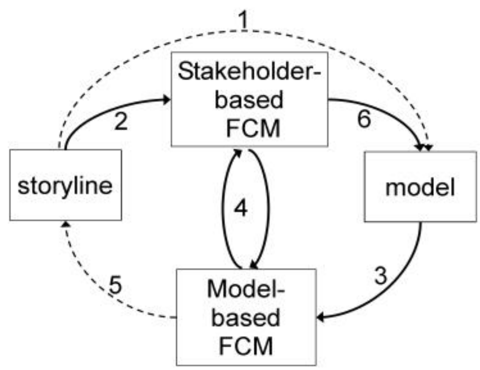

Figure 5.1 Usage of FCMs in the communication between stakeholders and modellers. For explanation of the numbers see text. Based on (van Vliet et al., 2010)

5.1.1. Objectives

The objective of this chapter is to analyse the potential of using FCMs to link stakeholder information to mathematical models. To study this we will:

- develop and analyse a Fuzzy Cognitive Map for the Mediterranean region based on the stakeholder-driven information from three case studies
- develop and analyse a Fuzzy Cognitive Map for the Mediterranean region based on the modelling architecture from a mathematical model
- compare both maps to identify crucial differences and similarities in system perception of stakeholders and modellers
- compare the dynamic output of both maps to output of a mathematical model

5.2. Materials and methods

The following sections describe the two main tools used in this study (FCM and WaterGAP), how FCMs were developed by stakeholders and modellers and how both FCMs were analysed.

FCMs were developed in the three Mediterranean Pilot Areas, situated in the Guadiana (south-west Spain), Candelaro (south-east Italy) and Seyhan (south Turkey) river basins. These Pilot Areas are similar because they all have large areas of irrigated agriculture but differ in, for instance, the type of irrigation systems, water users and amount of natural areas.

The global water model WaterGAP (Water – Global Assessment and Prognosis) (Alcamo et al., 2003; Döll et al., 2003; Verzano, 2009) was used to develop the quantitative pan-European scenarios. Data for the model was (partly) based on the quantification of storylines developed at the pan-European level.

As FCMs were developed at the Pilot Area scale and the WaterGAP model on the pan-European scale there was a need to upscale Pilot Area results and downscale WaterGAP to a common scale on which both would be valid. The regional scale was chosen. The three FCMs from the Pilot Areas were aggregated into one combined FCM. WaterGAP model outcomes of the three river basins and the three Pilot Areas' countries were considered.

5.2.1. Fuzzy Cognitive Maps

Fuzzy Cognitive Maps are a form of cognitive models that includes fuzzy logic to define the strength of relationships between two variables. Cognitive maps show relations among variables. Axelrod (1976) first used them to have stakeholders, instead of researchers, describe a system. Kosko (1986) added fuzzy logic to cognitive maps to incorporate qualitative knowledge, which were then called Fuzzy Cognitive Maps. Fuzzy Cognitive Mapping has been applied in a diversity of fields such as deforestation in the Amazone (Kok, 2009), solar energy (Jetter and Schweinfort, in press), lake ecosystems (Özesmi and Özesmi, 2003) and education (Cole and Persichitte, 2000) illustrating its flexibility.

FCMs consist of variables and connections. Each connection gets a weight between 0 and 1, depending on the strength of the relation (Kosko, 1986). A relationship can be either positive (when one variable increases, the other increases as well) or negative (when one increases, the other decreases) (Kok, 2009). FCMs can be represented graphically, in the

form of boxes and arrows, and mathematically in the form of a vector and a matrix. The matrix consists of the weight of the connections. The vector shows the current weight of the variable in the system.
Each variable is given a value, which forms the starting vector. The next state of the system can then be calculated via a vector matrix calculation. If iterated, the system shows whether the weight of a variable will increase or decrease. However, all outcomes are relative. See section 2.2.3 for more information on FCMs.

5.2.2. WaterGAP model

WaterGAP computes both water availability and water uses and thus computes the impact of climate change and other important driving forces on future water resources. The version of the model applied in this study, WaterGAP3, uses a 5 by 5 arc minutes grid (longitude and latitude, approximately 6 x 9 km in Central Europe). WaterGAP consists of two main components: a Global Hydrology Model to simulate the terrestrial water cycle and a Global Water Use Model (Flörke and Alcamo, 2004) to estimate water withdrawals and water consumption of 5 different water use sectors. The aim of the Global Hydrology Model is to simulate the characteristic macro-scale behaviour of the terrestrial water cycle in order to estimate water availability. Herein, water availability is defined as the total river discharge, which is the sum of surface runoff and groundwater recharge. The upstream/downstream relationship among the grid cells is defined by a global drainage direction map (DDM5) which indicates the drainage direction of surface water (Lehner et al., 2008). In a standard model run, river discharges in 19254 river basins in Europe are simulated. The effect of changing climate on runoff is taken into account via the impacts of temperature and precipitation on the vertical water balance.
River discharge is affected by water withdrawals and return flows. In WaterGAP, natural cell discharge is therefore reduced by the consumptive water use in a grid cell as calculated by the Global Water Use Model. This model consists of several modules that calculate water withdrawals and water consumption in the domestic, industry, irrigation, thermal electricity production and livestock sectors. In this context, water withdrawals depict the total amount of water used in each sector while the consumptive water use indicates the part of withdrawn water that is consumed by industrial processes or human needs or lost by evapotranspiration. For most water use sectors, except irrigation, only a small amount of water is consumed, whereas most of the water withdrawn is returned, probably with reduced quality or heated, to the environment for subsequent use. WaterGAP simulates water use for the agricultural and electricity production sectors on a grid scale, but for domestic and manufacturing sectors on a country scale. These country-scale estimates are downscaled to the grid size within the respective countries using demographic data. Grid cell outputs are then summed up to the river basin scale.

5.2.3. Development of stakeholder based FCM

The development of the stakeholder based FCM (FCM-SH) started at the Pilot Area level. Stakeholders were selected after a detailed stakeholder mapping exercise conducted in all Pilot Areas, so that the participants reflected different types of views and expertise in the water sector. Stakeholders ranged from government officials at regional and local levels, water authority personnel, farmers' associations to individual irrigators and nature conservation groups. The ample array of stakeholders in the different Pilot Areas

permitted the FCM-SH to represent the complexity and richness of the water and human systems.
In two successive workshops, stakeholders developed a FCM that represented their perception of the current (water) system in their Pilot Area. This was done in two to three small groups, of 6 to 10 people each. First, participants were asked to write down the most important aspects concerning the water system. Answers were clustered and the resulting clusters formed the variables of the FCM. Stakeholders then assigned the relations between the variables and the polarity and weights of these relations. In the second workshop results from the first round were refined. Although there were small differences in the method to obtain the FCM the general approach was the same in all Pilot Areas. After the second workshop one combined FCM was developed for each Pilot Area (see Cakmak et al., in press; Khadra et al., in press; Varela-Ortega et al., in press), also for more information on the development process of these FCMs).
These three Pilot Area FCMs were further aggregated into the FCM-SH presented here. The aggregation started with merging identical variables. In all Pilot Areas issues like water shortage, water demand, water price and water quality were addressed. Most variables were addressed in at least two of the three Pilot Areas (see table 5.1). Many Pilot Area variables dealt with similar issues in different terms, for instance water quality and pollution. Other issues were represented in detail in one FCM and by just one variable in another. Variables were merged until 19 remained (see table 5.1 to see which concepts of the Pilot Area FCMs were combined into the concepts of the FCM-stakeholder presented in this chapter).
Once the variables were merged, a similar procedure was followed to merge the connections. First, identical connections were merged. Subsequently, connections that were both direct and indirect (via another variable) were, if possible, merged. Some connections with very low strength that were only present in one FCM were deleted. Pilot Area representatives were involved both in the development of the FMC-SH and the analysis and discussion in this chapter. This way the FCM-SH could be simplified, while maintaining the general system perception of the stakeholders. This increased its usability in the communication with the modellers. A final step was the calibration of the FCM-SH to best represent the perception of the stakeholders and to get a stable output in the iteration, which facilitates the analysis of FCM output.
The FCM-SH represents the three Pilot Areas, which are assumed to be representative for Mediterranean basins in each of the countries.

5.2.4. Development of model based FCM

The FCM-WG only contains aspects that WaterGAP deals with, but does not show all aspects used in WaterGAP in the same detail. WaterGAP is driven by data generated by several other models, yet the FCM-WG only represents those components that are part of the WaterGAP model. For instance, results from the land use model LandSHIFT (Schaldach and Koch, 2009) are used in WaterGAP that are based on a relation between the number of livestock and area required for crop production. As this relation is not part of WaterGAP's main component, it was not represented in the FCM-WG, even though it is reflected in the WaterGAP output.
The connection strengths were assigned to fit the Mediterranean region. Some of the WaterGAP parameters are differentiated according to regions. From the modelling

Table 5.1; Overview of related variables in the three Pilot Area FCMs.

FCM-SH	**Seyhan (Turkey)**	**Guadiana (Spain)**	**Candelaro (Italy)**
Present in three Pilot Areas			
environmental policies	sustainable water management	Common Agricultural Policies environmental requirements protection of water courses	Water Framework Directive
water quality	water pollution	water quality	water quality
good ecosystem condition	soil degradation	wetland conservation biodiversity protection	alteration of environment and of territory
sustainable water management	sustainable water management	wetland conservation culture of water use water demand management	sustainable rural development model environmental awareness
climate impact	impacts of climate change	drought impact	climate and drought
water saving methods	use of water-saving methods	improvement of water technologies	technologic innovation use of non conventional water
groundwater exploitation	use of groundwater	imbalance demand/supply	groundwater exploitation
Population	impact of increasing urbanization	stabilization of rural population	socio-economic dynamics
water demand	water demand	imbalance demand/supply	water demand
water price	irrigation water price	water price	water cost
water availability	water supply irrigation water use	imbalance demand/supply	water scarcity
irrigation efficiency	irrigation efficiency	water use efficiency	technical assistance and efficiency
agricultural support policies	agricultural support policies	Common Agricultural Policy payments	Common Agricultural Policy
infrastructure	water delivery losses irrigation infrastructure	hydraulic infrastructure	lack of infrastructure
Present in two Pilot Areas			
rural development policies		rural development programs	sustainable rural development model financial resources
farm income		farm income socio-economic development	socio-economic dynamics
Governance		political will policy enforcement institutional coordination	economic planning local management policies control and vigilance of territory
Present in one Pilot Area			
water allotments		water allotments	
intensification of agriculture		intensification of agriculture	

perspective, quantitative information from two different regions, namely Southern Europe (Spain and Italy) and Western Asia (Turkey), are required. The connection strengths in the FCM therefore are an average for the two regions.
Note that a FCM-WG for other regions would have other weights and the focus of the FCM might also be on other parts of the model if, for instance, the manufacturing sector is the largest water user.

5.2.5. Comparison of both FCMs

The FCMs were compared in two ways, by using the two most important aspects. First the system configuration of both FCMs was compared; secondly the dynamic behaviour.

System configuration

For the comparison of FCMs a number of indicators can be calculated. The centrality (most in and outgoing connections) of a variable is an indication for the importance of that variable. More complex FCMs have a higher density, as they have more connections per variable. Pure transmitters (with only outgoing connections, sometimes referred to as external drivers) in the FCM drive the system but are not affected by the system themselves. They have an internal feedback so that they always keep the same value, which makes it possible that they continuously drive the system. Pure receivers only receive connections and do not have an effect on the rest of the system. The number of pure transmitters and pure receivers is another indication for complexity. The FCMs were further compared on aspects like the number of variables and connections.

Dynamic system behaviour

By running FCMs in which small changes are made to certain relations, the effect of these changed relations on the rest of the system can be shown. This gives a better idea of the system behaviour depicted by the FCM. Four separate modifications have been made to each FCM. The effects of each of these changes on similar variables in both FCMs were studied. One modification changed the value of the starting vector of the pure transmitter 'climate change'/'climate impact'. Three other modifications were made in the connection strength between a pure transmitter and one variable. To mimic a decrease in water availability the strength of the connection from 'drought impact' on 'water availability' (in the FCM-SH) and from 'climate warming' on 'fresh water resources' (in FCM-WG) was changed. An increase in irrigation efficiency was simulated by changing the strength of the connection from 'agricultural support policies' on 'irrigation efficiency' (FCM-SH) and the starting value of 'project efficiency' (FCM-WG). To mimic a decrease in intensification of agriculture the strength of the connection from 'environmental policies' on 'intensification of agriculture' (FCM-SH) and of 'irrigated crop production' on 'area required for crop production' (FCM-WG) were changed. These changes were chosen as they could be relatively easily dealt within both FCMs. As pure transmitters are never affected by changes in the system, this makes them ideal to manipulate the system.
All modifications were made by the same magnitude (changing the values from 0.5 to 0.9). For each modification both FCMs were iterated 200 times, which was sufficient to reach a stable state.

5.2.6. Comparison of model output with FCM results

To study the similarities in system dynamics between the WaterGAP model and the two FCMs, WaterGAP model output has been used as input for modifications in the FCMs. Two WaterGAP runs for water withdrawals were used. They differed in irrigated area, project efficiency and water withdrawals in different sectors. The percentage change between these concepts in WaterGAP were mimicked by equal percentage changes in corresponding variables in the FCMs. The impact on the total water withdrawals as computed by WaterGAP was then compared to the impact on the variable 'total water withdrawals' in the FCM-WG and 'water demand' in the FCM-SH.
The WaterGAP model was thus used to define the external 'shocks' that were applied on the two FCMs. For instance in WaterGAP the project efficiency increased by 12 percent in the second run compared to the first. Therefore the variable 'project efficiency' in FCM-WG (and 'irrigation efficiency' in FCM-SH) was also increased by 12 percent. See table 5.4 in section 5.3.4 for the details on the changes made.
The FCM-WG could also be compared to the model on some other variables than the change in total water withdrawals. Both FCMs were also compared with each other for changes in similar variables.
For the FCM-WG this process was more straightforward than for the FCM-SH as the variables were better linked to the model. In the FCM-SH not all variables were present. Industry water withdrawals and water demand for livestock were not present in the FCM-SH. To mimic the change in domestic water withdrawals, the connection from 'population' to 'water demand' was changed. Changing the variable population would not only directly affect water demand, but also water quality. For the change in irrigated area the variable 'intensification of agriculture' was used.
The Pilot Areas have been chosen to be representative for the countries, so it can be assumed that the FCM-SH is not only representative for the three Pilot Areas, but also for the three countries. As WaterGAP is a global-scale model, it is likely that it is more precise for large-scale pattern or country than for a single river basin. Therefore the comparison was done twice; on basis of WaterGAP data for the three Pilot Areas' river basins and for the three countries in which the Pilot Areas are situated.

5.3. Results

5.3.1. Stakeholder based FCM

The FCM-SH consists of 19 variables and 49 connections (see figure 5.2). It shows a complex and dense system. There are many feedback loops, some of them consisting of loops between two variables. For instance an increase in water demand leads to a decrease in water availability, which in turn leads to a decrease in water demand. The most central variable is water availability. Many of the other variables are related to agriculture and irrigation, and aspects like water quality and ecosystem condition. The FCM-SH is focused on water quantity and irrigation, but water quality and social issues also play a strong role. All parts of the FCM are related to each other.

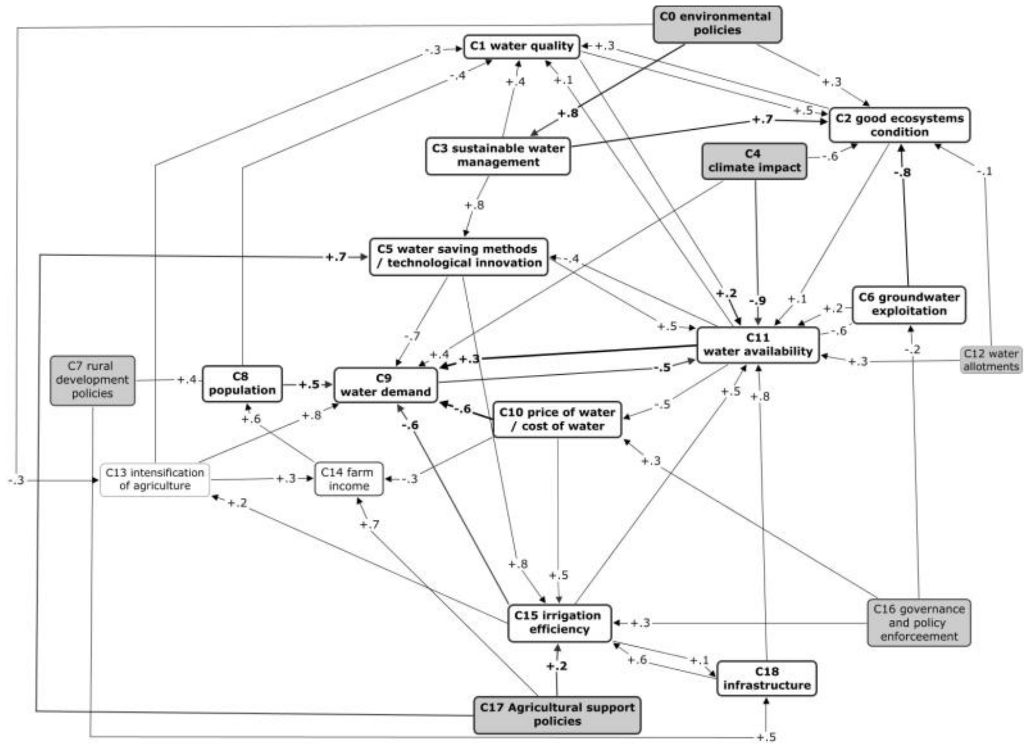

Figure 5.2; Graphical representation of the stakeholder based FCM. Grey variables are pure transmitters that drive themselves and thus the system. Bold variables and thicker connections were represented in two or three Pilot Areas.

In each of the Mediterranean Pilot Areas, the stakeholders who developed the FCM had a fairly good knowledge of the system and, in some cases, an excellent technical and social knowledge. The aggregated FCM reflects this knowledge and the different views of the concerned parties. As table 5.1 (see section 5.2.3) shows, most variables were present in at least two of three Pilot Areas, illustrating that the aggregated FCM is likely to be relevant for all the three Pilot Areas.

The starting values of the pure transmitters depend on the number of Pilot Area FCMs they were addressed in as indicator for their importance. Those that were present in all three Pilot Areas (environmental policies, climate impact and agricultural support policies) got a starting value of 1, those in two (rural development policies and governance and policy enforcement) a starting value of 0.6 and those in one (water allotments) 0.3. All other variables got a starting value of zero.

5.3.2. WaterGAP based FCM

The WaterGAP based FCM consists of 22 variables and 29 connections (see figure 5.3). The system is less complex and less dense. The most central variable is fresh water resources. It has a strong focus on agriculture and specifically on irrigation, but also includes other water withdrawals such as for domestic, thermal electricity production and manufacturing sectors. The FCM-WG focuses on water quantity, but also shows the

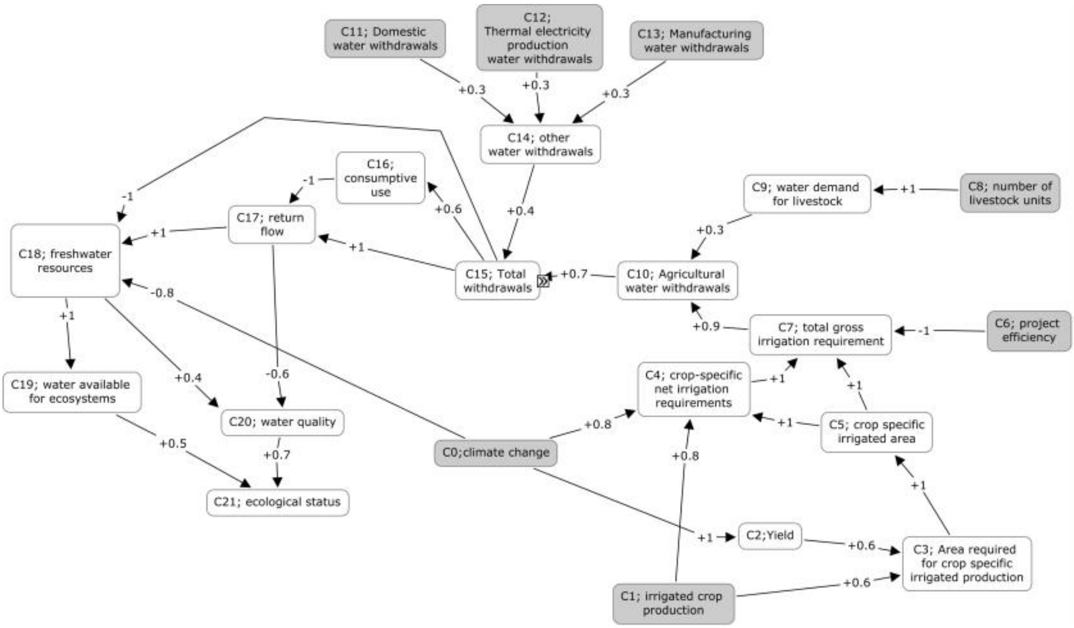

Figure 5.3; Graphical representation of the WaterGAP based FCM. Grey variables are pure transmitters that drive themselves and thus the system.

implications on water quality. The FCM is supposed to help in the communication with stakeholders and therefore had to be relatively simple, while showing the most important parts of the model. The modellers decided to focus on agricultural water use because this sector is the most important water user in the Mediterranean and, in addition, the main focus of the stakeholder FCM. Many of the pure transmitters are calculated in the relevant parts of WaterGAP, or by other connected models (e.g. LandSHIFT).

The FCM-WG has no feedbacks, which is in accordance with the fact that often in this type of models the number of feedbacks is low. Instead, changes in time (that might be caused by feedbacks) are represented by changing inputs, depending on the scenario used. For instance one can calculate how agricultural water use might change if policies are changed in reaction on water scarcity. This is not reflected in the FCM-WG (see figure 5.3). All pure transmitters got the same starting value.

5.3.3. Results of comparison of both FCMs

System configuration

The FCM-SH shows a more complex system description. It has many more connections (49 versus 29) and fewer variables (19 versus 22) and therefore a density that is more than double (0.14 versus 0.06, see table 5.2). FCM-WG has slightly more pure transmitters and one pure receiver, whereas the FCM-SH has no pure receivers. These indicators show that the system description in the FCM-WG is simpler than in the FCM-SH.

Table 5.2; Comparison of the stakeholder based FCM and WaterGAP based FCM

	stakeholder based FCM	**WaterGAP based FCM**
variables present in both FCMs	water quality irrigation efficiency water availability ecosystems condition climate impact water demand population	water quality project efficiency fresh water resources ecological status climate change total withdrawals domestic water withdrawals
variables present in only one FCM	intensification of agriculture environmental policies agricultural support policies governance and policy enforcement rural development policies ground water exploitation water price / cost of water sustainable water management effectiveness of control water saving methods water allotments farm income	crop specific irrigated area number of livestock water demand for livestock agricultural water withdrawals other water withdrawals irrigated crop production area required for crop specific irrigated production crop specific net irrigation requirement total gross irrigation requirement manufacturing water withdrawals thermal electricity production water withdrawals return flow consumptive use water available for ecosystems yield
number of variables	19	22
number of connections	49	29
Density (C/V^2)	0.14	0.06
average value per connection	0.46	0.74
# pure transmitters	6	7
# pure receivers	0	1 (ecological status)
highest centrality	water availability *(14 connections; abs value 5.9)*	fresh water resources *(5 connections; abs value 4.2)*
average centrality (mumber of out and ingoing connections)	5.16 connections *(abs value 2.37)*	2.64 connections *(abs value 1.96)*
most receiving connections	water availability *(9 connections)* Water demand *(7 connections)*	crop specific net irrigation requirements, total gross irrigation requirement, other water withdrawals, fresh water resources *(all: 3 connections)*
most transmitting connections	water availability *(5 connections)*	climate change, total water withdrawals *(both 3 connections)*

Table 5.3; Comparison of system description of both FCMs for four different changes, with the effects on a number of similar variables in both FCMs. Changes were made by changing the value of the connection or starting value from 0.5 to 0.9 (80%) of the variable mentioned in the second column.

		Variables affected						
	changes made	**water quality**	**water availability / fresh water resources**	**good ecosystems condition / ecological status**	**water demand / total withdrawals**	**population / domestic water withdrawals**	**irrigation efficiency / project efficiency**	**intensification of agriculture / crop specific irrigated area**
climate change impact increase	**stakeholder based FCM**: starting vector climate impact (C4)	decreases moderately	decreases moderately	decreases moderately	decreases strongly	decreases minimal	increases slightly	increases moderately
	WaterGAP based FCM: starting vector climate warming (C0)	decreases strongly	decreases strongly	decreases strongly	increases strongly	not affected	not affected	increases strongly
decrease in water availability	**stakeholder based FCM**: drought impact on water availability (C46->C11)	decreases slightly	decreases slightly	decreases slightly	decreases strongly	decreases minimal	increases slightly	increases moderately
	WaterGAP based FCM: climate warming on fresh water resources (C0->C18)	decreases slightly	decreases moderately	decreases moderately	not affected	not affected	not affected	not affected
increase in irrigation efficiency	**stakeholder based FCM:** agricultural support policies on irrigation efficiency (C17->C15)	increases minimal	increases moderately	increases slightly	Not affected	increases minimal	increases moderately	increases strongly
	WaterGAP based FCM: starting vector project efficiency (C6)	increases slightly	increases slightly	increases slightly	decreases slightly	not affected	increases strongly	not affected
decrease in intensification of agriculture	**stakeholder based FCM:** environmental policies on intensification of agriculture (C0->C13)	increases strongly	increases slightly	increases moderately	decreases strongly	decreases slightly	decreases minimal	decreases strongly
	WaterGAP based FCM: irrigated crop production on area required for crop production (C1->C3)	increases moderately	increases moderately	increases moderately	decreases moderately	not affected	not affected	decreases strongly

strongly >50%; moderately 15-50; slightly 5-15%; minimal <5%; not affected <1%

Yet, both FCMs are similar in a number of other important aspects. Firstly, there are seven variables that are very similar in both FCMs and one is exactly the same (water quality). Secondly, in both FCMs the 'water availability'/'freshwater resources' form a connection between the water quantity and water quality. Thirdly, in the FCM-SH 'water availability' has the highest centrality, likewise in the FCM-WG 'fresh water resources' has the highest centrality. This clearly illustrates the importance of water quantity issues in the Mediterranean. In both FCMs 'total water withdrawals' / 'water demand' have a high centrality.
Finally in both FCMs the variables with most receiving connections are 'water demand' / 'total withdrawals'. 'Water availability' has most transmitting connections in FCM-SH, while climate change and total water withdrawals have most transmitting connections in the FCM-WG.

There are also differences; FCM-SH gives more weight to social aspects and policies compared to FCM-WG, while FCM-WG shows aspects like water use in thermal electricity production, manufacturing industry and livestock sector that are not present in the FCM-SH. FCM-WG has a clearer split of water withdrawals into the different sectors.

Dynamic system behaviour

Table 5.3 shows the exact relations that were modified in relation to the four modifications as explained in section 5.2.5. It also shows the effects of the changes made on seven similar variables in both FCMs. An example showing the dynamic behaviour with two iteration runs of FCM-SH, is given in figure 5.4.

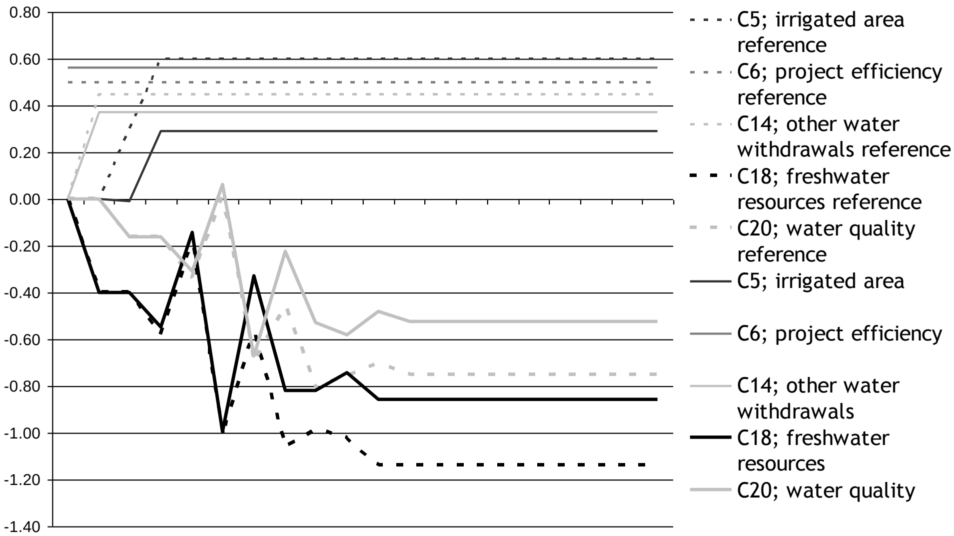

Figure 5.4; Iteration results of two FCM-SH runs with a change in climate impact (starting value 0.9 resp 0.5), showing the impact on water quality, water demand and water availability. Non-dotted lines show the reference iteration run; dotted lines the iteration with a change in climate impact. Y-axis showing the value of the variables, X-axis number of iterations

Climate impact increase
In both FCMs this variable had direct impacts on the water availability and (irrigation) water demands. It further directly affected ecosystems conditions in FCM-SH and yields in FCM-WG.
The climate change induced changes had the same direction of change in both FCMs, except for water demand. The magnitude of change was in most cases larger in the FCM-WG. Water demand decreased in the FCM-SH, while it increased in the FCM-WG. This is due to the mechanisms to mitigate climate impacts that are present in the FCM-SH. A decrease in water availability leads for instance to more water saving methods and a higher price of water, which both in turn lower the water demand. Also irrigation efficiency is increased as reaction on an increasing water price.

Decrease in water availability
In the FCM-WG quite many variables are not affected by a decrease in water availability as the model calculates the potential water demand of each sector, while in the FCM-SH almost all variables are affected. The directions of change are the same, while the magnitude of change for water availability and ecosystems condition is larger in the FCM-WG. This shows the role of feedbacks in the FCM-SH; the water availability decrease is partly balanced by a decreasing demand and increasing irrigation efficiency, which are pure transmitters in the FCM-WG and therefore not affected.

Increase irrigation efficiency
Directions of change are the same, but magnitudes differ in most variables. In both cases the water quality increases, but in the FCM-SH the change is smaller. FCM-SH describes a positive relation from irrigation efficiency via water availability to water quality, but also shows a negative influence. Increasing irrigation efficiency leads to an increase in intensification of agriculture, which has a negative effect on water quality. In the FCM-WG the irrigated area is not affected by the change in irrigation efficiency. There is only a positive effect on water quality via lower water withdrawals.

Decrease in intensification of agriculture
The directions of change are the same, but magnitudes differ. In both cases water demand decreases, which in turn increases water resources and water quality. The FCM-SH shows a stronger increase of water quality. The variables that are not affected in FCM-WG are slightly or minimal affected in the FCM-SH.

5.3.4. Results of comparison of model output with FCM results

WaterGAP model output has been used to compare the system behaviour of the model with that of both FCMs. Two WaterGAP runs have been used, for two set of data; Pilot Area data and country data. Table 5.4 gives the percentage difference between the two runs for both data sets.

Both FCMs were first iterated with the connection strengths and starting values as shown in figure 5.2 and 5.3 which forms the reference. In the second run, changes were applied to reflect the differences between the WaterGAP runs. The grey boxes in table 5.4 show which variables in each FCM were directly manipulated ex-ante. New values of the variables could then be compared with old ones, resulting in a percentage. Figure 5.5 shows (part of) the output of the FCM-WG reference and Pilot Area data iterations.

Both FCMs show similar system behaviour as the model; they have the same direction and magnitude of change. The percentage change in total water demand in the model and both FCMs are in the same order of magnitude. For the Pilot Area data the FCM-stakeholder gives a 10% lower change. This could be due to the large amount of balancing feedbacks in that FCM, which represent mitigation measures from farmers and other stakeholders. Note that both FCMs were not specifically calibrated to fit model results.

There were also a number of variables which were not calculated in the WaterGAP runs used, but that were represented in both FCMs. The changes in the FCM-SH for these three variables (freshwater resources, water quality and ecological status) were lower, which is likely caused by the large number of balancing feedback loops.

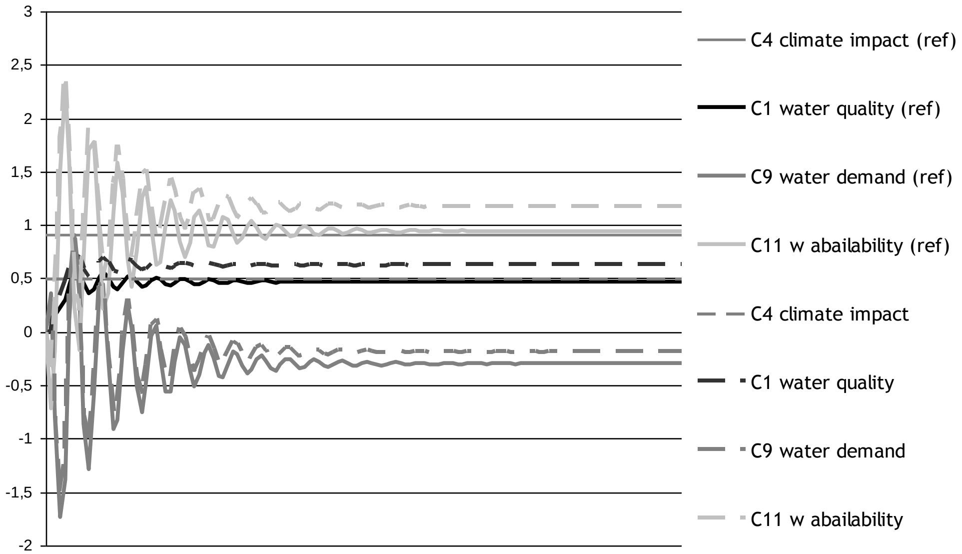

Figure 5.5; dynamic output of the FCM-WG for the reference run and a run based on WaterGAP data for the three Pilot Areas. Dashed lines are from the reference, non-dashed lines from iteration with the changes based on the WaterGAP data for the three Pilot Areas. Y-axis showing the value of the variables, X-axis number of iterations

Table 5.4; Comparison of WaterGAP model output, with output from FCM-WG and FCM-SH. The first column for each data set (Pilot Area data or country data) reflects the percentage change in each variable between the two WaterGAP model runs. The two other columns show the percentage of change of the value of the variables in the two FCMs. The grey shaded boxes show which variables in each FCM were directly manipulated ex-ante. The non-shaded boxes show the resulting changes in other variables. Grey variables were manipulated to reflect the WaterGAP data.

	average of Pilot Area data			**average of country data**		
	WG [a]	**FCM-SH** [b]	**FCM-WG** [b]	**WG** [a]	**FCM-SH**[b]	**FCM-WG** [b]
crop specific irrigated area / intensification of agriculture	-52%	-52%	-52%	-31%	-31%	-31%
project efficiency / irrigation efficiency	12%	12%	12%	12%	12%	12%
water demand for livestock	-9%		-9%	-8%		-8%
domestic water withdrawals / population	-33%	-1% [c]	-33%	-36%	0% [c]	-36%
thermal electricity production water withdrawals	-8%		-8%	-28%		-28%
manufacturing water withdrawals	-12%		-12%	-24%		-24%
other water withdrawals	-21%		-18%	-29%		-29%
total water withdrawals / water demand	-45%	-35%	-38%	-32%	-36%	-27%
freshwater resources		14%	25%		14%	17%
water quality		9%	30%		8%	21%
ecological status		8%	27%		8%	19%

a relative changes between two model runs.
b relative change to the reference iteration
c change reflected in connection strength of population on water demand, percentage change given is the change of the variable population.
Empty = no data available

5.4. Discussion and Outlook

The objective of this chapter was to analyse the potential of using FCMs to link stakeholder information to mathematical models. Four sub-objectives were identified, all of which will be discussed below. In the second part, the tool FCM is put in the context of other projects and tools. Both aspects combined lead to conclusions on the potential of FCMs to function as common base for linking stakeholders and modellers.

5.4.1. Development of FCM-SH, based on information from three case studies

The first steps towards the aggregation of three local FCMs into one regional stakeholder -FCM were relatively simple. The subsequent steps of merging similar variables, however, forced us to make choices in order to get a clear and relatively simple system. It turned out that detailed insights on the knowledge and perceptions of the stakeholders in the Pilot Areas were essential to make these choices. Somewhat surprisingly, after finalising this process it was concluded that the Pilot Area FCMs were more similar than they appeared at first sight. Often each Pilot Area used different variables to represent the same process. Once the names of these variables were

harmonized merging became easier.
Some of the external drivers had to be generalised so that they would be meaningful for all three countries. The Common Agricultural Policy (CAP), for instance, plays an important role within the EU. In Turkey similar policies are in place, but the CAP is not a driver there as Turkey is not part of the EU. Therefore the variable was named 'agricultural support policies'. In the end, the aggregated FCM included all the common variables and the generalised version of most drivers. As a result of the aggregation, some of the Pilot Areas' specific details and the diversity among them got lost in FCM-SH. Highly related variables were merged, which hides the different aspects that were present in the original Pilot Area specific variables.
Summarising, it can be stated that it takes relatively little time and effort to produce a higher-level FCM if local FCMs are available, despite potential difficulties in the process of variable generalisation.

5.4.2. Development of FCM-WG, based on a mathematical model

Developing a FCM to communicate about the model helped modellers to open the 'black box'; it forced them to be precise on how the model works. To keep the FCM simple, however, it could not show the complexity of the whole modelling processes. Therefore, the modellers chose to show only WaterGAP's main component, leaving out many links that are used in calculating the input for the main component. They further opted to give it the same (agricultural) focus as the FCM-SH. Other water users (domestic, thermal energy production and industry) were therefore represented by just one variable. It should be noted that each of these water uses could also be represented by a more extensive part, like that on agricultural water use.
Another issue was that the model uses multiple crops, which could not be reflected in the FCM, as it would have led to multiple variables for concepts like crop-specific net irrigation requirements. Therefore one variable was used with an average value for the connections leading from that variable.
On one hand, these choices resulted in an overly simplified representation of the model. On the other hand, however, it facilitated the presentation of the modelled system to non-experts and therefore the comparison with the system perceptions of stakeholders. Modellers should try to find a balance between being specific on how the model works and keeping it simple enough for stakeholders to understand. One could also opt for a simple version that can be extended with more detailed sections when necessary.
The dynamic output of FCM-WG did not fit the model runs completely. The starting values and connection strengths of the FCM-WG were not calibrated on the model. Nevertheless results show that modellers are capable of mimicking the system behaviour of the model in a FCM. However, as there were differences one could argue that the FCM of a model should be calibrated before the comparison with the FCM of stakeholders should be undertaken.

5.4.3. Comparing both FCMs to identify crucial differences and similarities

The analysis showed that although the systems show pronounced differences for key indicators (density, number of connections etc.), system dynamics were similar. This shows the added value of FCMs above qualitative conceptual models that can not simulate dynamical output. It is this dynamical output that can show the influence of

feedbacks (Kok, 2009). Results for an increase in climate impacts, for instance, showed the impact of adaptation measures that were included in the FCM-SH and not in the FCM -WG. The effects of multiple feedback loops are difficult to reason through without the dynamical output. The capability of FCMs to include these loops together with the consideration of policy and social issues by stakeholders, made it possible to show mitigation and adaptation processes that are not reflected in WaterGAP simulations.
The comparison of the dynamic output of two FCMs can be hampered by a lack of identical variables. There was only one identical variable in the stakeholder and model based FCMs. Similar variables can be used for the comparison, but they do not always match completely. For instance, intensification of agriculture and irrigated area are related, but there are also other ways to intensify agriculture than increasing the irrigated area. Likewise, population and domestic water demand are highly related, but water demand can increase while the population size does not. Part of this problem is caused by the process by which both FCMs are developed. Modellers have to be specific when developing the model, and will therefore include specific variables in their FCM. Stakeholders used clusters of issues to derive variables, a process that leads to less well defined variables. The FCM-SHs variables also do not necessarily have to be quantifiable, while those in quantitative model do.

5.4.4. Comparing both FCMs' dynamical output to output of a mathematical model

The comparison of FCM and model runs showed that there are a number of obstacles for directly linking FCMs and models. If the system descriptions are too different, it becomes very hard to compare them, especially if there are not enough variables that link directly to the model.
Another problem was caused by a small absolute value of a variable in the reference run. In the case of small absolute values, small changes lead to large percentage changes. Modellers come across the same problem when reporting back on model output in maps with percentage change. As the output of FCMs is only semi-quantitative, the absolute value change of a variable is difficult to use directly.
A related problem is that a percentage change in a variable with low absolute values results in a small absolute change of that variable's value. Because the effect on a connected variable depends on both the connection strength and the value of the variable, a small change in the value of a variable results in a small change in the connected variable. This was for instance the case with the variable 'intensification of agriculture' in the FCM-SH. The variable 'population' had a much larger value. A percentage change in the connection from 'population' to 'water demand' had therefore a larger impact on 'water demand', than a higher percentage change in the connection from 'intensification of agriculture' on 'water demand'. This illustrates how a comparison with model runs also dependent on the values of variables in the reference situation.
In FCMs only linear relations are used, whereas mathematical models also include non-linear relations (e.g. in WaterGAP for evapotranspiration and yield increase in case of climate change). This can lead to different dynamic system behaviour. One could include non-linear relations in the FCM, but there is a chance that the tool will then become overly complex for some stakeholder groups.
Given those problems with FCMs, it seems difficult to use them to directly give input for

the model. However, they can show the expected direction and order of magnitude of change, which can help in the quantification phase. Furthermore FCMs can be used to compare the system perspectives of stakeholders and modellers, which help to make both groups' assumptions explicit. The FCMs can for instance show important differences in system perspectives such as whether or not to include adaptation processes in society.

5.4.5. Comparison with other tools

It is unrealistic to expect that most stakeholder groups would understand a mathematical model (Martínez-Santos et al., 2010). In most cases it is difficult to clearly explain a mathematical model to stakeholders. This hampers the two way flow of information between stakeholders and modellers that is needed to achieve a process of shared learning (Voinov and Bousquet, 2010). In our approach FCMs form a common base for both parties to exchange knowledge, making a two way flow of information possible.

There are other tools available that could be used to form such a common base. The SCENE model, for instance, leads towards a transparent framework that could be used to develop a quantitative model (Grosskurth and Rotmans, 2005). It is, however, very time consuming to fully develop the framework in a participatory manner. This is also the case with the Syndrome's approach, which looks at archetypical 'syndromes' within a bigger overarching problem (Petschel-Held et al., 1999; Eisenack et al., 2006). As it is a rather complicated method it is less suitable in a highly participatory setting. Bayesian networks (e.g. Bacon et al., 2002; Cash et al., 2006) and other qualitative probabilistic networks can be linked to mathematical models (Kouwen et al., 2008), but encounter similar problems as FCMs (lack of spatial and temporal explicitness). They also have difficulties to deal with feedbacks (Martínez-Santos et al., 2010). Feedbacks can, for instance, be treated by continuously restarting the network with the new conditions (Voinov and Bousquet, 2010), but this is a cumbersome method if one wants to give more attention to feedbacks. Causal Loop Diagrams are only qualitative, but can be used as basis for system dynamic models (Sterman, 2004) that include stocks and flows. System dynamic models can give detailed system descriptions, including quantitative output for the stocks and flows. This way it can better give direct input for mathematical models. System dynamic models are, however, a difficult tool and it takes multiple workshops to develop a good system dynamics model (e.g. Magnuszewski et al., 2005). FCMs can be developed faster, but give a less detailed system description. The main reason in SCENES for choosing FCMs above these semi-quantitative methods was that FCMs are relatively easy to teach and use with stakeholders, and can be developed in a short period of time (van Vliet et al., 2010).

Because FCMs only produce semi-quantitative output, interpretation is sometimes difficult. Tools that can include more quantitative aspects within a conceptual model seem better suited for aiding the quantification phase. The problem is that often much more time is needed to develop them; time that is often not available. This is especially the case in scenario development workshops where also storylines need to be developed, like in SCENES.

A promising tool for obtaining stakeholder input that can be used directly by the model is Fuzzy Sets (Alcamo, 2008; Eierdanz et al., 2008). Fuzzy Sets have been used in scenario development to have stakeholders quantify assumptions. Stakeholders can, for instance, be asked what they perceive as low, medium and high economic growth. The answers of all individual stakeholders are then consolidated in a fuzzy membership function for each term (Kok et al., 2010). This tool, however, does not help stakeholders to obtain a better understanding of the model. It also neglects those parts of the system that are not part of the model. Possibly Fuzzy Sets could be used in combination with FCMs, to support the quantification of the semi-quantitative results of FCMs.

Others have worked on participatory modelling approaches in which stakeholders give input in the actual model building, such as Participatory Modelling, Group Model Building and Companion Modelling. Participatory Modelling is a widely used term but in general aims "*for the involvement of stakeholders in the development and use of systems models, which will lead to a better understanding of the system and its management*" (Hare et al., 2003). Group Model Building is based on Causal Loop Diagrams and system dynamics tools (e.g.(Vennix, 1999). Companion Modelling often involves a combination of role-playing games and agent based models (e.g. Worrapimphong et al., 2010). An overview of these approaches is given by (Voinov and Bousquet (2010). With such a co-development of the model, stakeholders will get a better understanding of the model and its applicability. It might, however, not always be possible to develop a new model, for instance in cases in which large scale data intensive models are needed or where resources are lacking. In these cases, FCMs can be used to communicate about an existing model, to increase the participants' understanding of the model, its possibilities and its limitations.

FCMs have also been proposed as a tool to add structure in participatory scenario development workshops (Kok and van Delden, 2009; van Vliet et al., 2010). In addition to asking stakeholders how they see the present system (baseline), one could also ask how the system will be differing in each scenario. This could help to structure the scenarios, and make stakeholders' assumptions more explicit. The future FCM can then be compared with the present FCM in a similar manner as both FCMs were compared in this study to show the changes in system behaviour in the scenario (van Vliet et al., 2007). The future FCM could further be compared to the models description of the scenario. FCMs could also be used to directly model scenarios (e.g. Kok, 2009; Jetter and Schweinfort, in press).

Need for a toolbox of conceptual and mathematical models

FCMs and models complement each other. As FCMs (like all conceptual models) are not well suited to be spatially explicit (Voinov and Bousquet, 2010), the FCM-WG could only depict the water system of the three countries as one big system. It therefore shows the general sense of direction of change that would occur in the Pilot Areas and countries, but misses the spatial diversity that can be represented by WaterGAP output (see figure 5.6). WaterGAP can also deal with regional-specific model input, which further increases the spatial explicitness.
Mathematical models, on the other hand, can only deal with changes in drivers that can

be quantified and for which data is available. The influence of other drivers has to be translated into a change in concepts that the model can deal with (Martínez-Santos et al., 2010). FCMs can then be used to show the effect of such external drivers on the system. Kok (2009) for instance has used FCMs to show the impact of different policies on the deforestation of the Amazon.
The mathematical models are thus well suited to show the time and spatial uncertainty of the problem, whereas an FCM can show the uncertainty in feedbacks and the effect of more social processes that are lacking in the mathematical model. This way FCMs and models are complementary to each other.

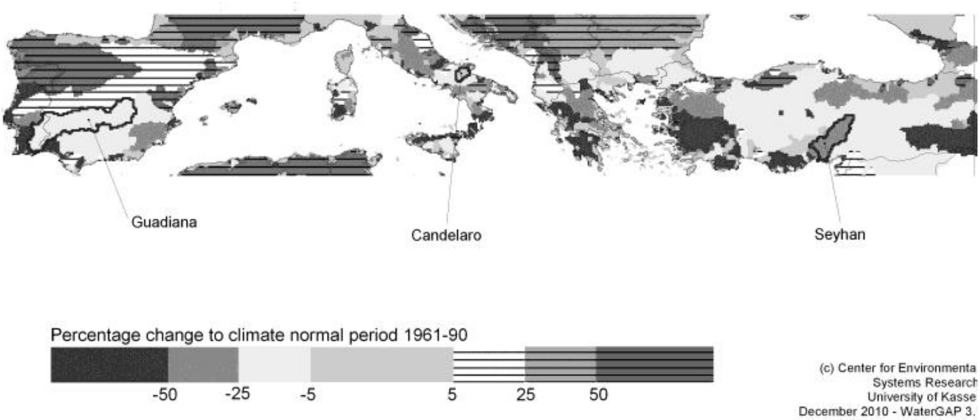

Figure 5.6; WaterGAP output for a change in irrigation water withdrawals under the Economy First scenarios (IPCM4-A2, 2050), showing the spatial differences in irrigation water withdrawals between the three Pilot Areas and within the three countries.

5.4.6. Outlook

In this study the possibilities of using FCMs as common base for comparison of stakeholder products and models have been studied. The actual feedback to the stakeholders was not part of this study. Based on the experience of the authors in working with FCMs in participatory workshops we expect that this will be a success, but it should be tested in future studies. For such a future study it is important to first make stakeholders familiar with FCMs by having stakeholders develop a FCM themselves. This will help them to understand how FCMs work and the FCM can be used to compare their perceptions with the model. In order to develop the FCM successfully, the moderator needs to be experienced with FCMs to guide the stakeholders through the process.
A multi-scale approach as used here is likely to make it more difficult to link back to the stakeholders. We therefore suggest that in future studies the whole process should be executed on the same scale.

5.4.7. Recommendations to better match FCMs and models to strengthen the bridge between qualitative and quantitative scenarios

Future studies should shed more light on how FCMs can be linked better to quantitative models, so that their input can be used directly in the model. They should work on further upgrading the FCM and look for options to combine FCMs with other tools.

Below a number of possible options are given:
- use of rounding functions
- round end results (scale back to 0-1)
- make FCMs more sophisticated (include delays, non-linear relations)
- use other system dynamics modelling tools (e.g. Vensim, SIMILE to include stock and flows)
- ask stakeholders to quantify (Fuzzy Sets)

Use of rounding functions

The use of rounding functions makes it possible that all values will remain between -1 and 1, so that the absolute values can be used directly. A change in absolute value from 0.01 to 0.02 than means an increase of 1%. However, different rounding functions can easily lead to different results. For instance a simple rounding function will just divert all values larger than 1 to 1, while other values remain unaffected. Other rounding functions will also affect the other values to a larger or smaller extend.

Round end results

Another option is not to use any rounding functions during the iterations, but only scale back the last vector to values between -1 and 1. Again, different rounding functions will lead to different results, but as these results are not used for the next iteration round, the effects are likely to be smaller.

Make FCMs more sophisticated

The FCM could also be adapted to be able to include non-linear relations, memory and delays. By incorporating these aspects FCMs could better mimic 'the real world'. Incorporating delays for instance can tackle part of the problem that time is ill defined. Memory in the form of an internal feedback of a variable on itself, can represent stocks. There is, however, a chance that this will make them overly complex for some groups of stakeholders.

Use other system dynamic models

Most system dynamic models (e.g. Vensim or SIMILE) can deal with delays, stocks and flows and non-linear relations, therefore they could be used to get a better system representation. One could either do the whole process with other system dynamic models or use them as next step after the use of FCMs. In the latter case they could build on the work done with the FCMs. Depending on the stakeholders knowledge this could be done with the same stakeholder group, a smaller group or only with experts. One should not forget that there might be limited time in the scenario development workshops to go into the details required for such a more detailed approach. These system dynamic models could lead to a more quantitative output that could be used directly in the mathematical model. The ability to use stocks and flows, for instance, might make it easier to get a direct link with quantitative mathematical models, as outcomes can be represented in for instance m^3 instead of a change in variable value.

Ask stakeholders to quantify

Stakeholders could also be asked to quantify the input for the models. They could use the results from FCM modelling as input. The FCMs can show the relative change in variables for each of the scenarios. Stakeholders can than give their expert guess on how this would translate into a quantitative change. However, most stakeholders don't have the knowledge to provide good estimates on all input needed. It can be assumed that with larger groups, the average will become more accurate. Therefore it seems advisable to include a larger stakeholder group in this phase, for instance via questionnaires.

5.5. Conclusions

This study showed the potential of FCMs to function as common base for linking participatory products and models. FCM can form the common base for comparison because both stakeholder products and the mathematical model could successfully be represented in FCMs. This made a comparison of system perceptions possible, both in the system configuration and dynamics.

The dynamic output of both FCMs has been compared to model runs. This has shown the possibilities and limitations of using FCMs to give direct input to mathematical models. It has become clear that direct use FCMs for input in mathematical models needs extreme care, but FCMs can be useful in the process of quantification of stakeholder products by showing the direction and magnitude of change and making assumptions explicit. FCMs can show the implications of social aspects in stakeholder output that are hard to deal with in mathematical models. Mathematical models in turn can show spatial and temporal details that are difficult to include in FCMs. FCMs and mathematical models are thus complementary.

FCMs is further likely to aid the communication between modellers and stakeholders, as a FCM of a model helps to open up the 'black box' of that model. At the same time, FCMs make stakeholders' assumptions explicit and structure the often vague stakeholder output.

Concluding we can state that FCM is a very promising tool for linking stakeholder and modellers. It can function as common base for comparison and to illustrate differences between stakeholder perceptions and models in detail. The system dynamics of FCMs can play an important role in the quantification and dissemination process.

Chapter 6

Backcasting within exploratory scenarios; looking for robust actions across futures and scales

Based on: van Vliet, M. and K. Kok, submitted, Backcasting within exploratory scenarios; looking for robust actions across futures and scales, Technological Forecasting and Social Change

6. *Backcasting within exploratory scenarios; looking for robust actions across futures and scales*

6.1. Introduction

In our increasingly interconnected world social and biophysical systems are tightly coupled, which leads to an increased uncertainty on future developments. Social and environmental problems become more and more complex and therefore the search for solutions becomes harder. Because of the inherent uncertainty, it becomes necessary to analyse several plausible futures in stead trying to predict future challenges (Peterson et al., 2003; Biggs et al., 2007). Exploratory scenarios are increasingly used to gain insights in plausible future outlooks. They provide important insights in the future that may lie ahead, but it is argued that they sell short when addressing certain societal problems for which it is important to study how a desirable solution can be attained (Robinson, 1990). The search for such desirable visions has lead to the development of a so-called backcasting approach, which is a normative scenario approach (Robinson, 2003).
Both normative and exploratory approaches have their advantages. We hypothesise that there is an added value in combining them. In this chapter we describe and test a method of combining exploratory and normative scenarios.

What is backcasting?

Börjeson et al. places backcasting under the normative, transforming scenario studies. The main question is: "*How can a target be met, when prevailing structure blocks necessary changes?*" (Börjeson et al., 2006). Backcasting is more an approach than a method (Dreborg, 1996) and it has been implemented in multiple ways. Although there is no single methodology to backcasting, there are two main characteristics that most backcasting methods have in common. The first is its normative nature, the second its "*working backwards from a particular desired future end-point*" (Robinson, 2003). This often translates in methods that at least include a step during which desirable images of the future are developed and a second step during which these images are analysed working backwards (see also Robinson, 1988; Höjer and Mattsson, 2000). Some argue that the vision making process is part of the backcasting methodology (e.g. Quist and Vergragt, 2006; Giurco et al., 2011; Svenfelt et al., 2011), while others only refer to the part of working backwards from the vision to the present (e.g. Kerkhof, 2006; Kok et al., in press). We use the term backcasting in the latter way.

The origins of backcasting lie in the electricity sector, where Lovins (1976) and Robinson (1982) used similar backwards working approaches. Many of these, more technical focused, backasting exercises included a relatively small variety of stakeholders, often limited to the companies involved. From the 1990s onwards participation of wider groups of stakeholders became more popular (Quist and Vergragt, 2006). Some backcasting exercises depend strongly on models (e.g. Robinson, 2003) others take a more qualitative approach (e.g.Partidario and Vergragt, 2002; Carlsson-Kanyama et al., 2008). By far most, if not all, backcasting studies use a desirable vision to backcast from. Most of the technical oriented studies focus on technical aspects, with less emphasis on (contextual) social changes. Some more recent studies have started to structurally include an analysis of different (plausible) futures. Carlsson-Kanyama (2008) developed four different futures prior to the backcasting exercise, using these as key additional input. The reason was to "*cope with the rather likely possibility of differing opinions and values among the group of stakeholders*" (Carlsson-Kanyama et al., 2008). Stakeholders were asked to select the most desirable future, and work on actions to realise it. Quist and Vergragt (2006) give an overview of the historical developments of backcasting.

Exploratory scenarios

Exploratory scenarios sketch plausible futures, showing what can happen. The scenarios used in our approach best fit the term strategic exploratory scenarios as introduced by Börjeson (2006). This type of scenarios shows the implications of several external drivers. They do not predict, but give "*plausible and often simplified descriptions of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces and relationships*" (Millennium Ecosystem Assessment, 2005b). Often two main external drivers are used to develop four scenarios. Many of the existing scenarios fit on the axes, global versus regional and self-interest/reactive versus solidarity/pro-active. Figure 6.1 shows the exploratory scenarios used in this study on those axes.

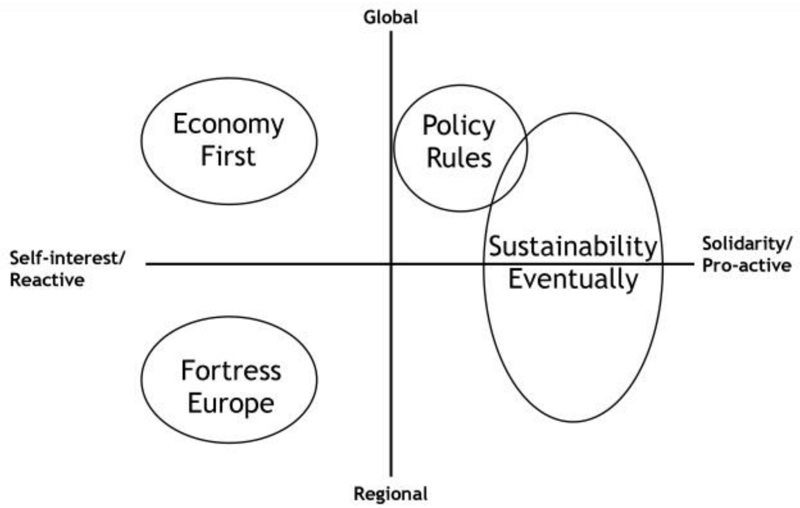

Figure 6.1; Exploratory scenarios, as developed in this study, and their place on the axes global versus regional and self-interest/reactive versus solidarity/pro-active. (based on Kok et al., in press)

Exploratory scenarios can either be qualitative, often in the form of storylines, or quantitative, often in the form of models. Both types of scenarios are increasingly combined (e.g. Rotmans et al., 2000; UNEP, 2002; Millennium Ecosystem Assessment, 2003; European Environmental Agency, 2006; Kok et al., 2006a; Kok et al., 2006b). For this chapter, the most important feature of exploratory scenarios is their aim to describe distinctively different plausible futures, each showing different developments of social, economic and environmental factors. This diversity captures a broad range of the uncertainty on the future. More detail on this influential methodology of scenario development can be found in e.g. Rotmans et al., 2000; UNEP, 2002; Börjeson et al., 2006; Kämäri et al., 2008).

Combining exploratory and normative scenarios

Kok et al. (in press) have identified a number of added values for combining exploratory and normative scenarios. It can maximise stakeholder involvement as different methods appeal to different stakeholders, it can shed light on different aspects and it can help to address both long term explorations and short term actions. Where Kok et al. described the overall process on the pan-European level this chapter focuses on the added value of the identification of robust actions, and we analyse the influence of the exploratory scenarios on the backcasts. The focus is on the river basin scale workshops.

In the methodology described in this chapter, exploratory scenarios form the context / boundary conditions for the development of backcasts. In other words, backcasts have to be executable in the social and environmental situation that is described in the exploratory scenario. Those actions from the different backcasts that are effective within all exploratory scenarios are robust actions; they are robust to the different societal and environmental changes that are described in the scenarios.

Within our study, several case studies on three different scales executed backcasting workshops. This made a cross-scale comparison possible. The same reasoning as for robustness across scenarios can be used for actions that are effective in different regions. They are robust to different cultural backgrounds, and therefore more likely to be effective in other regions. Robust actions that are identified in multiple regions can be said to be robust across regions. They are also likely to have implications for higher scales.

6.1.1. Objectives

The main objective of this chapter is to evaluate a methodology for combining normative and exploratory scenario development, with the ultimate goal of defining robust actions. Four specific objectives were defined:

1. to present the methodology and its novel aspects
2. to test the methodology and evaluate its perceived success by analysing organiser and stakeholder feedback
3. to analyse and evaluate the results, focusing on the influence of the exploratory scenarios on the backcasting results and the robust actions
4. to evaluate the possibilities for cross-scale comparison and upscaling of the results.

6.2. Context

This chapter is based on the results of backcasting workshops that took place in eleven case studies within SCENES. The backcasting workshop was the last in a series of three workshops. This illustrates the relative importance of the development of exploratory scenarios in SCENES. Participatory workshops haven been held on river basin (Pilot Areas), regional and pan-European scale. This chapter focuses mainly on the results of the Pilot Areas. For more information on the pan-European scale see (Kok et al., in press).

Goal of the backcasting workshops was to define a number of robust (policy) actions, by working backwards from a desired objective in 2050. Besides the identification of robust actions the backcasting methodology helped SCENES to translate the long-term exploratory scenarios to short-term actions, expand the mental model of participants towards out-of-the-box thinking by working backwards and show the policy relevance of the previously developed exploratory scenarios.

The four exploratory scenarios that were developed in the first two workshops (see Kämäri J. (ed.), 2008; van Vliet, 2009) were used to set the context for the backcasting exercise. There was room for manoeuvring within the main assumptions of the scenarios.

6.3. Methodology

6.3.1. Backcasting approach

Below an overview of the different steps of the backcasting approach is given. The approach is in general based on the backcasting approach of Robinson (1982) and builds upon the work on interactive backcasting of Van der Kerkhof (2006) and the work done in MedAction, where it was one of the first attempts where a more formal exploratory scenario development methodology preceded the backcasting (Patel et al., 2007). Novel aspects are included to facilitate the link with exploratory scenarios; especially step 2 was tailored to link to existing exploratory scenarios and step 6 to look for robustness. As backcasting is an iterative process the different steps were in practice often less explicitly followed in the workshop than shown below.
Workshops lasted one to two days, and included a diverse group of about 15-20 stakeholders. In all workshops the same backcasting approach was used, although some deviations were possible to better fit the local circumstances.

1. Desired objective in 2050

A desired objective, related to water, was chosen in plenary. It needed to be a major issue that all participants agreed upon. The same objective was used by all small groups while working within different exploratory scenarios. Therefore the objective had to be specific enough to focus the discussion, but not so specific that it leaves no room for action within any of the scenarios.

2. Obstacles, opportunities and milestones

2a. Participants had to identify the obstacles and opportunities. Novel was that the obstacles and opportunities were derived from the exploratory scenario that they were working with. Products created in the previous workshops like storylines and a range of other (exploratory) products (see van Vliet et al., 2010; van Vliet et al., subm.-b) were used in the discussion. The use of very detailed storylines, illustrated by different products, is a novel part of the approach which should lead to a strong influence of the exploratory scenario on the backcasting. The strong growth of economy, with limited environmental laws under a Economy First scenario could for instance be a barrier to a better water quality

2b. At the same time milestones were defined. The milestones formed the main steps from the desired objective back to the present. They were often linked to one or multiple obstacles and opportunities, and thus to the exploratory storylines.

3. (Policy) actions

The milestones provide a framework for the identification of more concrete actions. These actions were targeted to overcome obstacles and lead to the fulfilment of milestones and the desired objective. The actions were plotted on a timeline to show the relations between them and with milestones, obstacles and opportunities.

4. Timetrends

Timetrends (simple graphs without units on the axis, see e.g. Website MSP, 2010) were used to illustrate the temporal dynamics. This was for instance done for the desired objective or important indicators. Timetrends help to illustrate the main effects of series of actions.

5. strategies

Strategies are main strings of actions and milestones that lead to the desired objective. They give a simplified overview of the whole backcasting timeline. In most Pilot Areas the strategies were identified after the workshops by the Pilot Area coordinators on basis of the workshop results.

6. Robust actions

In the final part of the workshop each small group of participants presented the possible actions within their exploratory scenario. These were discussed to look for robust actions, which is a novel part of our approach. Because all groups used the same objective, actions that were identified in all scenarios can be identified as being robust. As next step one can identify more robust actions by looking for actions that could be effective all scenarios.

The main outputs of the backcasting exercise were twofold:

1. Four timelines with actions, milestones, obstacles, opportunities and the desired objective, illustrated by timetrends, showing how the desired objective can be reached (or why not); one for each exploratory scenario.
2. list of robust actions, independent of the scenarios

6.3.2. Evaluating the methodology

To test the methodology and evaluate its perceived success questionnaires among stakeholders and reports from the organisers from nine Pilot Area workshops and one regional have been analysed. Two aspects were analysed; the extent to which the proposed methodology was it used in the Pilot Areas and the reaction of organisers and participants after the workshop.

An overview of activities in the Pilot Areas will show the level of acceptance and practicality in use of the methodology. All organisers were asked to file a report on the workshops, including a part on process related issues. A questionnaire has been held among the stakeholders. The questionnaire included questions on the satisfaction with the workshop, desired objective and resulting policy actions. It further included questions on the usability of results and the level of out-of-the-box thinking. On most questions a score of 1 to 5 could be given, with 1 being a very bad and 5 a very good score. A score of 3.7 or higher was considered as good. On others a yes or no answer was possible. A score of more than 80% yes was considered as good.

6.3.3. Influence of exploratory scenarios

To analyse the influence of exploratory scenarios on the backcasts, data from the nine Pilot Area workshops and one regional have been analysed. Obstacles, opportunities and strategies were grouped in eight categories: legislative/policy, management, economical, social, environmental, research/technologies, cooperation and other. It is expected that under each exploratory scenario different categories will have a higher share of obstacles, opportunities or strategies. Given the scenario characteristics of the Pan-European Panel (PEP) scenarios (see figure 6.1 and Kok et al., 2010) we expected an impact on the eight categories in each scenario as shown in table 6.1. As the Pilot Area scenarios are down-scaled versions of the PEP scenarios, we expect their influence will be similar.

Table 6.1; Scenario characteristics in eight categories and expected impact on the backcasts.

category	Economy First	Policy Rules	Fortress Europe	Sustainability First
legislative / policy	- little, market controls	++ very important	++ important, to steer changes	+ mainly on local scale
management	- little	+ some, to execute the policies	+ some, to execute the policies	++ important, from top-down to bottom-up
economical	++ important, driving force	+ some attention	+ some, to keep stable	- Economy becomes less important
social	- low importance	+ important	- low importance	++ Large social changes
environmental	- low importance	+ important	- low importance	++ very important
research / technologies	++ many innovations	+ some	- little	+ some
cooperation	+ mainly global	++ on all levels	+ within EU	+ within eco-regions
other	n.a.	n.a.	n.a.	n.a.

With plusses we expect a relatively higher share of opportunities and strategies in this category, with minuses relatively less. For the obstacles an opposite influence is expected.

To analyse the influence in more detail, the content of the obstacles, opportunities and strategies is studied by looking at common obstacles, opportunities and strategies (mentioned in multiple workshops). For instance the type of technologies used (highly technological or natural approach) or social strategies (top down, strong government control or bottom up, participation) might differ depending on the scenario.

6.3.4. Identification of robustness across regions and scales

For the cross-scale comparison the results of both the local and regional workshops and the pan-European panel have been used.
Robust actions of all Pilot Areas and the regional workshop were compared to see which were mentioned in multiple Pilot Areas and regions. Given the large differences in cultural background, physical and climatic circumstances and identified problems between the regions and the low number of robust actions in some regions, we considered those robust actions that were present in at least two regions to be robust across regions.
There were a number of robust actions from the Pilot Areas that addressed the pan-European level directly. These robust actions and those that are robust across regions are compared to robust elements from the PEP workshop. This can show which actions are robust across scales and which are more scale specific.

6.4. Results

6.4.1. Evaluating the methodology

Extent to which the methodology is used

Most workshops followed the methodology as described in section 6.3 to a large extent (see table 6.2). Only Danube Delta and Seyhan adapted the methodology to a larger extent. Overall, there were fewer changes to the general methodology than in previous workshops (see for instance Chapter 2).
In all Pilot Areas obstacles, actions and milestones were identified. Some Pilot Areas did not identify opportunities, but instead placed milestones directly to speed up the process. In all except one Pilot Area, robust actions were developed. Most Pilot Areas made one backcast per scenario, some made two.

The regions cover a broad range of issues from irrigated intensive agriculture in the south of Spain to water quality and flooding in the Baltic region (Kämäri et al., 2008; Kämäri et al., in press). The desired objective therefore differed per Pilot Area. In the Mediterranean region the focus was on water quantity, in the Baltic region on water quality. In the Black Sea region both water quality and quantity aspects were seen as important. Due to time limitations, however, the Lower Don did the backcasting only for water quality. In the Lower Danube the focus was mainly on water quality, but water quantity was also studied. The desired objectives were often ambitious, e.g. good status of water quality and quantity, realisation of sustainable irrigation. The objectives of the workshops can be found in Appendix 1.

Table 6.2; Overview of results from the backcasting workshops.

		robust	scenarios used [a]				number of	
Pilot Area	**date PAWS3**	**strategies**	EcF	FoE	SuE	PoR	**backcasts**	**consists of** [b]
Pan-European panel	20-22/01/’10	yes	x	x	x	x	4	a, m, ob, op
Baltic region	11-12/01/’10	yes	x	x	x	x	4	a, m, ob, op
Narew	18-19/06/’09	yes	x		x		3*2 [c]	a, m, ob, op
Peipsi	8-9/12/’09	yes	x		x	x	3	a, m, ob, op
Tisza	26-27/11/’09	yes	x	x	x	x	4*2 [c]	a, m, ob
Danube Delta	8-9/10/’09	yes			x		1	a, m, ob
Crimea	20-21/10/’09	yes	x	x	x	x	4	a, m, ob
Lower Don	18/12/’09	yes	x	x		x	3	a, m, ob
Candelaro	10/12/’09	yes		x		x	2	a, m, ob, op
Guadiana	12/02/’10	yes	*PoR+EcF and PoR+SuE* [d]				2	a, m, ob, op
Seyhan	23/10/’09	no			x		1	a/m, ob

a) EcF = Economy First, FoE = Fortress Europe, SuE = Sustainability Eventually, PoR = Policy Rules
b) a: actions, m: milestones, ob: obstacles, op: opportunities
c) each group did 2 scenarios
d) scenarios were a combination of the scenarios mentioned

Table 6.3; Results from questionnaires held after the third Pilot Area workshop.

question/statement	**score**
How would you grade this workshop as a whole?	4.06 [a]
Are you satisfied with the chosen desired objective?	91% yes [b]
Are you satisfied with the policy actions identified in the backcasting? / Did the backcasting help to find policy options?	90% yes [b]
The produced backcastings are useable for river basin management planning	3.87 [c]
Participating in the workshops has helped me in understanding the policy actions needed	4.06 [c]
The backcasting done in the third workshop created a clear link between the future visions and the present day decision-making needs	3.96 [c]
Participating in the workshops has helped me to see water management in a new way	3.88 [c]
The fact that we worked together with different participants raised fresh ideas that were new to all participants	4.33 [c]

a) on a scale of 1 to 5 with 1 being poor and 5 excellent
b) percentage of yes (out of 3 possibilities yes, no, no answer)
c) on a scale of 1 to 5 with 1 being disagree completely and 5 agree completely

Participants' feedback on method

Participants and organisers were enthusiastic about the backcasting method. On average the participants of the Pilot Area workshops graded the workshop with a 4.1 on a scale of one to five, with one being poor and five excellent. The vast majority of participants was satisfied with the chosen desired objective and the policy actions identified.
Participants acknowledged the usability of backcasting; they thought the results were useable for river basin management planning (3.9, see also table 6.3). It also helped them to get a better understanding on the policy actions that are needed (4.1). They further agreed with the statements that backcasting created a clear link between the future and the present (4.0). The workshop further helped participants to think out of the box; it helped them to see water management in a new way (3.9) and new ideas were raised (4.3).
Although participants and organisers were very satisfied with the workshops, not everything went smoothly. A number of problems were identified by the coordinators in their reports:

- it was often difficult to define one specific desired objective that made sense for all the four scenarios,
- distinction between actions and milestones gave some difficulties,
- policy aspect was difficult for non-policy makes,
- working backwards was difficult.

These issues are further discussed in Section 6.5.

6.4.2. Influence of the exploratory scenarios

Influence on obstacles and opportunities

In total about 140 obstacles and 50 opportunities were identified. Obstacles were identified in all ten workshops, while opportunities were only identified in five workshops. There were differences between the scenarios. Fortress Europe had the highest average number of obstacles and least opportunities. Sustainability Eventually had, on average, the most opportunities and lowest number of obstacles.

Opportunities

The total number of opportunities was relatively low (50) partly because not all Pilot Areas defined them. All backcasts contained a relatively large amount of economical opportunities. There were relatively little opportunities in the categories legislation/policy, cooperation, other and, to a lower extent, research/technologies.
Backcasts within the Economy First scenario contained many management and economy opportunities, and a low number of policy and environment opportunities (see table 6.1). Table 6.4 shows that this was to be expected for backcasts developed within Economy First. Typical opportunities for Economy First were related to technological development, which is assumed to be high in this scenario.
Backcasts within Policy Rules were surprisingly low on environmental opportunities. The large shares of social and management opportunities were expected. The share of legislation/policy opportunities is low, but this is the case in all scenarios. Typical opportunities for Policy Rules were large programs and improved planning.

Table 6.4; Percentage of opportunities per scenario, divided per category.

category	Economy First	Policy Rules	Fortress Europe	Sustainability Eventually
legislative / policy	0%	8%	10%	8%
management	19%	17%	10%	12%
economical	25%	25%	30%	24%
social	13%	25%	10%	24%
environmental	13%	8%	30%	32%
research/technologies	19%	8%	10%	0%
cooperation	0%	0%	0%	0%
other	13%	8%	0%	0%
*number**	13	11	7	**19**

** Opportunities could be placed under multiple categories; number per scenario is excluding doubles*

Backcasts within Fortress Europe had a surprisingly high percentage of environmental and economy related opportunities. The relatively high percentage of policy related opportunities (compared to other scenarios) was as expected, as was the relatively low percentage of social opportunities. Typically for Fortress Europe was the attention to centralisation as an opportunity.

Backasts within Sustainability Eventually had an unexpected high percentage of economical opportunities. As expected there was a high percentage of social and environmental opportunities. Organic farming and a shift in social values were typical opportunities.

Overall it seems that most of the opportunities related back to the general background of the scenarios. Not all results were that straightforward, for instance the large share of environmental opportunities in backcasts within Fortress Europe.

Obstacles

There were almost three times more obstacles identified than opportunities, also because all workshops identified them. Management obstacles had relatively high shares in backcasts within all scenarios except Fortress Europe. There were few research/ technology obstacles (see table 6.5).

Backcasts within Economy First had the highest percentage of legislation obstacles (17%) compared to backcasts within other scenarios. They also had a high number of management obstacles, as was expected. Apparently legislation, policies and management are more perceived as being an obstacle in an economy orientated world. A common management obstacle was for instance the lack of regulation (see also table 6.6). The share of environmental obstacles is relatively low, this was not expected. Even though backcasts were developed within an economy oriented scenario, there are also economical obstacles. Common economical obstacles were a lack of financial support.

Table 6.5; Number of obstacles by scenario and the percentage per category.

Category	Economy First	Policy Rules	Fortress Europe	Sustainability Eventually
legislative / policy	17%	7%	12%	8%
management	24%	37%	14%	38%
economical	15%	24%	33%	8%
social	16%	10%	11%	21%
environmental	9%	12%	26%	10%
research/technologies	4%	2%	2%	4%
cooperation	7%	0%	0%	12%
other	11%	7%	2%	2%
*number **	*37*	*34*	*35*	*35*

** Obstacles could be placed under multiple categories; number per scenario is excluding doubles*

Backcasts within Policy Rules had the lowest share of policy related obstacles, which was assumed. Common policy obstacles were the correct coordination of all new polices and that current policies sometimes obstruct the desired objective. The relatively low shares of social and environmental obstacles were expected. The high share of management obstacles was not expected.

Backcasts within Fortress Europe included many economical and environmental obstacles. In Fortress Europe the environment is not important, which is further reflected by the common obstacle of a high pressure to produce food and energy. Chances of getting funding for a water quality related objective are low within this scenario. In that respect the high share of economical obstacles is not very strange, although it was not expected on forehand. The relatively low share of social obstacles was also not expected.

Management obstacles have a very large share in backcasts within Sustainability Eventually as do social obstacles, which were not expected. A typical obstacle in this respect is the lack of capacity to make the (large) changes needed. These large changes are needed to move from a top down approach to a localised and governance approach as is used in the Sustainability Eventually scenario. In several Pilot Areas participants identified problems with (the introduction of) participatory processes as an obstacle (e.g. due to inexperience). The low share in economical obstacles was also not expected. The low levels of policy and environmental obstacles were as expected.

The link with the scenarios in the obstacles seems mixed. Especially in Sustainability Eventually and Fortress Europe the shares were not always as expected. Yet, the common obstacles often illustrate the link with the exploratory scenarios well. Under social issues for instance, involvement of stakeholders is difficult in a Fortress Europe world, which will be more centralised. In Sustainability Eventually involvement will be easier, but the capacity to do it right is currently often lacking.

Table 6.6; Most often mentioned obstacles per category.

Category	Economy First	Policy Rules	Fortress Europe	Sustainability Eventually
legislative / policy	– Political instability, – lack of regulation, – lack of financial support	–	– political instability	– lack of support
management	– lack of finances, – ineffective control	– lack of coordination, – to strict guidelines	– conflicts of interests, – lack of stakeholder involvement, – lack of funding	– lack of financing, – problems with participatory processes.
economical	– lack of financial support	– lack of funding, – wrong results of existing subsidies	– much pressure on certain sectors (like energy and agriculture) to produce	– lack of financing – high environmental taxes
social	– demographic issues: population decrease / urban sprawl	–	– Lack of involvement of stakeholders	– not enough capacity to make the changes
environmental	– increase in pollution	– increasing pollution (from agriculture and other sectors)	– pressure to produce food and energy might lead to pollution and water shortage	– long recovery from pollution – intensification
research / technologies	– introduction of new polluting technologies	–	–	– need for new indicators
cooperation	– problems with cooperation	–	– conflicts and lack of cooperation	–
other	–	–	–	–

If no obstacles are given there were no obstacles mentioned more than once in that category and scenario.

There were also similarities between scenarios; a lack of finances was an obstacle that was mentioned in many Pilot Areas and across all scenarios and is likely to always be a problem when aiming for ambitious goals.

Influence on the main strategies

In total more than 130 main strategies (based on circa 500 actions and 350 milestones) have been defined.
The share of management strategies was highest under all scenarios (see table 6.7), illustrating the often large changes that were needed to reach the ambitious objectives.
Backcasts within Economy First have the highest share of economical strategies compared to the other backcasts. The relatively high share of legislative and policy strategies (20%) was is unexpected given that market liberalisation is at the core of the scenario. The common legislation and policy strategies are, however, economical in nature (see table 6.8). The level of management strategies is lowest of all backcasts. As expected, social and environmental strategies are also underrepresented if compared to the other backcasts.
Backcasts within Policy Rules have the highest percentage of all backcasts in legislation/ policy. Also management and environmental strategies have a relatively high share. This was what we expected for backcasts within Policy Rules. The low share of social strategies was, however, not as expected.
Backcasts within Fortress Europe have a high percentage of social strategies. The common social strategies include aspects like strong control, but education is also often mentioned. The relatively low share of legislative/policy strategies was not as expected, but the relatively low share of environmental strategies was.
Backcasts within Sustainability Eventually included a high percentage of social strategies. The share of environmental strategies is second highest, but was expected to be higher. Common social and environmental strategies were participation and awareness raising. The relatively low share of legislative strategies was expected. The large share of management strategies could be related to the large share of management obstacles that were identified for this scenario. It illustrates that in many of the Pilot Areas much need to be changed to become a bottom up society. Backcast within Sustainability Eventually did not have any strategies under cooperation, which is difficult in a strongly bottom-up, regionalised world.

All in all, most strategies related to the scenarios within they were developed. The common strategies further illustrate the influence of the scenarios, with for instance the strong focus on awareness raising and increasing participation in backcast that were developed within Sustainability Eventually, control of population and rules for water use for Fortress Europe backcasts, regulations and plans in Policy Rules backcasts and taxes and economical means Economy First backcasts. As there was more freedom in developing strategies compared to the identification of obstacles and opportunities it was expected that they would deviate more from the exploratory scenarios within they were developed. This was not the case, showing that stakeholders kept the within the context of the scenarios.

6.4.3. Identification of robustness across regions and scales

The wide range of strategies and actions shows the diversity of options that policy makers have.
The robust actions bring structure in this diversity by showing those actions that are most likely to be effective in the future. In total 59 robust actions were identified out of

Table 6.7; Number of strategies by scenario and the percentage per category.

category	Economy First	Policy Rules	Fortress Europe	Sustainability Eventually
legislative / policy	20%	24%	13%	11%
management	22%	28%	24%	30%
economical	18%	7%	9%	14%
social	10%	7%	22%	23%
environmental	10%	26%	11%	16%
research/technologies	6%	6%	11%	2%
cooperation	8%	2%	2%	0%
other	8%	0%	9%	5%
*number of strategies**	*33*	*32*	*39*	*31*

**Strategies could be placed under multiple categories; number per scenario is excluding doubles*

Table 6.8; Common strategies by scenario and category.

Type\scale	Economy First	Policy Rules	Fortress Europe	Sustainability Eventually
legislative / policy	– taxes, – stimulate industries and environmental protection by economical and regulatory means	– taxes, – standards, – improvement of legislation	– rules for water use	– increase participation
management	– work on infrastructure – implement technologies	– regulations and plans – implement technologies	– infrastructure	– water saving, – technological measures
economical	– create conditions for investments – taxes	–	– subsidies	–
social	–	– awareness raising / education	– education, – control of population	– raise awareness – public participation
environmental	– technologies	– environmental regulations – pollution taxes	– fish protection	– raise awareness – increase water quality
research/ technologies	– technologies	–	– technologies	–
cooperation	– cross border projects	–	–	–

500 actions. The number of robust actions ranged from two to twelve per Pilot Area. The robust actions showed the need for both social and technical actions. Most of them fitted in the legislation, management, social and environment categories (all about 20%). About ten percent of the robust actions fell under the economy and research categories. The last four percent were related to cooperation.

Robustness across Pilot Areas and regions

If the same robust action is identified in at least two regions, they are not only robust within one Pilot Area, but also across regions. This was the case for fourteen robust actions that were identified in at least two regions and in as many as six of the nine Pilot Areas. They are likely to work in different cultural and regional backgrounds.
One robust action was identified as robust in all four regions; the development, improvement and integration of legislation and policies. Other actions like monitoring, financial incentives (taxes, subsidies, etc) and increasing awareness were identified as robust actions in three of the four regions (see table 6.9 in section 6.4.3). None of the robust actions was identified as robust in all Pilot Areas.

Robust actions from the Pilot Areas that directly addressed the (pan)-European level

There were a number of robust actions identified on the Pilot Area level that either addressed, or could use involvement from, the European Union. They are listed in table 6.9 in the next section and include, among others, actions on the Water Framework Directive (WFD), Common Agricultural Policy (CAP), cooperation and (financial) support for development of new technologies and awareness raising.
On the WFD there were some more broad actions to 'improve the WFD', but also more specific remarks on perceived shortcomings in the WFD, such as better guidelines, more specific targets and indicators and more transparent information on the implementation process. There further was a plea to delete exemptions and derogations from achieving the good status and to review criteria for heavily modified water bodies.
Robust actions on the CAP included actions to better take water quality and quantity aspects into account.
Financial support for the development of new technologies was needed, as technologies were often seen as one of the key methods to reach a better water quality or lower water demand. Support, for instance via establishing investment programmes and grants, can help to make them become available sooner.
There are many trans-boundary rivers within and on the border of the EU. As many water issues can only effectively be dealt with on the river basin level, (financial) support is needed from the EU for cross-border cooperation on these trans-boundary waters.
Awareness raising programs are another action that got much attention in the Pilot Areas. Relevant actions for the EU level are setting up or financing programs that promote the WFDs 'good water status', more general educational environment programmes and establishing and financing stakeholder panels.
Although the workshops were held on a more local scale, the local participants also identified actions at higher scales, including the EU. This shows the direct linkages that exist between scales, also in the perception of stakeholders.

Comparison of Pilot Area level robust actions with robust actions from the pan-European panel workshop

Kok et al. (in press) analysed the results from the SCENES pan-European panel (PEP) workshop. The desired objective in this workshop was "*Sustainable management, supply and use of water"*, which included both water quality as well as water quantity issues. In the PEP a slightly different approach than in the Pilot Areas was used in identifying robustness, which not only included actions, but also strategies, obstacles and opportunities. This resulted in a list of 15 robust elements. They can be compared with the robust actions that were robust across regions, and those that addressed the EU directly (see table 6.9).

Most of the two types of robust actions from the Pilot Areas can be linked to the fifteen robust elements that were identified by the PEP.
Robust issues that were identified in all three analyses were:

- Institutions and international agreements; Legislation and policies need to adapt to future situations and challenges. This often will lead to changes in institutions. International agreements are important, especially in trans-boundary river basins.
- Economy; Financial instruments, such as subsidies and water pricing can be used to create changes in society, businesses and industry.
- Awareness raising, education and promotion campaigns can be used to change peoples' behaviour.
- Lack of money; although not specifically addressed in the Pilot Areas there was much attention to the financial aspects, including actions like taxes that can decrease the lack of money.
- Weak governance; there seems to be a need to improve the governance capacity, including the use of more participatory methods.
- Water saving strategies; not all regions experience problems with water shortage, therefore there were few water saving strategies robust across regions. Updating water infrastructure was identified as a robust action in two regions. The EU could help in searching for better technologies and changes in agriculture subsidies (CAP).
- Technological investments; technological changes are often needed to create a better water quality and quantity.

There were also a number of issues that are not addressed in the Pilot Areas but were by the PEP:

- Climate change was often not explicitly mentioned in the backcasts of the Pilot Areas. It did not (and did not need to) trigger changes. In the PEP it was seen as an opportunity for making change happen, but in the Pilot Areas it was rather an obstacle to change.
- Pilot experiments were not addressed in the Pilot Areas, possibly because they themselves can be seen as a sort of pilot experiment.
- Flood prevention only plays an important role in one or two Pilot Areas and a role for the EU in this was not perceived as robust action.
- Energy only played a larger role in two of the regions, but this did not lead to robust actions.

Table 6.9; Overview of robust elements from the pan-European Panel, robust actions that are robust across Pilot Areas and robust actions identified on the Pilot Area scale that address the EU level.

robust elements from pan-European Panel	**robust actions across regions** (*number of regions / number of Pilot Areas*)	**robust action on the Pilot Area scale that address the EU level**
institutions + international agreements	– develop legislation (4/5) – cooperation (cross border and sectors) (2/3)	– institutional development and capacity building – financial support for cross-border cooperation on trans-boundary waters
economy (taxes, water pricing, voluntary agreements)	– financial mechanism, taxes, subsidies and investment programs (3/6)	– establish investment programmes and grants for prevention of pollution – taxes and charges to motivate reduction of pollution – revise agricultural subsidy system – stimulate private financing for water quality improving measures – financial support for cross-border cooperation on trans-boundary waters
agriculture (spatial planning)	–	– revise agricultural subsidy system * – free educational environment programmes for farmers
awareness raising	– increase awareness (3/5) – education (3/4) – environmental education (3/3)	– support awareness raising measures – promoting good water status as high priority – establishing and financing stakeholder panels – free of charge educational environment programmes for farmers, industry, etc
private-public partnership	–	– support development of new technologies in prevention of pollution – support cost-effective measures to improve water quality – stimulate private financing for water quality improving measures *
CAP reform	–	– revise agricultural subsidy system *
climate change impact	–	–
pilot experiments	–	–

(Table 6.9 continued)

failure of WFD	–	– rework the WFD – need for better guidelines, specific targets and relevant indicators for WFD – more transparent information on implementation process – delete exemptions and derogations from achieving the good status of the WFD – review criteria for heavily modified water bodies (WFD) – implement the WFD – keep WFD
lack of money	– financial mechanism, taxes, subsidies and investment programs (3/6)	– hinted at in several robust actions (see under economy, awareness raising, technological investments
weak governance	– improve governance capacity (2/2) – governance (2/2)	– support the establishment of stakeholder panels – free of charge educational environment programmes for farmers, industry, etc
water-saving strategies	– update (water) infrastructure (2/3)	– revise agricultural subsidy system* – free of charge educational environment programmes for farmers, industry, etc – technology development to increase efficiency
flood prevention	–	–
energy	–	–
technological investments	– update (water) infrastructure (2/3) * – new technologies (2/4) – improve/expand waste water treatment (2/3)	– support development of new technologies in prevention of pollution * – support cost-effective measures to improve water quality * – technology development – to increase resource use efficiency and to decrease pollution load *
no matching robust element from the PEP	– monitoring (3/4) – development of tourism sector (compatible with the environment) (2/2)	– implement necessary monitoring programmes

** linked to two or more robust element*

Two robust actions addressed in the Pilot Area workshops could not be linked to robust elements of the PEP. These are monitoring programs and the development of the tourism sector (in an environmental friendly way).

Other issues were addressed as robust actions that addressed the EU directly, but were not robust across regions. Apparently there were either too many differences between regions or there was too little attention in most regions on: agriculture (spatial planning and CAP), public private partnerships and the WFD as such. Some robust actions like monitoring can, however, easily be seen as part of the WFD approach.

6.5. Discussion

6.5.1. Evaluating the methodology

Extent to which the methodology is used

For the analysis, data of ten different workshops was used. Although most workshops followed the same methodology, there were important differences. In a large participatory project like SCENES the diversity in culture, background and previous experience of the stakeholders makes it impossible to follow exactly the same methodology in all case studies.

An important difference was that two Pilot Areas only developed one backcast within one scenario. One of them did study the robustness by discussing the effectiveness of actions within the other three previously developed scenarios. The other Pilot Area did not study the robustness. Another important difference was that not all workshops included opportunities and some assigned obstacles at the end of the exercise. Reasons were for instance lack of time (especially in one day workshops). The influence on the link with the exploratory scenarios is discussed in section 6.5.2. Here we want to highlight the need to be flexible when working in large participatory projects, and illustrate the consequences it can have on the methodology. With the flexibility offered, the acceptance of the method was still high.

Participants' and organisers' feedback

The methodology was well evaluated by participants and organisers alike, but there were also some more critical notes: working backwards is difficult, having one specific objective for all four scenarios gave some problems, the division between milestones and actions was not always clear and the policy aspect was difficult for non-policy makers.

Working backwards is difficult

Pilot Area coordinators reported that some participants found working backwards difficult. As backcasting is an iterative process, it is normal that the focus is sometimes already more on the short and middle term. In order to make this process a bit easier we introduced the milestones to first make some larger steps backwards from the desired objective. However, the overall process did and should focus on working backwards from the desired objective.

Bradfield (2004) describes scenario development from a cognitive psychology viewpoint. He states that, thinking backwards, makes it easier to think 'out of the box'. Because of

how the human mind works, exploratory scenario development leads to different scenarios than those developed via backcasting. Backcasting forces participants to look from a different perspective, which is likely to lead to new solutions.
We hypothesise that using backcasting in combination with exploratory scenarios forces participants to come up with even more creative solutions in order to reach the desired objective, even in exploratory scenarios in which they would not easily envision such an objective to be reachable. This should, however, be tested with a comparative study.

One specific objective for all four scenarios

It was often difficult for participants to deal with a desired objective that did not fit very well the logic of the exploratory scenario. A good water quality for instance, is easier to reach in a more environmental friendly scenario (Policy Rules or Sustainability Eventually) than in a less environmental friendly scenario like Fortress Europe. Overall, backcasts in Fortress Europe resulted in most obstacles and least opportunities. In the end, however, most groups managed to find ways to reach the desired objective within their exploratory scenario, even if it did not fit the logic very well. It should be clear to the participants that, although the backcast had to stay within the main assumptions of the scenario, there is room for manoeuvring within these main assumptions. Given the problems reported this should be communicated better in futures exercises.
The focus on reaching the objective in all four scenarios might have led to less realistic result (e.g. installing a dictator). In these cases it can be good to tell participants that not reaching the objective (or reaching it later) is also a result in it self. The backcast can than show why the objective could not be reached and what is realistically possible within a certain scenario. On the other hand, the will to reach the objective did lead to very creative solutions. These creative solutions will be lost if it becomes too easy to say that the objective cannot be reached. A good balance should therefore be found.
Svenfelt et al.(2010) recently conducted a similar exercise of checking the robustness of actions with exploratory scenarios. Their actions were derived via questionnaires. From their research it became clear that the vast majority of issues could only be used in the two scenarios with much government regulation (see figure 2 in their paper). This shows a lack of robustness against a situation with an uninfluenced market. With our approach, it can be ensured that a discussion on suitable actions takes place in all four exploratory storylines, making it more likely to have a more equal spread over the scenarios. This increases the likelihood of identifying robust actions.

Division between milestones and actions

The division between actions and milestones was mainly made to first lay out the backbone of the backcast (as a series of milestones), which could than be made concrete by assigning the actions needed to reach the milestones. Sometimes it was unclear if something was a milestone or an action, and it might also depend on the exact wording (e.g. ‘setting up education programs’ as action, or ‘education programs set up’ as milestone). The distinction between milestones and actions was, however, not very important for the overall process.

Policy aspect difficult for non-policy makers

Some Pilot Areas reported that the policy aspect was difficult for non-policy makers. Indeed policy makers formed a small minority in these workshops. Having more policy makers could make the policy aspects more realistically incorporated in the backcasts. It is therefore advisable to include more policy makers in backcasting workshops. This could also enhance the link with actual policy making processes. However, the input from other stakeholders is equally important, as they can bring in new, original actions that are not policy related.

Although there were some problems both the organisers and the participants were enthusiastic about the methodology and the workshop results, which was also illustrated by the questionnaire results.

6.5.2. Influence of the exploratory scenarios

A key novel aspect of the methodology was the use of obstacles and opportunities to establish the link with the exploratory scenarios. As said, not all workshops included opportunities and some discussed obstacles at the end of the exercise. Participants in these workshops had to make the link in a less explicit way. Opportunities were for instance directly translated into milestones. In Pilot Areas where obstacles were discussed at the end of the workshop, they showed more the problems that might arise if the timeline was followed. We did not study the influence of this on the results, as the group sizes would become rather small, but it can be assumed that in those cases the link with the exploratory scenarios is less explicit. On the other hand, in the workshop reports there were no signs that the resulting strategies in those cases did not link with exploratory scenarios.
As shown, the use of obstacles and opportunities successfully provided the means to include information from the exploratory scenarios. Yet, it is important to keep in mind that *the same group of stakeholders* developed the exploratory scenarios. In fact, an objective of developing those during workshops is to internalise these in the stakeholders' mind. As such, the backcasts can be hypothesised to be inherently and closely linked to the exploratory scenarios. This is one reason to involve participants in the development of the exploratory scenarios before the backcasting. A comparative study should be conducted to study the differences between backcasting with and without exploratory scenarios in more detail.
One aspect that might have hampered the analysis is that all workshops used their local scenarios. These are downscaled versions of the scenarios used on the pan-European level. It is therefore likely that the scenarios differ per Pilot Area, which might especially be the case for the two more regional scenarios Fortress Europe and Sustainability First. Indeed those two scenarios fitted least well with the assumed levels of opportunities, obstacles and strategies. These assumptions were based on the PEP scenarios.

6.5.3. Identification of robustness

Robustness across Pilot Areas, regions and scales

None of the robust actions were robust across all Pilot Areas. This is not surprising considering the large diversity in Pilot Areas, desired objectives and the fact that some Pilot Areas identified only very few robust actions.
It was noted, however, that some actions were robust across both water quality and water quantity oriented objectives. These included actions like updating infrastructure, cross border cooperation, improvement of governance capacity, monitoring and

increasing awareness. As the cross scale comparison showed, some actions were also robust across scales, as they were identified as robust on different scales. So, although there was no total robustness, there was robustness across futures, scales, regions, and issues. Still it is evident that there is no silver bullet solution for all water related problems. A complex problem like this will always call for a toolbox of solutions in order to address all the underlying issues and stakeholders.

Methodological issues concerning the identification of robustness

Most of the Pilot Areas studied the robustness of actions by comparing the actions developed under different scenarios. In the PEP each small group studied the robustness of elements from their backcast in the other scenarios. Subsequently, in a plenary discussion, more elements were identified as robust. In an a posteriori analysis two key obstacles were identified as robust element (Kok et al., in press). It is likely that if the Pilot Areas used the same methodology, more robust actions would have been identified.

Theoretically scale differences were expected between the pan-European and Pilot Area scale. Previous research has shown that issues are often scale dependent (e.g. Biggs et al., 2007; Kok et al., 2007a; Zurek and Henrichs, 2007). The cross-scale comparison, however, showed there were relatively small differences between the pan-European and Pilot Area scales. Reasons for the small differences may include: 1. the use of similar exploratory scenarios in all workshop; 2. input as participants from regional coordinators in the PEP workshops; 3. scale insensitivity of factors (such as the WFD that is important at all scales). This also links to the issues on multi-scale scenario development as raised by Kok et al. (2007a).

Looking for robustness across regions gives a good indication of issues that might play on other scales, but it does not capture the full extent of issues that might be important for the higher scales or the exact nature. Some issues were for instance addressed on both scales, but with different result. The PEP was for instance rather pessimistic about the compliance with the WFD. Although there were also robust actions in some of the Pilot Areas to improve the WFD, all regions – including the Black Sea – were more positive on the possibilities for full compliance with the WFD than the PEP.

6.5.4. Overall methodology

Overall the workshops showed that the methodology could successfully be implemented on different scales. There were several process related problems, but most of them seem to be inherent to backcasting. However, backcasting within exploratory scenarios did cause some additional problems. Especially backcasting a desirable objective within a less friendly future proved difficult. Given the results it seems that these difficulties were handled successfully by the majority of participants and organisers. A structural analysis was not conducted, but there is a chance that some participants did not constructively participate because of these difficulties.

Once solutions were found to reach the desired objective in less friendly futures, it enthused the participants and the reasons for the process became clearer. It also helps to show how a less friendly (and less desirable) future can be avoided.

Some difficulties might be experienced when presenting both the exploratory scenarios and the backcast in dissemination processes. As it is likely that the exploratory scenarios will tell a different story than arises from the backcasts this might create confusion. One should clearly explain why this is the case and why both products are relevant in their own right.

Notwithstanding the difficulties, also using exploratory scenarios has large advantages. It makes it possible to study the robustness of actions against other futures, including less friendly ones. The search for solutions has likely led to more creative solutions that might not have been discovered in more friendly futures. Another added value of backcasting within exploratory scenarios is that it shows the relevance of the exploratory scenarios. Resulting actions show the impact of the different futures, and therefore showing the need for scenarios to be used in policy making processes.

Besides the possibility to check for robustness, there can be another reason to use exploratory scenarios. Carlsson-Kanyama (2008) used different exploratory scenarios to give participants the option to choose their most desired future. Interestingly, different participants regarded different futures as most desirable. This was also noted within and between Pilot Areas. Because different stakeholders perceive different futures as most desirable, using different exploratory scenarios can better inspire diverse stakeholders, some of which might otherwise feel left out. In other words, developing normative scenarios in the context of a number of different exploratory scenarios can be attractive as stakeholders will not perceive one future (exploratory scenario) as the most desirable.

Quantification

The methodology as described here can be followed by a calculation of the effects of the different strategies, especially if the backcasts have a more technical (and better quantifiable) objective. This will give an extra robustness check. In order to stimulate a learning process and combine stakeholder knowledge with modellers' knowledge a second round of backcasting workshops should be held to discuss the calculation results. In order to shorten the whole process the development of exploratory scenarios could be limited to one workshop. It should not be skiped completely as stakeholder involvement in the development of the exploratory scenarios will help to 'internalise' them more, making it more likely that they will be reflected in the backcasts.

Structure in diversity

The large pool of actions provides a good overview of actions available for policy makers and water managers. They, however, often require straightforward input for their decision making process. Therefore the diversity in scenarios and actions / strategies from the backcasts needs to be structured. The combined approach of backcasting within exploratory scenarios facilitated the search for robustness and thus structured the diversity. The robust actions structure the diversity that is inherent of exploratory scenarios, and of the wide range of actions and strategies that were developed in the backcasting. This increases the policy relevance of the backcasting results, but also from the used exploratory scenarios by showing how they can be used.

6.6. Conclusions

We can conclude that our approach of backcasting normative objectives within exploratory scenarios can successfully be used in participatory workshops. The developed obstacles, opportunities and strategies reflect the context of the contextual exploratory scenarios to a large extent. This leads to a wide range of actions, milestones and strategies, which provide policy makers with a good overview of the diversity of choices available. As the actions were developed within the constraints of the exploratory scenarios, these that were effective in all scenarios show robustness to different social, economical and environmental circumstances. The robust actions showed the need for both social and technological changes. Executing this methodology in multiple case studies on different scales not only made it possible to study the robustness across futures, but also across regions, issues, cultural backgrounds and scales.

Finally, methods of combining exploratory scenarios and backcasting are in their infancy. More research is needed, particularly in new methods to facilitate and monitor information flow between exploratory scenarios and backcasts.

Chapter 7

General discussion and synthesis

7. General discussion and synthesis

7.1. Introduction

The main theme of this thesis was to develop bridges between different types of scenarios. These bridges should bring the different involved communities in contact with each other. The interactions between the communities and the different types of scenario should lead to better scenarios. Two bridges have been studied; one between qualitative and quantitative exploratory scenarios and the other between qualitative exploratory scenarios and decision support scenarios.
The study has focussed on three overall research questions:

- How can the gaps be bridged between qualitative and quantitative exploratory scenarios, and between exploratory and decision support scenarios?
- How can these bridges be used to contribute to the communication between the different communities?
- What is the effect of the bridges on the quality of the resulting scenarios?

Before addressing these research questions three more issues will be evaluated and discussed in the first part of this chapter, which contribute to in better answering the second and third question.The communication function of bridges, their role in multi-scale projects and the scenario quality criteria are evaluated and discussed in more detail. It addressed the function of so-called 'boundary objects' in the communication between communities and how the tools used in this thesis could play such a function. This also leads to a reflection on communication across scales and multi-scale scenario development. The quality criteria will be addressed in more detail as it became clear in the second and third chapter that they need further refinement when used to analyse the quality of scenarios.

In the second part (section 7.3) the previous chapters are synthesised, which leads to a critical look at the overall scenario development framework that was presented in Chapter 2. This leads to the last part (section 7.4 and 7.5) in which recommendations are given for refining the scenario development framework and future scenario projects in general. In section 7.5 conclusions will be drawn on basis of the three overall research questions given above.

7.2. Further discussion and evaluation of bridges and scenario quality criteria

7.2.1. Boundary objects

In this thesis bridges have been built between different type of scenarios, and thus between different communities (see section 1.1.5). Xiang and Clark (2003) see bridging as one of the main functions of scenarios, arguing that scenarios encourage communication between different communities. Experts and modellers can share information, knowledge, expertise and insights via scenarios to the users of those scenarios. In stakeholder processes the participants can include experiences, knowledge

and insights in the scenarios and modelling efforts (Xiang and Clarke, 2003).
In other literature such a bridging function is linked to 'boundary objects' (e.g. Star and Griesemer, 1989; Guston, 1999; Cash et al., 2003). Boundaries roughly correspond with what I have called gaps. They can be found between different communities (e.g. between scientists and decision makers), but also between different scientific fields (Guston, 1999). Boundaries should not be regarded as clear gaps, but rather as fuzzy borders that can shift over time. Boundaries are 'created' by people, organisations and institutions on both sides of the boundary (Cash and Moser, 2000). In other words, boundaries are social constructs (Hulme and Dessai, 2008) and can be changed via education and other learning processes (Sterman, 2002).
In scenario development boundaries exist between different scenario development groups. This is reflected in the use of different definitions of scenarios: The definitions from natural scientists and modellers focus on internal consistency and clear assumptions, while those of social scientists focus more on facilitation of creative thinking and changing mindsets.

Boundary objects are tools that can be used to bring different communities of both sides of the boundary together (Cash et al., 2003). They are "*adaptable to different viewpoints and robust enough to maintain identity across them*" (Star and Griesemer, 1989) and should be understandable for both communities to gain legitimacy in each community (Hulme and Dessai, 2008). Boundary objects should provide a 'language' or syntax that both parties are comfortable with. They should help both parties to share their knowledge and provide a process that leads to new, shared, knowledge (Carlile, 2002). Boundary objects can thus lead to social learning.

In this thesis Fuzzy Cognitive Maps (FCMs, a semi-quantitative conceptual model see Kosko, 1986 and Chapter 2) have been used as boundary object to bring the stakeholders and modellers communities together. Backcasting within exploratory scenarios allows communication with decision makers. Stakeholders and scientists can give their views and ideas on the future (as shown by the exploratory scenarios) and the actions that need to be taken in the short term (as shown in the backcasts). At the same time it gives decision makers a platform to share their points of view and explain why certain actions need to be taken.

Boundary objects can also affect the boundary itself (Guston, 1999). If stakeholders get a better knowledge of mathematical models it can help to soften the boundary. Because there is less of a boundary and more understanding, the credibility of the model results - and therefore of the whole scenario project - can increase. From the modellers perspective, the use of FCMs as boundary object can help to overcome the boundary towards the fuzzy and vague stakeholder products. This communication can lead to more trust between the different communities (Cash and Moser, 2000) and learning processes.

Cash (2001) stated that boundary objects can not only bridge between communities, but also between scales. The boundary between different scales has also been identified in scenario theory.

7.2.2. Bridging scales

Processes can have stronger impacts at some scales than on others, and there are relations between scales (Millennium Ecosystem Assessment, 2003; Biggs et al., 2007; Zurek and Henrichs, 2007). That processes and relationships change with scale was first recognised by ecologists (O'Neill, 1988; Meentemeyer, 1989), but is now also addressed in scenario studies (e.g. Biggs et al., 2007; Kok et al., 2007a; Zurek and Henrichs, 2007). As consequence of this, there is no scale that is best to focus on when addressing a complex problems. Solutions on one scale can lead to problems at other scales (Cash et al., 2006; Buizer et al., in press). This is a major reason for developing multi-scale scenarios. Participatory multi-scale approaches can further increase the relevance of resulting scenarios across multiple decision-making scales (Lebel et al., 2005). By doing so, scenarios can not only help to bring different communities together, but also the same type of communities that work on different scales. It can, for instance, increase the communication between policy makers working on different scales (Wollenberg et al., 2000) and their awareness of influences of higher and lower scales.

On the modelling side of the story, data availability is important. On different scales different type of data may be available. Models that cover a wide spatial extent tend to have a lower resolution (Biggs et al., 2007) and lack the data and precision that local scale models have (Veldkamp and Fresco, 1996). Single scale models only deal with dynamics on that scale. Multi-scale models can include inter-scale dynamics which can lead to more realistic simulations (Veldkamp and Fresco, 1996).

Multi-scale approaches further make it possible to study possible mismatches between the decisions taken on one scale and the impacts on socio-ecological processes on other scales (Brown, 2003).

State of the art

It has been said that a multi-scale scenario approach is better suited to detect cross-scale interactions (Biggs et al., 2007). Formal approaches for linking scenarios across the different scales are, however, not yet very well developed or tested. Most multi-scale scenario exercises (especially the tighter coupled) have been primarily top-down, with the emphasis being on downscaling in stead of on up-scaling (Biggs et al., 2007).

According to Berkes et al. (2006) bridging scales can be addressed in different ways: understanding how systems work on the different scales, how systems interact across scales, and focusing on one scale while being aware of the possible influence from other scales. According to Döll (2008) multi-scale scenario exercises are best carried out within one project, with a common framework. This common framework can be in the form of using a similar scenario development process on all scales, or by linking elements and results of the scenarios across scales (Zurek and Henrichs, 2007). Recent multi-scale scenario studies used such a common framework. Some used the drivers of higher scale scenarios as boundary conditions for local scale scenarios to maintain comparability. MedAction, for instance, used the European level scenarios from VISIONS in local, Mediterranean case studies to explore the land degradation (Kok et al., 2006a; Kok et al., 2006b). These local scenarios were iteratively linked to regional scenarios (Kok et al., 2007a). In other projects the higher scale storylines were adapted to fit lower scales. The Millennium Ecosystem Assessment scenarios for Portugal, for instance, were constructed by using the assumptions and decision-making paradigms from the global scenarios

(Pereira et al., 2004). VISIONS (Rotmans et al., 2000) used the same factors, actors and sectors for all scenarios. In GEO-4 (Rothman et al., 2007) regional and global scenarios were developed in which a common set of driving forces, time scales and other parameters were used.
Some studies do not use such a framework and local scale scenarios are linked to higher scale scenarios only after they have been produced (e.g. Lebel et al., 2005). This kind of loosely coupling makes sure that local stakeholders can address issues they deem important.

Although progress has been made in the last years, there still remain challenges. According to Biggs et al. (2007) the emphasis has been on downscaling in stead of up-scaling because of the difficulties that arise when incorporating diverse and inconsistent elements from smaller scales into the larger scale storylines. Often, the local scale scenario processes emphasize qualitative scenario development, while large scale development focuses on quantitative scenarios (Biggs et al., 2007). Up scaling of the local scenarios to higher scales is then especially challenging and important, as difficulties in up-scaling also make the connection between the storylines and models more complicated.

Biggs et al. (2007) identified a number of challenges in developing multi-scale scenarios:
- Different goals and methods are used on the different scales which leads to problems with the comparison.
- Linking is hampered by different focus, due to different issues and processes that are important on each scale.
- Credibility is sacrificed at one scale or another, as one scale is taken as starting-point, but the important issues on that scale might not be relevant and credible on other scales.

Multi-scale aspects in this thesis

Also within SCENES a multi-scale approach was taken; scenarios have been developed in a participatory manner on three geographical scales (continental, regional and river basin, see section 1.4). In the previous chapters there were links to this multi-scale approach: in Chapter 4 it was shown that one of the added values of a toolbox is that it increases comparability between scales. In Chapter 5, Pilot Area FCMs were aggregated to form a higher-scale FCM and in Chapter 6 robust actions were checked for robustness between regions and across scales.

Toolbox

The use of one toolbox for all Pilot Area and regional workshops increased the comparability of the results. Although there was flexibility to use different tools, all Pilot Areas used FCMs, spidergrams, storylines and backcasting. This made it easier to compare the different Pilot Areas and to up-scale results in order to derive a regional perspective. The analysis of concepts in the Pilot Areas' FCMs, for instance, showed differences between water rich and water poor regions (van Vliet, 2008). The analysis of spidergrams further illustrated this divison: "*water quantity was seen as most important in the Mediterranean (…) and Black see countries, while it scored lower in the Baltic Pilot*

Areas“ (van Vliet, 2008). The division of Europe in water poor and water rich areas that showed up in the meta-analysis of Pilot Area data was also acknowledged in the Pan-European panel (PEP). As chapter 3 showed, storylines can be compared as well. However, this is in general a more time consuming effort than comparing FCMs as storylines are often vaguer and the analyser has to identify the issues himself.

FCM

FCMs can be used in multi-scale studies in two ways: they can be compared or aggregated to form a higher scale FCM.

Comparison

Comparison of FCMs is facilitated by the structured nature of FCMs. As was shown in chapter 5 the comparison can be done by comparing concepts, by using several indicators of the complexity of the FCM and by analysing the system dynamics. Comparison of concepts can show differences in focus between different case studies on one scale and between two or more scales. Comparing the system dynamics shown by the FCMs takes more time, but can be especially interesting in cross-scale comparisons. Often on lower scales, external drivers are used that originate from higher scales, such as global warming or European policies. Comparing their influence on local scales with their influence on higher scales can learn us more about the relations between scales and how the higher scale could influence processes on lower scales.

Aggregation

Several FCMs of one scale can be aggregated into a higher scale FCM. In chapter 5 FCMs of the Pilot Areas were aggregated into a regional FCM. According to the regional coordinator the resulting FCM represented the dry Mediterranean river basins well. There was also quite some overlap with the WaterGAP (Alcamo et al., 2003; Döll et al., 2003) model based FCM, while WaterGAP was developed for higher scales and the FCM ‘downscaled’ to the Mediterranean scale.

This showed that aggregation of local FCMs can help to up-scale the results. Because of scale dependencies, it does not automatically lead to a correct system representation. This was also a major advantage of having scientists with a large regional expertise as co-authors on the paper that formed the basis for chapter 5. Issues or feedbacks that play a major role on the local scale might not be important on the higher scale and visa versa. Any up-scaled FCM should therefore be checked by people with knowledge of that scale to deal with scale dependent issues.

There are also other problems with aggregation of FCMs. As FCMs are not spatially explicit, it is hard to aggregated FCMs from rather different areas. If relations are stronger in one FCM than in the other, the relation strength can be averaged, but relations with opposing polarity are more difficult to deal with. If opposing relations are averaged they can cancel out each other, which might not do justice to the real systems. The FCMs from chapter 5 illustrated the dry Mediterranean, if it also had to represent the wetter parts of the Mediterranean countries an average had to be found or two similar FCMs had to be made. Aggregated FCMs are thus likely to show an increasingly coarse picture on higher scales.

Backcasting

In the last chapter, the robust actions from Pilot Areas were compared across regions and with the PEP’s robust elements. The condensed list of actions that were robust across regions facilitated a cross scale comparison. It showed relatively small differences between the pan-European and Pilot Area scale, while a larger difference was expected given the attention to scale dependency in literature (e.g. Veldkamp and Fresco 1996; Cash 2001; Kok et al. 2001; Berkes et al. 2006). This could be a sign that the scales were too tightly coupled, leaving too little freedom on the Pilot Area level. Also the use of the very similar exploratory scenarios in all workshops and the input from regional coordinators as participants in the PEP workshops, could have caused part of these small differences between scales. Including the regional coordinators in the PEP could also have made sure that part of the regional diversity was already included in the PEP scenarios, which made them more relevant for lower scales. Additionally, there were a couple of EU policies, which were already expected to be scale insensitive, such as the Water Framework Directive and Common Agricultural Policy. However, the analysis itself also made it more likely as well that mainly scale independent actions were found. By taking into account only those actions that were both robust across exploratory scenarios and across regions most local diversity was taken out. If one is more interested in the differences between scales, it could have been better to look at all robust actions, including those that were not robust across regions. This would likely show much more scale dependent issues.

7.2.3. Scenario quality indicators

The last research question focussed on the quality of scenarios. In chapter 4 quality criteria were used to study the added values of different toolboxes and their influence on the quality of scenarios. It became clear that these criteria gave a first idea of what scenarios should entail in order to be of good quality, but that they were too vague to be measured effectively. These criteria introduced by Alcamo and Heinrich are, however, not the only scenario quality criteria that have been developed. In this thesis, for instance, structure was added as criterion. A further literature study showed a diversity of criteria. Mietzner and Reger (2005) give a good overview of many of these criteria. Based on their work and other literature, I derived a set of six overall criteria: relevance, credibility, legitimacy, creativity, clarity/transparency and structure. Clarity was added as it shows the need for good communication and a clear and transparent two way flow of information. This criterion also links to the use of boundary objects, which could increase clarity. Although several authors used different criteria sets, most of them could be related to these six criteria. For each of the six criteria descriptions or related criteria found in the literature are included in Table 7.1. This review did not aim to cover all the work on scenario criteria, but is intended to serve as first step to a better defined concept of what ‘good‘ scenarios are.

Relevance

Relevance: Being closely connected or appropriate to the matter in hand (Website Oxford Dictionary, 2011).

Scenarios are deemed to be relevant if they address the concerns and needs of users (Alcamo and Henrichs, 2008; Hulme and Dessai, 2008; Vervoort et al., 2010), take the local situation into account (Mitchell et al., 2006), connect to current or future decision, policy, and scientific processes and challenges (Xiang and Clarke, 2003; Mitchell et al.,

2006), and bring new insights (Wilson, 1999; Alcamo and Henrichs, 2008).
Decision makers are mentioned specifically by several authors. Scenarios should aid current or future decision making processes, for instance, by widening the scope of alternatives considered (Xiang and Clarke, 2003). This shows the importance of the bridge to decision support scenarios.
As divergent parties are involved in scenario development, it is possible that an increase in relevance for one group can lead to a decrease in relevance for another group (Hulme and Dessai, 2008). Relevance should thus be tested under all stakeholders and end users, including scientists themselves.

Credibility

> *Credibility: The quality of being trusted and believed in; the quality of being convincing or believable (Website Oxford Dictionary, 2011).*

According to many authors scenarios can only be credible if they are plausible and internally consistent (e.g. Schoemaker, 1993; Wilson, 1999; Vervoort et al., 2010). Credibility depends not only on the content, but also on the source and the way it is communicated (Schoemaker, 1993). Both the process and the resulting products should be credible (Alcamo and Henrichs, 2008). Mitchell et al (2006) state that results are only credible if they are unbiased and includes alternative knowledge sources, which also links to legitimacy. Like relevance, credibility can be different for different communities, for instance because not all communities might trust the same sources. Importantly, scientific credibility can differ from credibility for policy makers.

Legitimacy

> Legimitacy: Make lawful or justify / conformity to the law or to rules
> Ability to be defended with logic or justification; validity (Website Oxford Dictionary, 2011).

Scenarios should be unbiased and avoid a promoting a certain set of ideas and values (Mitchell et al., 2006; Alcamo and Henrichs, 2008). Therefore it is important that a wide range of stakeholders, experts and policy makers is involved in the process (Alcamo and Henrichs, 2008). Both the process and the results should be perceived as 'fair' (Mitchell et al., 2006). Often, only the satisfaction of participants with the process and results is studied, but end users and other stakeholders should also be included to get a true sense of the scenarios' legitimacy. Some studies have used a chart wheel to map the diversity of stakeholders and their level of attendance (e.g., Kaljonen et al., submitted). This seems a good method to map the diversity of stakeholders involved, which is an important indicator for the level of legitimacy.

Creativity

> Creativity: The use of imagination or original ideas to create something; inventiveness (Website Oxford Dictionary, 2011).

Scenarios should be creative in order to challenge mental models and perceptions of the future (e.g. Wilson, 1999; Xiang and Clarke, 2003; Alcamo and Henrichs, 2008). Therefore scenarios should cover really different futures (Heinecke and Schwager, 1995). According to Schoemaker (1993), non-desirable futures should also be included to overcome the availability bias.

In the second chapter three indicators for creativity were used:

- Length of storylines,
- Percentage of new ideas compared to description of present,
- Agreement with statements that scenarios brought up fresh ideas (that were new to all).

In literature on creativity, diverse thinking is mentioned as a main component of creativity (e.g. Guilford, 1956; Baer, 1997; Silvia et al., 2009). Other important aspects include novelty and transformation capability (e.g. Jackson and Messick, 1965). Especially these two elements link to the descriptions of creativity that are given in scenario literature. This literature could be used to develop better indicators for creativity.

Clarity

Clarity: The quality of being clear, in particular:
- the quality of being coherent and intelligible
- the quality of being easy to see or hear
- the quality of being certain or definite
- the quality of transparency or purity

(Website Oxford Dictionary, 2011).

Scenarios should be understandable for the reader (Heinecke and Schwager, 1995): clarity and transparency are important to achieve this. To achieve clarity, not only the storylines should be written in a clear way, but also underlying assumptions, data, methods and models should be explained clearly (Mitchell et al., 2006; Alcamo and Henrichs, 2008). A lack of clarity and transparency in the IPCC lead, for many people, to a lack of trust and decrease in credibility of their results. Vervoort (2010) highlight the importance of using tools that enhance the communicative clarity and engagement of scenarios. Clarity and transparency are also issues that are highlighted in much literature on participation (e.g. van de Kerkhof and Wieczorek, 2005; Stirling, 2008; De Stefano, 2010).

Structure

Structure: The arrangement of and relations between the parts or elements of something complex; Construct or arrange according to a plan; give a pattern or organization to. (Website Oxford Dictionary, 2011).

Structure was added as extra criterion in the third chapter. Structure is hard to grasp but links to aspects like the number of rules, internal consistency and explicitness. Stakeholders should get a better idea of how the different parts of the problem are related. Vervoort (2010) included aspects that link to structure when he states that scenarios should be able to capture Complex Adaptive Systems. He uses criteria such as showing systems connectedness, feedbacks and transferability of methods to other scenario exercises and contexts.

It is crucial to understand that all six criteria bear relevance both for the process and the products. Often there is a relation between product and process. Workshops, for instance, become more relevant to stakeholders (process) if there is a feedback of information (products). In the second Pilot Area workshop in SCENES no new tools were used. Although the stakeholders could not learn new tools, they did learn from the new information they got in the form of quantified scenarios, or information from other Pilot Areas and regional and PEP information. In one workshop there were no quantified scenarios and only limited information from other Pilot Areas available, which made the workshop too much a rehearsal of the first workshop. This workshop got clearly lower scores for stakeholder satisfaction. Other relations between process and results are for instance the relation that creative tools lead to more creative products (see third chapter). A lack of credibility of tools used in the process is also likely to lead to a lack of credibility of the products.
There are also relations between the different criteria. Sometimes they can enforce each other (for instance by increasing the legitimacy it becomes more likely that the scenarios are deemed credibly and relevant by more communities) other times they can hamper each other (using complicated models to increase credibility can limit clarity).
Although several authors have addressed these or similar criteria, there is little to no literature on how they can be actually measured in scenarios. Current literature on the criteria can serve as starting point for indicators. A more or less standardised set of indicators and questionnaires would make it easier to compare different scenario projects and methodologies. Scientists from the different scenario fields should be included in the development of these indicators. As the criteria link to important issues on participation, boundary objects, social learning and mental models, scientists from these fields should also be asked to contribute.

Table 7.1; quality criteria for scenarios and description for them from literature.

	descriptions in literature
Relevance	– Address the concerns and needs of users? [1]
	– Suitability of scenarios for users needs [7]
	– Connect to local conditions and concerns [4, 10]
	– Bring in local knowledge and concerns [4]
	– Link to ongoing visioning, planning and implementation processes [4,5]
	– Relevance in different planning processes [2]
	– Produce information with an eye toward the decisions that need to be taken [4]
	– Link to issues that decision makers work on [4]
	– Relevant to current scientific questions and/or policy decisions? [1]
	– Cohesion with object of investigation [2]
	– Broaden the understanding of experts, policymakers, general public? [1]
	– Contribute to new insights into (future) problems, to aid decision-making [3]
Credibility	– Plausibility [1,2,3,10]
	– Technical credibility [4]
	– Source, content and channel credibility [9]
	– Was development process scientifically rigorous? [1]
	– Were the models used credible? [1]

(Table 7.1; continued)

Credibility (*continued)*	– Local credibility (does it fit local context) [4] – (Internally) Consistent[3,5,9] – Trend, outcome and stakeholder consistency [9] – Coherence [2,10] – Constitution and relationship of scenarios among themselves [2] – Completeness [2] – Flawlessness (no invalid assumptions) [2] – Information content (precision, universality, utility) [2] – Content compatible with current understanding of the world? [1] – Future developments recognisable in the present? [1] – Is it unbiased? [4] – Availability of alternative knowledge sources [4]
Legitimacy	– Perception of process and results as 'fair' [4] – Messages politically acceptable and perceived to be fair? [1] – Is it unbiased? [4] – Avoid promoting a particular set of beliefs or values[1] – Consider values, concerns and perspectives of stakeholders [4,10] – Wide enough range of stakeholders and/or experts involved? [1] – Involve all relevant stakeholders (these affected by issue) [4] – Are users satisfied with the process used to develop and communicate scenarios? [1]
Creativity	– Do scenarios provoke new, creative thinking? [1,6] – Are scenario results thought-provoking and surprising? [1,5,10] – Do they challenge current views about the future? [1,3] – Do they inform about the implications of uncertainty? [1] – Differentiation: not simple variations on the same theme [2,3] – Stretching function (widen range of alternatives considered)[5] – Overcome availability bias [9]
Clarity / transparency	Transparency on output and process [1,2,8] Assumptions transparent and well documented? [1] Understandable for the reader [2] Understanding underlying data, methods and models [4] Avoid misunderstandings [2] Suitability [2] Recognise credentials for the scenario work of participants? [1] Cognitive ergonomics [10] Sensorially direct communication [10]
Structure	Number of rules[6] Internal consistency[6] Explicitness[6] Understanding the methods and models used[4] Show systems connectedness and feedbacks [10] Method should be transferrable to other scenario exercises and contexts [10]

7.3. Synthesis

In the introduction (Chapter 1) different types of scenarios were introduced. It showed the need for building bridges between qualitative and quantitative exploratory scenarios, and qualitative exploratory and decision support scenarios. These bridges will also bring the different related communities together.

The second chapter described the participatory scenario development framework that should make these bridges possible. This framework has been used in all Pilot Area and regional workshops of SCENES. It offers a toolbox that includes qualitative, creative tools, as well as semi-quantitative, structured tools. It starts with mapping diversity in opinions and perceptions among stakeholders with the use of creative tools. It then uses structuring tools to get results that are more structured and consensus oriented, which is needed to link to quantitative models. This process was illustrated by a figure that used two axes; creativity versus structure and diversity versus consensus (figure 2.8). Quantitative models are placed in the quadrant structure and consensus, while qualitative scenario development starts in the creativity and diversity quadrant. FCM was the tool that got most attention as the characteristics of FCMs show that they can form a common base between storylines and models (see table 7.2). Furthermore, FCMs combine the flexibility needed in participatory scenario development with structure needed to link to the models. The second chapter further hypothesised how FCMs can be used in the communication between stakeholders and modellers, which formed the basis for the fourth chapter.

Table 7.2; some characteristics of storylines, FCMs and quantitative models.

Storylines	**Semi-quantitative conceptual models**	**Quantitative models**
– qualitative – capture future worlds in stories, ideas and visions – all aspects important to stakeholders can be included – no rules for validation on current system – above leads to large flexibility – social effects included – no fixed set of assumptions – not always internally coherent – no clear system understanding – no data needed	– semi-quantitative – capture future system in description of concepts and relations between them – in principle, all aspects can be included – no clear rules for validation on current system – above leads to large flexibility – social effects can be included – explicit on assumptions – internally coherent – system understanding – no data needed	– quantitative – capture future system in numbers and rules on systems' behaviour – inclusion of aspects depends on data availability – validated on current system – leads to limited flexibility – hard to include social effects – fixed set of assumptions – internally coherent – system understanding – need for data

In the axes figure presented in the second chapter (figure 2.8), creativity and structure are opposite ends of the same axis, what implies that adding structure lowers creativity. The third chapter studied this relation between creativity and structure; does the use of structuring tools lower the creativity of storylines? The type of tool used (creative or structuring), did have the largest (and significant) influence on both process and content of the workshop. The creativity of storylines that were developed with creative tools was significantly higher than storylines developed with structuring tools. Contrary to expectations, creativity was not significantly affected by the length of the workshop. The third chapter showed that FCMs can successfully be used in workshops and that they are flexible enough to maintain a part of the creativity. It further showed that an added value of a toolbox is that it can include a mix of creative and structured tools, which can make sure that both structure and creativity are maintained.

The fourth chapter discussed three more added values of using a toolbox; (1) toolboxes are more adaptable to specific case study conditions, (2) can adapt to a broad range of stakeholders and (3) increase the comparability across case studies and scales. A mix of different types of tools increased the adaptability to stakeholders, while the size of the toolbox had ambiguous effects on the stakeholders' appreciation of the workshop and developed scenarios. Contrary to what we expected, the length of the workshops did not influence the stakeholders' appreciation of the workshop and results. The influence of the toolbox on the scenario quality criteria was also studied. Results showed that a toolbox with different types of tools is likely to increase the quality of scenarios, also because it makes the building of bridges between different communities possible. It became clear that the criteria can be used to give an overall indication of the quality of scenario processes, but also that they need better indicators to be able to use them better.

Chapter 5 tested the last stretch of the bridge: can FCMs be used to link stakeholder output to mathematical models? Results show that FCMs can form a common base to compare stakeholder products with model results. Given these results and the good experiences with using FCMs with stakeholders, FMCs can also be used in the communication between stakeholders and modeller, which can lead to learning processes and a better tuning between qualitative and quantitative scenarios. However, there are a number of limitations in FCMs that make it difficult to directly use FCM output as input for the model. Several recommendations have been done to deal with these difficulties.

The sixth chapter studied the bridge between qualitative exploratory and decision support scenarios. By combining exploratory scenarios and backcasts (a decision support scenario type) actions were designed to reach the same desired objective in the context of each exploratory scenario. A large and diverse overview of possible actions was obtained. This long list could be structured by searching for robustness across futures, regions, objectives and scales. This approach increases the relevance of the previously developed scenarios for policy and decision makers.

Boundary objects, scales and scenario quality indicators
The concepts of boundary objects, scales and the scenario quality indicators are interlinked, as will be shown below. They also link back to the previous chapters. In the first chapter it was hypothesised how FCMs can be used in the communication between stakeholders and modellers. Chapter 5 showed that FCMs can indeed be used to compare system perspectives of modellers and stakeholders. In other words, it showed that FCMs can be used as boundary object. Backcasting and robust actions can function as boundary objects between stakeholders and decision makers.
FCMs and backcasting can also be useful in cross-scale comparisons and up-scaling. It therefore seems likely that they can also be used as boundary objects between scales. Aggregated FCMs could be used to show differences in system perceptions between stakeholders on lower and higher scales. A search for robustness across case studies can show the common aspects on one scale, which can be compared to robust actions at higher scales. The results of such comparison can be used to discuss relations between scales. Multi-scale models (e.g. CLUE, Veldkamp and Fresco, 1996) could be used by modellers to study differences between scales. This use of FCMs and robust actions as boundary objects between communities and between scales is illustrated in figure 7.1.

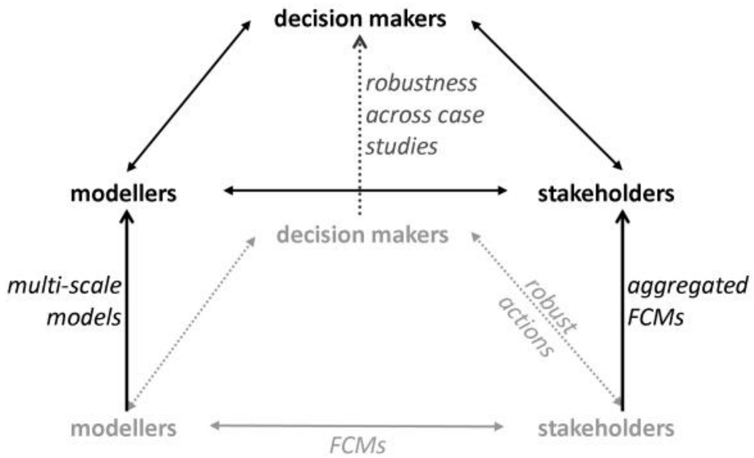

Figure 7.1; the role of boundary objects (shown in Italics) in connecting different communities on one scale, and connecting similar communities on different scales (vertical arrows).

It seems that structure is important in making cross-scale comparisons and up-scaling possible. Structuring tools have great potential as more structured output is easier to compare. Comparing all storylines from all Pilot Areas, for instance, is more difficult than comparing the concepts of an FCM. The same holds for timetrends and spidergrams. Semi-quantitative information can further aid the comparison. Chapter 5 showed how FCMs can be combined to form a higher scale FCM. Also the robustness check across regions provided extra structure, which made the output easier to use for cross-scale comparison. In previous projects extra structure was also used to facilitate up-scaling and cross-scale comparison. In the project VISIONS, for instance, this was done by presenting participants in all workshops with the same list of factors, sectors and actors that they should address (Rotmans et al., 2000). However, there is a chance that this approach forces participants to focus on aspects that are less relevant to them. A toolbox consisting of structured and creative tools does leave room for creativity, while also facilitating comparison (see Chapter 4). FCMs and backcasting provide structured output while leaving participants the freedom to include those aspects that they find important.

Boundary objects and the inclusion of multiple scales in scenario development also affect the quality of scenarios. The use of boundary objects can increase the credibility, legitimacy and relevance of scenarios. Credibility increases when, with the use of boundary objects, different communities understand each other better, which leads to better links between the different scenario types and the inclusion of different knowledge types. However, one can also envision a situation in which the use of boundary objects leads to a lower credibility. If beforehand stakeholders have the idea that models provide a certain scientific and objective truth, they might become disappointed when they learn that they don't agree with the model assumptions. In that case the model no longer provide them with an objective truth, but a subjective 'wrong'. This can even widen the boundary between the stakeholders and modellers. The process of opening up the black box of the model should therefore be facilitated carefully. It is important that modellers are willing to explain the assumptions of the model, and that they are flexible enough to change them to better fit stakeholders perceptions. A boundary object alone cannot bridge the gap; both parties should be willing to learn from each other as well.

Legitimacy is increased by increasing the intensity of participation, which is made possible by the right boundary objects. Up to now stakeholder involvement in the development of quantitative scenarios is often limited. The use of FCMs could increase the level of participation. Increasing the level of participation can also increase the relevance. Relevance is further increased by including decision makers in the development of decision support scenarios.

Cross- and multi-scale scenario development can make sure that scenarios become more legitimate, credible and relevant for a larger group of stakeholders and end-users. Multi-scale approaches increase legitimacy because more diverse stakeholders are involved, spread over different scales. They can make sure that the scenarios become relevant for different scales. As processes of complex issues play on different scales and there are relations between those scales (e.g. Biggs et al., 2007), scenarios become more credible when they can include these cross-scale processes and relations.

7.3.1. Participatory scenario development framework revisited

Chapter 2 presented the participatory scenario development framework. This framework was widely used in all Pilot Area and regional workshops and received positive feedback from the organisers.

During the start of my PhD I noticed the lack of clear descriptions on how participatory scenario workshops should be held. In this section I will therefore revisit the framework. Feedback from the stakeholders, who were asked to fill in a questionnaire after each workshop and reports from the organisers (see Kämäri, 2008; Kämäri J. (ed.), 2008; Kämäri J. (ed.), 2010) were studied. This, combined with the knowledge gained in the last four years, will lead to an overview of strong and weak points of the framework, which will be used in the next section to give recommendations for future use of the framework. Although there were no data available from all Pilot Areas and all workshops, some general conclusions could be drawn.

Overall, the vast majority of participants (85-90%) was satisfied with the produced scenarios and the process that was used to develop them. This resulted in high grades of all three workshops (on a scale of 1-5; WS1 4.04, WS2 4.05, WS3 4.09). Also the organisers were satisfied with the proposed methodology.
The workshop organisers indicated that they would give a slightly higher scores for the second as the first workshop (on average they gave a score of 4.1 for the second workshop). Only the Lower Don gave a lower score for the second workshop. They also stated that participants did not like the second workshop that much. The main reason given by the organisers was that in the second workshop no new methodologies were used. Some other organisers also said that participants did find it a pity that they could not learn new tools. However, participants could learn a lot about the information from other Pilot Areas and regional and pan-European information. In many Pilot Areas also model results were available. This made it possible to increase the quality of results. In the Lower Don there was, however, little information given back to the participants, possibly because there was too little time with 4 tools to be dealt with in one day. Participants therefore felt that there was little to learn for them. Organisers were not asked to give a score for the third workshop, but general feedback was good.

After each workshop, participants were asked to react on the same 10 statements (see table 7.3). Participants could agree completely (score 5), disagree completely (score 1) or give scores in between. Overall, all statements scored a 3.7 or higher, which is generally considered as satisfactory.

As with the overall scores of the workshops, scores were getting a bit better every time but in general differences were small.
The second workshop aimed to make the link with the quantitative scenarios. After this workshops participants agreed most with the statement that "Participating in the workshop helped me to build a more comprehensive understanding of the area". This can be seen as a sign that indeed the link with quantitative approaches can help to increase structure and credibility. Given the different focuses of the different workshops, however, I hoped to see larger differences. The second workshop scored higher than the first on the statements 5 and 6 (on raising fresh ideas), which is surprising as in the first workshop most use was made of creative tools, while the second workshop there was less room for real creative sessions. Possibly, the inclusion of new information in the second workshop led to an increase in the creativity.

Table 7.3; Average score on the ten statement for the three workshops.

statements	**score by workshop**		
	WS1	**WS2**	**WS3**
1. The workshop increased understanding between different views and interests	4.20	4.39	4.39
2. succeeded in taking advantage of the different types of knowledge and expertise of the participants	4.32	4.43	4.52
3. During the workshop I learned new things about interests and perceptions of other participants	4.25	4.26	4.33
4. Participating in the workshop helped me to build a more comprehensive understanding of the XX area	3.82	4.25	4.09
5. Other participants brought into discussions fresh ideas	3.96	4.27	4.28
6. working together with different participants raised fresh ideas that were new to all participants	3.70	3.76	4.05
7. Working with different scenarios helped me in envisioning futures	4.00	4.14	n.a.
8. My ideas were included in the scenario outcomes	4.11	4.20	4.14
9. The scenario-making process as a whole is useful for river basin management planning	4.20	4.11	4.24
10. The produced scenarios/backcastings are usable for river basin management planning	3.97	3.84	3.87
average	***4.05***	***4.17***	***4.21***

The third workshop aimed to link the future scenarios to the present. Stakeholders agreed that it did so. This should have increased the relevance, but the statements that can be linked to relevance (statement 9 and 10) did not score much higher after the third workshop than after the other workshops. All in all it seems that stakeholders in general were satisfied, but that the expected differences between workshops were not measurable in the questionnaires' results.

After the third workshop the participants were given an extra long questionnaire. Participants were asked to react on a number of statements on the whole series of workshops. All statements scored higher than 3.7.The methods used in the workshops helped participants to see water management in a new way (3.9) and understand the policy actions needed (4.1). The methods helped to both allow surprising issues to surface (3.8), as well as to find novel linkages between factors (4.0). This shows that the framework can increase system thinking and structure while also allowing for creativity. The use of the long time horizons of the scenarios helped participants to assess the problems faced in the area (4.1). Also the cross-scale comparison contributed to this (3.9). Developing backcasts within exploratory scenarios managed to link the future scenarios to the present (4.0).

Based on these questionnaires, the reports of organisers, the previous chapters and my own experiences the following positive and negative points can be identified for the participatory framework.

Positive points of the participatory framework

- Uses a flexible toolbox that can be adapted to local conditions.
- Stakeholders and organisers were satisfied with the given participatory framework, and only small adaptations were made.
- Can form a bridge between qualitative and quantitative scenario with structuring tools and FCM in particular.
- Using a toolbox made it possible to strive for more structure, while also giving enough attention to creativity.
- Using different tools made it possible to get input from different types of stakeholders who could bring in different types of knowledge and expertise.
- Combines exploratory scenarios with backcasting, which shows how scenarios can be used during decision making processes and therefore increase their relevance.
- Structure in the form of structuring tools and robustness check facilitates cross-scale comparisons and up-scaling.
- Includes tools that can function as boundary object between stakeholder, modellers and decision makers.

Negative aspects of the participatory framework

- Long time between workshops due to the feedbacks needed between scales and for quantification.
- Too many tools (needed to cover the different criteria for scenarios and address different types of stakeholders) can make the overall process less clear. Explain clearly how tools fit in the overall process, especially when using more than three tools.
- Need for enough new input/tools in the second workshop. If no local model is available, other ways to keep it interesting for participants have to be found.
- FCMs are difficult for some participants, and this might be increasingly so for ‘upgraded’ FCMs. Therefore organisers should know well how to work with FCMs, to guide the participants trough the process and explain the results. In workshops were no direct link will be made to a quantitative model normal conceptual models could be used if FCMs are too difficult for the participants.
- Framework focuses on workshops, while there are also many other participation modes possible (questionnaires, online discussions, online modelling, etc.) that could be used more.
- Lack of quantification and relative vagueness of actions from the backcasting disappointed part of the participants. An extra round of workshops could make the backcasts more relevant, especially if in that extra round quantified results of the backcasts are available.

7.4. Recommendations

7.4.1. Updating the participatory scenario development framework

Following the strong and weak points of the scenario development framework used in this thesis the following recommendations can be done:

First round of workshops

- In one day workshops, use questionnaires to derive a list of concepts for the FCMs before the workshop.
- Make sure that there is at least room for short creative sessions to increase the creativity of the results.
- Develop Future FCMs on basis of the FCMs developed for the present and brainstorm sessions on the future of the Pilot Area.
- Start workshops with a creativity session, to get people into a creative mood. This can be combined with introducing the participants.
- In longer workshops combine creative tools like collages with FCMs of the Future to develop scenarios. E.g. create collages, to show what the higher scale scenarios mean for the case study. After a first free phase, the participants should make sure that also the main concepts from the FCMs are addressed. Future FCMs can then be developed on basis of the FCMs of the present and the collage.

Second round of workshops

- Make sure that there is enough new input or tools in the second workshop, to make it interesting enough for the participants.
- Present quantitative scenarios and explain the model and its assumptions with a FCM. Modellers should be open for possible changes.
- Compare Future FCMs (that form a representation of the storylines) with model assumptions on scenarios.

Third round of workshops

- Include more policy and decision makers and experts that can help to check the feasibility of the actions.
- Create a clearer link with current decision making policies.
- Add a round of quantification of the results. This would make a fourth workshop necessary in which the quantified results are presented and discussed. Assumptions made in the quantification phase need to be made explicit. Possibly, FCMs can be used to explain the model and assumptions used.

7.4.2. Quantification of backcasting results

The backcasting in SCENES was purely qualitative. As with qualitative scenarios this has it advantages, e.g. as there is no need for underlying hard data. However, quite some participants mentioned that they had problems to check to feasibility of actions. They wanted some sort of reality check. Quantification would help them to test if actions are realistic. Therefore it would be good to show the impact of developed actions, like qualitative scenarios are quantified to show the impact of changes. The need for quantification will depend on the knowledge and expertise present in the workshops.

Economists could study how much actions would costs, engineers provide data on how long it typically would take to build infrastructure and politicians how long it would take to get acts developed and implemented.

Most backcasting exercises have been technical oriented, and often lead to quantitative results. Robinson has been working on participatory quantitative backcasting (e.g. Robinson, 1988; Robinson, 2003) in which participants can tune simple models to reach their desired future. Such a purely quantitative approach limits the creativity of stakeholders. Participants can try out different policies by manipulating model input, but there is little or no possibility for them to change model assumptions or think outside the options given by the model.

Having the quantification done after the workshop would make sure that the creativity is not hindered by in the box thinking. It would, however, make a second backcasting workshop necessary in which the quantitative results are shared with the stakeholders, who can then refine the backcasts.

7.4.3. Linking qualitative and quantitative scenarios

In chapter 5 a number of options have been given to make the link with models stronger, by upgrading FCMs or combining them with other tools. These options should be tested. What the optimal solution is will depend on the different contexts; how much resources are available, how much time can be allocated to the development of FCMs, and how experienced are the moderators with FCMs? When there is enough time and expertise available, FCMS could be adapted to address if-then-else and non-linear relations. If a new model is being developed, stakeholders could even be included via participatory model development. When expertise and resources are limited, approaches like Fuzzy Sets seem more fitting. One should not forget that FCMs are best used as part of a larger toolbox, which should be adapted to the specific situation and questions asked.

The feedback of the model based FCM to stakeholders was not tested here. The previous chapters have shown how FCMs can be used in participatory workshops as discussion tool among the participants and that modellers can develop a FCM that represents the model system description. It therefore seems likely that these FCMs could also be used in workshops to explain the model to the stakeholders, but this should be tested in actual workshops. Prerequisite is that the stakeholders should learn to work with FCMs first.

7.4.4. Better indicators for scenario quality

In section 7.2.3 an updated set of criteria for assessing the quality of scenarios is presented, including an overview of how they are described in literature. In order to better define these criteria and make them measurable, a set of indicators for these criteria should be developed. These indicators should be developed in cooperation with other scientific fields. For a criterion like creativity, for instance, it is important to cooperate with fields like psychology where work is done on the development of creativity tests for people. Social scientist working on participation and boundary object can be asked to cooperate on criteria like clarity and legitimacy. The bridges that need to be built with neighbouring scientific fields can lead to cross-fertilisation and help to bring scenario studies further outside the domain of arts into the domain of science. The resulting set of indicators should be legitimate for a large range of scientists in order to be used in many scenario projects, which would help to overcome the problems of small data sizes and make larger comparative studies possible. This can lead to a better understanding of the processes that play a role in workshops and their effects on the results of the workshops.

7.4.5. Overcoming some disadvantages of building bridges

Although building bridges has proved to be important, building too many bridges in one project is problematic. After all, every extra bridge that is made takes time, which leads to long time delays between workshops. In SCENES Pilot Area information had to be up-scaled to the PEP scale, via the regions. Qualitative scenario had to be quantified and models had to be run. This caused workshops to be six months to a year apart. It is difficult for stakeholders to maintain the knowledge build in the previous workshop. Long time delays are also likely to lower the stakeholders feeling of ownership, and increases the likelihood of changes in stakeholder representation in the workshops. Also as it is difficult to include all bridges in one workshop (and in one project) choices have to be made.

Even with one bridge it is likely that long time delays cannot be avoided, therefore other ways of maintaining knowledge, ownership and interested should be found. More use should be made of novel approaches that include new media. In SCENES online discussions were held among the PEP participants on specific questions in between workshops. One could also make more use of groups on social media like Facebook, LinkedIn and ResearchGate. This way participants can be involved more in-between the workshops, and immediately be asked to react when questions arise. It also makes it possible to include larger audiences, by opening discussion up for people who did not participate in the workshops. This can increase the legitimacy of the scenarios. Scenarios can be presented in attractive ways such as short movies or powerpoint collages, fictional newsfeeds and blogs or games (see for instance Vervoort (in prep). for innovative visual communication techniques).

Another problem of building bridges is that different scientific disciplines need to work together, which is not always easy. Different fields often have their own vocabulary and scientific methods. This can give communication problems, which was also noted in SCENES. Social scientists had problems in explaining their methodology of analyzing the workshop process to the more technical oriented scientists in the project. Boundary objects need to be found that can help to overcome these communication problems in multi-disciplinary projects, so that the activities can be better geared to one another. Projects should start with developing a shared syntax, concepts and conceptual models that can serve as boundary objects.

7.5. Conclusions

In the introduction three research questions were formulated. With the knowledge gained from this thesis we can answer these questions.

How can the gaps be bridged between qualitative and quantitative exploratory scenarios, and between exploratory and decision support scenarios?

Adding structure helped to get results that are easier to interpret. Especially the use of a toolbox of creative and structuring tools, including FCMs, was successful in bridging the

gap between qualitative and quantitative scenarios. FCMs were successfully used in all participatory workshops on local and regional scale. They added extra structure to participatory scenario development processes by introducing system thinking and result in structured output. At the same time they can maintain a large part of the creativity needed. FCMs can make the quantification of storylines easier, as they make the assumptions behind them explicit and can illustrate expected changes. However, the direct link with mathematical models proved to be difficult. Given the good experiences with the tool, future research should test how this link can be further enhanced.
Backcasting within exploratory scenarios proved a useful new approach to bridge the gap between exploratory and decision support scenarios. The exploratory scenarios influenced the actions and strategies developed. The possibility to check the resulting actions for robustness showed the need for exploratory scenarios. The approach should be tested further and be refined. Quantification of the results can show impacts, which can make them more relevant. The challenge is further to include more decision makers and link to ongoing policy processes.

How can these bridges be used to contribute to the communication between the different communities?

FCMs can be used as communication tool between stakeholders and modelers. Robust actions can form a powerful message to decision makers. Both tools can function as boundary objects between the different communities. Such a shared tool that both parties understand and find credible, forms the shared language that they can use to exchange ideas. FCMs have proven to be useable by stakeholders and modellers. It is flexible enough to incorporate a large diversity of issues, and can be used to explain quantitative models. Robust actions can be compared to (policy) actions that have been developed by decision makers. By having a shared syntax communities can communicate better and share their knowledge. This can lead to cross fertilisation and social learning.
Structure and boundary objects are not only important for bridging different scenario types and communities, but also for connecting different scales. The approaches for developing both bridges therefore also seem to be able to form a third bridge: between different scales. This bridge needs more testing.

What is the effect of the bridges on the quality of the resulting scenarios?

The bridge between qualitative and quantitative scenarios increases the legitimacy, creativity, structure and credibility of the scenarios. The use of FCMs as boundary objects can further increase the clarity of the assumptions of stakeholders and models.
The bridge between exploratory and decision support scenarios increases the creativity of the resulting actions and the relevance of the scenario process.
When these approaches are used to link scales, they can further enhance the credibility, relevance and legitimacy of the scenarios. Structure is important to successfully conduct cross-scale comparisons and up-scaling.
Indicators should be developed for the six scenario quality criteria to make a more precise analysis possible. This will make comparisons possible between the approaches taken here and other approaches. The indicators should be developed in cooperation with the different scenario fields (qualitative, quantitative, decision support, etc.) and scientists from related field such as psychology and participation research.

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Appendix 1; Main focus points of the workshops

In the first round of workshops clusters were created in a card session, to map the most important issues in each Pilot Area. These clusters have been used as boxes in the FCMs of the present. They were also analysed on their content by categorising them into nine categories (see also van Vliet, 2008).

Table A1.1; Percentages of cluster under each category by Pilot Area.

Pilot Area	Peipsi	Narew	Candelaro	Guadiana	Crimea	Lower Don	Danube delta
water quality	13.3	18.8	4.2	2.4	12.5	27.3	16
water quantity	6.7	18.8	25	19.5	12.5	9.1	0
management	6.7	18.8	12.5	12.2	37.5	18.2	4
government	20	12.5	8.3	9.8	12.5	9.1	12
non-water sectors	20	12.5	4.2	17.1	6.3	0	28
social aspects	13.3	0	16.7	12.2	6.3	18.2	4
environmental aspects	6.7	12.5	8.3	4.9	6.3	9.1	16
economical aspects	6.7	0	8.3	9.8	0	0	0
other	6.7	6.3	12.5	12.2	6.3	9.1	20
number of issues [1)]	15	16	24	41	16	11	25

[1)] number of issues identified includes doubles (that were placed under two categories)

Table 2 gives an overview of the desired objectives used in during the backcasting workshops in each Pilot Area. Most Pilot Areas used one desired objective, but in the Tisza two objectives were used for each of the four scenarios. Danube Delta used several objectives within the Sustainability First scenario.

The desired objectives were diverse; none of the objectives was the same. Most of Pilot Areas used an objective on water quality, three objectives were on water quantity and three Pilot Areas included both water quality and quantity aspect in the same objective. In the Mediterranean region the focus was mainly on water quantity, whereas in the Baltic region the focus was mainly on water quality. In the Black Sea region both water quality and quantity aspects were seen as important. Due to time limitations, however, the Lower Don did the backcasting only for water quality.

Table A1.2; overview of the desired objectives per Pilot Area, clustered by region.

Pilot Area	desired objective	water quality / quantity	notes
Baltic regional panel	Good water status by 2050 for all freshwaters	both	further specified: both good ecological status and sufficient water quantity
Narew	a good water status according to EU Water Framework	quality	
Peipsi	stabilize anthropogenic eutrophication in the lake and to decrease the average total P concentration to the level below 0.04 mg/l	quality	
Tisza	The water balance of the Hungarian section of the Tisza is not negative	quantity	two objectives for each of the four scenarios
	Pollution reaching the Hungarian Tisza section is minimal	quality	
Danube Delta	Sustainability future – several water quality issues	quality	7 objectives for 1 scenario (SuF)
Crimea	efficient water use for food production	both	includes both quality and quantity aspects
Lower Don	water quality is in compliance with certain standards	quality	second objective on water quantity was not used due to time limitations
Candelaro	adequate water availability for the future in agriculture	quantity	
Guadiana	Good status of water ecosystems, compatible with socio-economic viability	both	includes both quality and quantity aspects
Seyhan	realization of sustainable irrigation	quantity	

Appendix 2; Overview of stakeholder types and sectors

Table A2.1; Number of participants and percentages of stakeholder types per workshop.

				stakeholder type								
							administration					
case study	**round**	**number of participants**	**number of questionnaires**	**association**	**consultant**	**private sector**	**local**	**regional**	**national**	**research/ education**	**other**	**no answer**
Lake Peipsi	1	31										
	2	21	17									
	3	17	10		10%			30%	30%		30%	
Narew	1	18	16	6%		6%		25%	13%	25%	25%	
	2	16	15	7%		7%	6%	20%	20%	20%		20%
	3	15	14			14%	7%	29%	36%	7%	7%	
Baltic regional	1	23	21	19%		19%		10%	19%	29%	5%	
	2	19	16	13%		19%		6%	13%	31%		18%
	3	20	14	14%	21%	7%	7%		50%			
Candelaro	1	30	18	6%		11%	17%	22%	6%	22%	17%	
	2	20	13	23%			8%	31%		8%	15%	
	3	15	14			29%	7%		64%		0%	
Guadiana	1	18	17	13%		31%		13%	13%	31%		
	3	22	n.d.									
Seyhan	1	33	n.d.	30%			26%	17%	22%			5%
	3	22	n.d.									
Crimea	1	28	17	11%				11%	17%	22%	39%	
	2	29	17			6%	25%	41%	6%	24%		
	3	26	15		13%	7%	20%		13%	7%	40%	
Lower Don	1	22	11			8%	8%	8%	46%	23%	8%	
	2	18	n.d.									
	3	21	14				14%	36%	43%		7%	
Danube Delta	1	12	9						44%	56%		
	2	21	21	10%		5%			14%	71%		
	3	19										
Tisza	1		n.d.									
	2	39	n.d.	15%		5%			45%	30%		5%
	3	34	n.d.									
PEP	1	15										
	2	15										
	3	13	13									

n: number of questionnaires filled in.
n.d.: no data.

Table A2.2; Percentage of stakeholders per sector.

			sector						
case study	round	n	fishery	nature protection	water	agriculture	multiple sectors	other	no answer
Lake Peipsi	3	10			60%				40%
Narew	1	16		13%	44%	6%	6%	25%	6%
	2	15	7%	27%	47%	7%		13%	
	3	14		21%	43%		7%	29%	
Baltic regional	1	21		11%	72%	6%			11%
	2	16		13%	69%			19%	
	3	14		7%	64%			21%	7%
Candelaro	1	18		6%	39%	17%	17%	11%	11%
	2	13		8%	38%	23%	15%		15%
	3	14			29%	14%	14%	7%	36%
Guadiana	1	17		13%	62%	25%			
Seyhan	1	n.d.			35%	45%		20%	
Crimea	1	17		18%	71%			12%	
	2	17			15%	65%	20%		
	3	15			73%	13%			13%
Lower Don	1	11	9%	9%	36%	9%		27%	9%
	3	14		14%	43%		7%	21%	14%
Danube Delta	1	9			33%	11%		44%	11%
	2	21	5%	10%	38%	5%	33%	10%	

n: number of questionnaires
n.d.: no data
Workshops for which there was no data available at all are not in this table.

Appendix 3; Overview of creativity results per Pilot Area

Table A3.1; Process results per Pilot Area.

statement	Baltic region	Narew	Crimea	Lower Don	Danube Delta	Guadiana	Seyhan	Candelaro	*average*
1	3.74	4.00	3.54	3.91	3.78	4.13	3.59	3.89	3.82
2	3.94	4.31	3.36	4.36	4.33	3.41	3.65	4.28	3.96
3	3.37	3.88	3.79	4.27	3.44	3.35	3.65	3.83	3.70

Average scores for the question "How much do you agree or disagree with each of the following statement?" per statement per Pilot Area. statement 1. Participating in the workshop helped me to build a more comprehensive understanding of the river basin area statement 2. Other participants brought into discussions fresh ideas statement 3. The fact that we worked together with different participants raised fresh ideas that were new to all participants

Table A3.2; Output results per Pilot Area.

Pilot Area	number of FCM used	percentage of FCM used in storyline [1)]	number of new issues	percentage of new issues in storyline [2)]	average length of storyline [3)]	creativity index
Baltic region	11.0	81%	5.5	34%	19.5	6.5
Narew	6.8	51%	9.3	58%	42.3	24.4
Peipsi	10.0	91%	5.3	34%	19.0	6.5
Danube Delta	6.5	28%	6.3	50%	19.0	9.5
Candelaro	11.0	50%	12.0	52%	20.5	10.7
Guadiana	8.5	43%	12.5	58%	15.5	9.1
Crimea	6.0	46%	8.3	59%	22.5	13.2
Lower Don	6.7	67%	7.7	53%	35.3	18.7

[1)] as a percentage of the total amount of issues in the FCM of the present
[2)] a percentage of the total amount of issues in the storyline
[3)] in lines of text in Trebuchet MS 11 point

Table A3.3; Grades for the workshop per Pilot Area.

	average	**std**
Narew	4.22	0.56
Candelaro	4.06	0.54
Lower Don	4.64	0.50
Danube Delta	4.00	0.50
Guadiana	3.53	0.83
Seyhan	4.00	0.84
Crimea	4.06	0.85
Baltic region	3.86	0.79
average	*4.05*	

How would you grade (from 1-5) this workshop as a whole?
Rating: 1= poor; 2= needs improvement; 3= satisfactory; 4= good; 5= excellent

Appendix 4; Results for Chapter 4 per Pilot Area

Table A4.1; Grade for the whole workshop per Pilot Area.

	average	**std**
Narew	4.22	0.56
Candelaro	4.06	0.54
Lower Don	4.64	0.50
Danube Delta	4.00	0.50
Guadiana	3.53	0.83
Seyhan	4.00	0.84
Crimea	4.06	0.85
Baltic region	3.86	0.79
average	*4.05*	

Question asked: How would you grade (from 1-5) this workshop as a whole?
Rating: 1= poor; 2= needs improvement; 3= satisfactory; 4= good; 5= excellent

Table A4.2; Grade per tool per Pilot Area.

	Narew	**Candelaro**	**Crimea**	**Lower Don**	**Danube Delta**	**Guadiana**	**Seyhan**	**total**
card session	3.88	4.00	3.71	4.82	3.86	3.64	4.24	**4,02**
spidergrams	4.00		4.12	4.64	4.22		4.05	**4,21**
FCMs	3.63	4.12	4.63	4.91	3.22	3.54	4.00	**4,01**
visions	4.21	3.69	4.13	4.73	4.00		3.95	**4,12**
averages	3,93	3,94	4,15	4,78	3,83	3,59	4,06	

Question asked: How would you grade (from 1-5) this tool?
Rating: 1= poor; 2= needs improvement; 3= satisfactory; 4= good; 5= excellent

Table A4.3; satisfaction with scenarios per Pilot Area.

	Narew	**Candelaro**	**Danube Delta**	**Guadiana**	**Seyhan**	**Crimea**	**Baltic region**	***average***	***std***
Yes	88%	94%	89%	81%	100%	82%	71%	*89%*	*0,09*
No	6%	6%	11%	13%	0%	18%	24%	*9%*	*0,08*
blanc	6%	0%	0%	6%	0%	0%	5%	*2%*	*0,03*

Question asked: Are you satisfied with the scenarios that were produced?

Table A4.4; satisfaction with the scenario development process per Pilot Area.

	Narew	**Candelaro**	**Danube Delta**	**Guadiana**	**Seyhan**	**Crimea**	**Baltic region**	***average***	***std***
Yes	81%	94%	100%	88%	95%	88%	71%	*91%*	*0,10*
No	13%	6%	0%	0%	5%	12%	24%	*6%*	*0.08*
blanc	6%	0%	0%	12%	0%	0%	5%	*3%*	*0.05*

Question asked: Are you satisfied with the process by which the scenarios were made?

Table A4.5; scores per statement per Pilot Area.

statement	**Narew**	**Candelaro**	**Crimea**	**Lower Don**	**Danube Delta**	**Guadiana**	**Baltic Region**	**Seyhan**	*avg*
1.	4.56	4.39	4.07	4.91	4.22	4.11	4.16	4.13	*4.32*
2.	3.88	4.28	4.21	4.27	3.86	4.53	3.89	4.00	*4.11*
3.	4.25	4.28	4.07	4.27	4.11	4.22	4.21	4.22	*4.20*
4.	3.81	3.78	4.07	4.18	4.11	3.68	3.79	4.35	*3.97*

1. The participatory process succeeded in taking advantage of the different types of knowledge and expertise of the participants
2. My ideas were included in the scenario outcomes
3. The scenario-making process is useful for river basin management planning
4. The produced scenarios are usable for river basin management planning

English Summary

In the introduction an overview is given of the concepts and practices of scenarios, why they are used, which gaps exist between different scenario types and why these gaps need to be bridged. The focus is on the three scenario types that are used in this thesis: qualitative and quantitative exploratory scenarios and decision support scenarios. Each of these scenario types have their own advantages and disadvantages. They also address different scenario quality criteria (see table 1). By combining them all scenario quality criteria can be addressed.

Table 1; Main relations between scenario types and scenario quality indicators.

scenario type	credibility	relevance	legitimacy	creativity
quantitative exploratory	X	x		
qualitative exploratory		x	X	X
decision support		X	x	

x: relation
X: strong relation

Stakeholders are involvement in scenario development because they make scenarios more legitimate, increase their relevance and make them more credible by including both scientific and local knowledge.
The main involvement of stakeholders is often in the development of qualitative scenarios. Quantitative scenarios are mainly developed by modellers, while decision support scenarios mainly address decision makers (see figure 1).

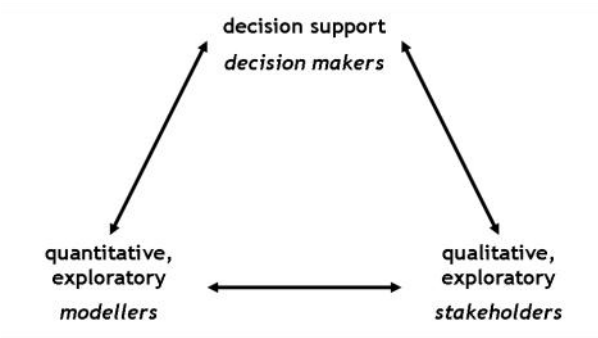


Figure 1; Three scenario types and involved communities and possible links between them.

The building of bridges between the three scenario types could also be used to increase the communication between the three communities, which makes it easier to exchange knowledge, expertise, and ideas.
The gaps between the different scenario types are, however, not easy to bridge. The right tools and methods to do so seem to be lacking. This thesis tests participatory tools

used to build the two bridges originating from the qualitative exploratory scenarios; one to the quantitative exploratory scenarios and the other to the decision support scenarios. These bridges should make it possible to enhance the communication between the involved communities and increase the qualities of the scenarios by addressing all scenario criteria.

This thesis focuses on the following three research questions:
- How can the gaps be bridged between qualitative and quantitative exploratory scenarios, and between exploratory and decision support scenarios?
- How can these bridges be used to contribute to the communication between the different communities?
- What is the effect of the bridges on the quality of the resulting scenarios?

The last part of the introduction introduces the European project within which this research was conducted: SCENES; Water Scenarios for Europe and Neighbouring States.

The second chapter presents the participatory scenario development framework that has been used in the Pilot Area and regional workshops. It involves a mix of qualitative, semi-quantitative and quantitative methods (see figure 2).

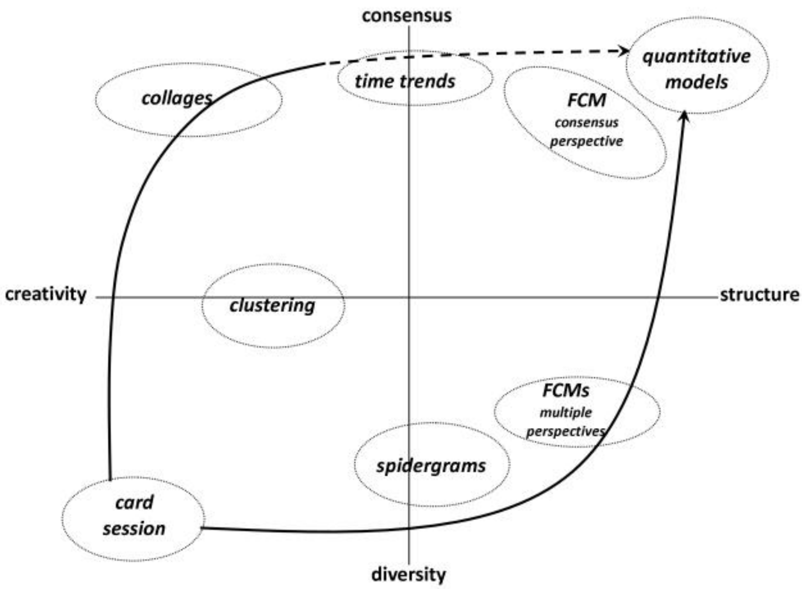


Figure 2; the different tools used in the scenario development framework placed on the axis of creativity versus structure and diversity versus consensus.

The main assumption is that the use of structured, semi-quantitative, tools will structure the participatory output, which provides a more solid base for quantification. Fuzzy Cognitive Maps (FCMs) is a semi-quantitative conceptual model and has a central place in the proposed framework. Its dynamical output can provide more insight in the system dynamics. The second chapter gives a detailed description of the implementation of

FCMs in participatory workshops, also because of a lack of documented testing of its implementation in participatory workshops. Results are presented of test sessions with Fuzzy Cognitive Maps as part of the framework in two trainings; both gave encouraging results. Results show that the tool provides a structured, semi-quantitative understanding of the system perceptions of a group of participants. Participants perceived the method as easy to understand and easy to use in a short period of time. This supports the hypothesis that Fuzzy Cognitive Maps can be used as part of a participatory scenario development workshop. At the end of the second chapter it is illustrated how FCMs can potentially facilitate the communication between stakeholders and modellers in order to further bridge the gap between qualitative and quantitative exploratory scenarios.

In the third chapter the effect of adding structure to on the creativity of the process and the resulting storylines is studied, as it was expected that introducing more structure might hamper the creativity (see figure 2). The analysis is done on basis of questionnaire results showing participants' perception of the creativity and an analysis of the resulting storylines of nine case studies across Europe. Results show that the use of structuring tools can indeed have a significantly negative effect on the creativity of the workshop, but the influence varies widely between the different tools. Timetrends significantly lower creativity, but Fuzzy Cognitive Maps show good promises that creativity can be maintained while incorporating structure.

In increasingly more participatory scenario projects a toolbox of methods is employed to facilitate stakeholder input. In Chapter 4 it is hypothesised that a toolbox helps scenario development processes to:

1. Be adaptable to specific case study conditions. Main differences between cases can include: different phase of participatory process; different issues that are of importance; or different culture and traditions.
2. Be adaptable to a broad range of stakeholders during a workshop. Different stakeholders might be more comfortable with different tools.
3. Be comparable across case studies and across scales, which calls for a comparable set of tools.
4. Contain creative elements, yet within a structured and consistent overall scenario.

These potential added values are evaluated, together with the effects of different toolboxes on the quality of resulting scenarios. The results from the first round of Pilot Area and regional workshops are used together with feedback by stakeholders and local organisers. Results indicate that all hypothesised added values materialised to some extent. There are indications that the use of a toolbox has increased the quality of the resulting scenarios on all indicators. The scenarios are creative and structured, while being relevant, credible, and legitimate for most stakeholders present at the workshop. However for optimal results the toolbox needs to be flexible so that it can be adapted to the length of workshop, number and type of tools employed, and previous experience of stakeholders and local organisers. Finally, more structured tests are needed to analyse the quality of scenarios.

In the second chapter it was hypothesised that FCMs can be linked to mathematical models. This has been tested in Chapter 5, for the Mediterranean region. FCMs developed by stakeholders from three local Mediterranean case studies were combined. The resulting stakeholder-based FCM was then simplified so that it can be used in the discussion with the modellers. The FCMs and its dynamic output are compared with a FCM based on a quantitative model (WaterGAP) and runs from the model itself. Results show that FCMs indeed have the ability to serve as common base for linking participatory products and models. Even though the FCMs had to be simple enough to be used in communication with stakeholders, they were capable of mimicking basic system behaviour of the model. The comparisons showed that FCM is a very promising tool for linking stakeholders and modellers. It can function as common base for comparison and illustrate differences between stakeholder perceptions and models in detail. The system dynamics of FCMs can play an important role in the quantification and dissemination process. Due to the semi-quantitative nature of the dynamic output of the FCMs, it is difficult to be used directly in mathematical models. Therefore a set of recommendations has been done to overcome part of the problems.

Chapter 6 focuses on the second bridge that has been build; the bridge between qualitative exploratory scenarios and decision support scenarios. Backcasting is a decision support scenario approach that is used to analyse how a normative vision can be reached. Exploratory scenarios sketch plausible futures, showing what can happen. Backasting sketches normative futures, showing what needs to be done in order to reach (or avoid) that future. A novel approach is tested in which a normative objective is backcasted within the context of exploratory scenarios. The approach was successfully used in 11 multi-scale case studies, making a cross-scale comparison possible. The methodology is as follows: First a desired objective is chosen, then the storylines of the exploratory scenarios are searched for obstacles and opportunities that prevent or accelerate the realisation of the objective. Interim milestones and actions show how the desired objective can be reached by overcoming obstacles and making use of the opportunities. The main advantage of combining exploratory and normative scenarios is in identifying robust actions: actions that are effective in each exploratory scenario. This approach was tested and evaluated on basis of questionnaires among the participants and an analysis of the resulting timelines. The analyses of the timelines showed that the exploratory scenarios influenced the content of the backcasts. Robustness to different scenarios could be studied, while the use of multiple case studies showed the robustness across regions and objectives and the implications for higher scales. The approach shows high potential for searching for different types of robustness. As the methodology is in its infancy more research is needed, particularly in methods to facilitate and monitor information flow between exploratory scenarios and backcasts.

Chapter 7, General discussion and synthesis, consists of three main parts. It evaluates and discuss three more issues that help in better answering the research questions: boundary object, multi-scale issues and scenario quality criteria. The second part synthesises the results of this thesis, which leads to recommendations and the conclusions.

The first part addresses the function of boundary objects. Boundary objects are tools or methods that are understandable for both communities and flexible enough to deal with concepts used on both sides. FCMs and robust actions can function as boundary objects that bring stakeholders and modellers (FCMs) and stakeholders and decision makers (robust actions) in contact with each other. Boundary objects can also be used to link scales, which is also important in scenario development. FCMs and robust actions can therefore play an important role in multi-scale scenario development, by linking communities on different scales (see figure 3).

The quality criteria are addressed in more detail as it became clear in the third and fourth chapter that they need refinement. A short literature study leads to the identification of six criteria (credibility, legitimacy, relevance, creativity, structure and clarity) and an overview of how these criteria are addressed in the current literature.

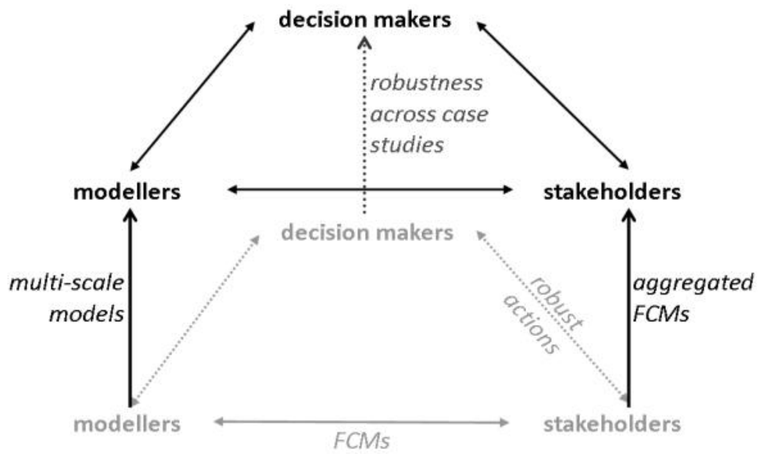


Figure 7.1; the role of boundary objects (shown in Italics) in connecting different communities on one scale, and connecting similar communities on different scales (vertical arrows).

In the second part (section 7.3) the previous chapters are synthesised, which leads to a critical look at the overall scenario development framework that was presented in Chapter 2. The Synthesis ends with a set of recommendations for refining the scenario development framework and future scenario projects in general. The backcasting results should be made more credible and relevant via a form of quantification. Indicators need to be developed for the six scenario quality criteria, so that the effects of toolboxes on the quality of scenarios can be measured better and scenario projects can be compared better. Although building bridges between scenario types is important, there are also some disadvantages. Recommendations are done to deal with the identified disadvantages.

In the last part conclusions are drawn on basis of the overall research questions.

How can the gaps be bridged between qualitative and quantitative exploratory scenarios, and between exploratory and decision support scenarios?
Adding extra structure to the participatory process lead to more structured outputs which helped to bridge the gap between qualitative and quantitative scenarios. The use of FCMs in bridging the gap between qualitative and quantitative scenarios was especially successful. They can add extra structure to participatory scenario development processes while maintaining a large part of the creativity needed.
Backcasting within exploratory scenarios proved a useful new approach to bridge the gap between exploratory and decision support scenarios. Especially the possibility to check the resulting actions for robustness was a major advantage. The approach should be tested further and be refined.

How can these bridges be used to contribute to the communication between the different communities?
FCMs can be used as communication tool between stakeholders and modelers. Robust actions can form a powerful message to decision makers. FCMs and robust actions function as boundary objects forming a shared language that both communities can use to exchange ideas. Therefore they can communicate better and share their knowledge, which can lead to cross fertilisation and social learning.

What is the effect of the bridges on the quality of the resulting scenarios?
The bridge between qualitative and quantitative scenarios increases the legitimacy, creativity, structure and credibility of the scenarios. The use of FCMs as boundary objects can further increase the clarity of the assumptions of stakeholders and models.
The bridge between exploratory and decision support scenarios increases the creativity of the resulting actions and the relevance of the scenario process.
When these approaches are used to link scale, they can further enhance the credibility, relevance and legitimacy of the scenarios. Structure is important to successfully conduct cross-scale comparisons and up-scaling.
To make a more precise analysis possible indicators should be developed for the six scenario quality criteria.

Samenvatting

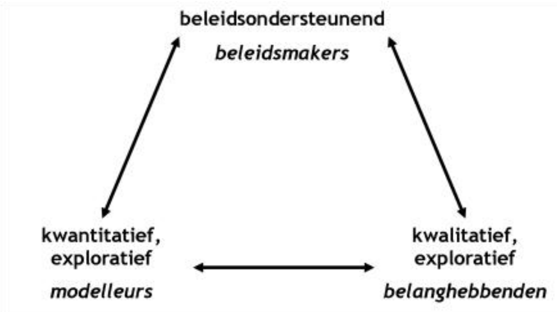
In de inleiding word een overzicht gegeven van het gebruik van scenario's in de praktijk en de concepten die daarbij gebruikt worden. Aangegeven wordt waarom scenario's worden gebruikt, welke verschillende typen scenario's er zijn en waarom deze scenariotypen aan elkaar gekoppeld zouden moeten worden. De focus ligt op de drie typen scenario's die in dit proefschrift worden gebruikt: kwalitatieve en kwantitatieve exploratieve (of verkennende) scenario's en beslissingsondersteunende scenario's. Elk van deze scenariotypen heeft zijn voor en nadelen. Ze richten zich primair op het voldoen van verschillende kwaliteitscriteria van scenario's (zie tabel 1). Door de drie typen te combineren kunnen alle criteria worden bereikt. Daarnaast verschillen ze ook in de groep mensen waar ze zich primair op richten.

Tabel 1; Belangrijkste relaties tussen de scenariotypen en de kwaliteitscriteria.

scenario type	**geloofwaardigheid**	**relevantie**	**legitimiteit**	**creativiteit**
kwantitatief exploratie	X			
kwalitatief exploratie		x	X	X
beslissingsondersteunend		X	x	

x relatie
X sterke relatie

Belanghebbenden worden betrokken bij de ontwikkeling van scenario's om de relevantie en legitimiteit van de scenario's te vergroten. Daarnaast worden de scenario's geloofwaardiger doordat ze dan wetenschappelijke en lokale kennis kunnen combineren. Belanghebbenden worden vooral betrokken bij het maken van kwalitatieve scenario's, terwijl kwantitatieve scenario's vooral ontwikkeld worden door modelleurs. Beslissingsondersteunende scenario's richten zich vooral op beleidsmakers en die mensen die beslissingen moeten nemen (zie ook figuur 1).



Figuur 1; De drie scenariotypen, de verschillende groepen die daarbij betrokken zijn en de mogelijke relaties daartussen.

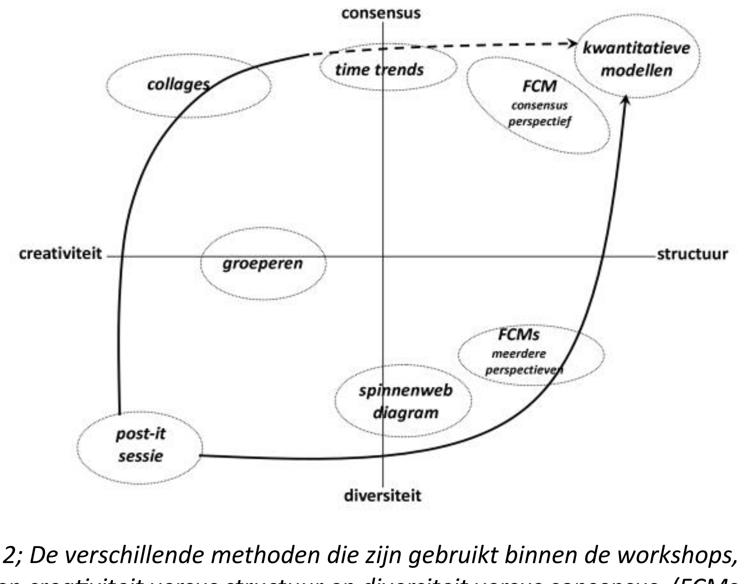
Het bouwen van de bruggen (leggen van verbanden) tussen de drie scenariotypen kan ook worden gebruikt om de communicatie tussen de drie bovengenoemde groepen te verbeteren. Dit maakt het gemakkelijker om kennis, inzichten en ideeën uit te wisselen. Het is echter niet makkelijk om de verschillen tussen de scenariotypen te overbruggen.

Het lijkt te ontbreken aan het juiste gereedschap en de juiste methoden om de brug te bouwen. Dit proefschrift test participatieve methodes om twee bruggen te bouwen die beginnen vanuit de kwalitatieve exploratieve scenario's; ten eerste een naar kwantitatieve exploratie scenario's en ten tweede naar beleidsondersteunende scenario's. Deze bruggen moeten ook zorg dragen voor een betere communicatie tussen de verschillende groepen en zorgen dat de kwaliteit van de scenario's wordt verhoogd door alle bovengenoemde kwaliteitscriteria aan te pakken.
Dit proefschrift richt zich op de volgende drie onderzoeksvragen:

- Hoe kunnen bruggen worden gebouwd tussen kwalitatieve en kwantitatieve exploratieve scenario's en tussen exploratieve en beleidsondersteunende scenario's?
- Hoe kunnen deze bruggen bijdragen tot een betere communicatie tussen de betrokken groepen?
- Wat is het effect van de bruggen op de kwaliteit van de resulterende scenario's?

Het laatste deel van de introductie beschrijft het Europese project waarbinnen het promotie onderzoek is uitgevoerd: SCENES, wat staat voor Water scenario's voor Europa en aanliggende staten.

In het tweede hoofdstuk wordt de overkoepelende, participatieve scenario methodologie gepresenteerd die gebruikt is in de locale en regionale workshops binnen SCENES (workshops zijn bijeenkomsten op voet van gelijkwaardigheid van de deelnemers en gericht op een bepaald doel, bijvoorbeeld het ontwerpen van scenario's). Deze methodologie bevat een mix van kwalitatieve, semikwantitatieve en kwantitatieve methoden (zie figuur 2).



Figuur 2; De verschillende methoden die zijn gebruikt binnen de workshops, uitgezet op de assen creativiteit versus structuur en diversiteit versus consensus. (FCMs: Fuzzy Cognitive Maps (zie tekst), Timetrends: simpele grafieken die het verwachte verloop in de tijd van zaken weergeven.)

Een belangrijke aanname binnen het onderzoek was dat het gebruik van gestructureerde, semikwantitatieve methodes de uitkomsten van het participatieve proces meer structuur zouden geven. Door die extra structuur zijn de uitkomsten dan beter te kwantificeren en beter te gebruiken in de modellen, die immers zelf ook erg gestructureerd zijn. Fuzzy Cognitive Maps (FCMs) is een semikwantitatieve conceptueel model. Het geeft de belangrijkste concepten en de relaties daartussen weer. Bovendien geeft het via iteraties weer wat de gevolgen van de verschillende relaties zijn op de concepten. FCMs namen een belangrijke, centrale, plek in binnen de voorgestelde overkoepelende methodologie. Het tweede hoofdstuk geeft een gedetailleerde beschrijving van het gebruik van FCMs in participatieve workshops, mede omdat er op dit gebied nog weinig literatuur bestond. De resultaten van twee cursussen waarin FCMs werden ontwikkeld door groepen PhDstudenten worden gepresenteerd; beide gaven hoopgevende resultaten. De resultaten lieten verder zien dat FCMs leiden tot een gestructureerde beschrijving van hoe de deelnemers het systeem zien. De deelnemers vonden de methode vrij makkelijk te begrijpen en te gebruiken, zelfs in de vrij korte tijd die beschikbaar was. Dit onderschrijft de hypothese dat FCMs gebruikt kunnen worden binnen participatieve scenario workshops. Aan het eind van het tweede hoofdstuk wordt inzichtelijk gemaakt hoe FCMs gebruikt kunnen worden in de communicatie tussen belanghebbenden en modelleurs, om zo de kloof tussen kwalitatieve en kwantitatieve scenario's verder te overbruggen.

In het derde hoofdstuk word ingegaan op het gevaar van het aanbrengen van teveel structuur in participatieve processen. Het effect van verschillende, meer of minder gestructureerde methodes op de creativiteit werd geanalyseerd op basis van interviewresultaten en een analyse van de ontwikkelde scenario's van negen workshops. De resultaten laten zien dat het gebruik van structurerende methoden inderdaad een significant negatief effect heeft op de creativiteit, maar dat de invloed sterk verschilt tussen de verschillende methoden. Het gebruik van Timetrends (schetsen van de veranderingen in de tijd in een grafiek) had een sterke negatieve invloed. Het gebruik van FCMs had een kleinere negatieve invloed. FCMs konden meer creativiteit behouden terwijl ze toch een gestructureerde output geven.

In steeds meer participatieve scenarioprojecten word een verzameling van methoden gebruikt om de ideeën van de belanghebbenden vast te leggen. In het vierde hoofdstuk wordt ingegaan op het gebruik van dergelijke 'toolboxen'. De hypothese is dat het gebruik van meerdere methoden binnen een workshop een aantal toegevoegde waardes heeft voor de scenario-ontwikkeling. Dit zijn:

- Beter aan te kunnen sluiten op specifieke situaties binnen de verschillende contexten. Belangrijke verschillen kunnen zijn: verschillende fases waarin het participatieve proces is; verschillen in wat de belangrijkste punten zijn; of verschillen in cultuur en tradities.
- Beter te kunnen laten aansluiten bij de wensen en werkwijzen van verschillende belanghebbenden in een workshop. Verschillende belanghebbenden voelen zich waarschijnlijk meer vertrouwt met verschillende methoden.

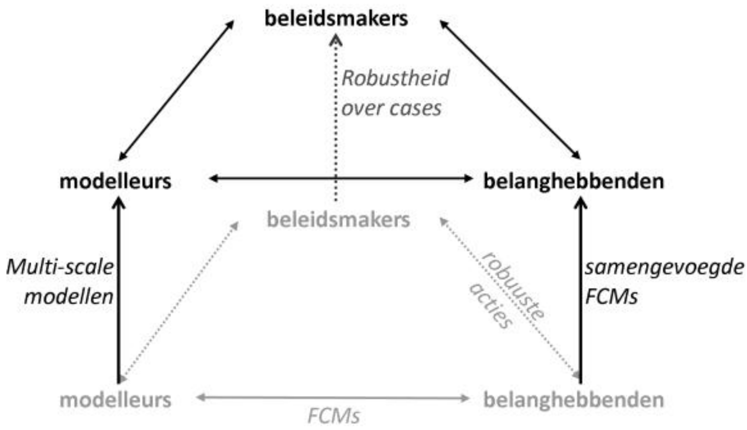
- Beter te kunnen vergelijken tussen voorbeeld projecten en geografische schalen; daarvoor moeten de zelfde soort methoden worden gebruikt in de verschillende voorbeeld projecten.
- De scenario's creatieve elementen te laten bevatten, binnen een gestructureerd en consistent geheel.

In hoofdstuk 4 worden deze toegevoegde waarden bestudeerd en geëvalueerd, samen met de effecten van verschillende toolboxen op de kwaliteit van de resulterende scenario's. Hiervoor werd gebruik gemaakt van de resultaten, enquêtes, en opmerkingen van de organisatoren over de eerste ronde van locale en regionale workshops. De resultaten laten zien dat alle vier de verwachte toegevoegde waarden tot op zekere hoogte zichtbaar waren. Ook zijn er aanwijzingen dat het gebruik van de toolboxen de kwaliteit van de scenario's, gemeten op basis van de verschillende kwaliteitsindicatoren, positief heeft beïnvloed. De scenario's waren in de ogen van de meeste deelnemers creatief, gestructureerd, relevant, geloofwaardig en legitiem. Wel werd het duidelijk dat de toolboxen flexibel in gebruik moeten zijn, zodat ze gemakkelijk aangepast kunnen worden aan de omstandigheden, bijvoorbeeld de duur van de workshop en hoe ervaren de deelnemers en organisatoren zijn. Bovendien werd duidelijk dat er betere en meer gestructureerde methodes moeten komen om de kwaliteit van de scenario's te meten.

Een van de redenen om FCMs te gebruiken was dat de dynamische systeemweergave van de FCMs kan worden gebruikt als invoer voor de mathematische, kwantitatieve modellen die gebruikt worden om de kwantitatieve scenario's te maken. In hoofdstuk 5 is dit getest voor het Middellandse Zeegebied. De FCMs die waren gemaakt door belanghebbenden in de drie Middelandse Zee pilot gebieden zijn daarvoor gecombineerd tot een regionale FCM. Deze FCM is vervolgens vereenvoudigd opdat het beter gebruikt kon worden in discussies en overleggen met de modelleurs. De modelleurs hebben een FCM gemaakt op basis van hun mathematische model (WaterGAP). Beide FCMs en de dynamische resultaten zijn met elkaar vergeleken.
De resultaten lieten zien dat FCMs inderdaad goed kunnen worden gebruikt als discussie - en communicatiemethode. Daarnaast zijn de dynamische resultaten van beide FCMs vergeleken met resultaten van het model zelf. Daarbij bleek dat, ondanks dat de FCMs vrij simpel moesten zijn om bruikbaar te blijven in de communicatie, de FCMs vergelijkbare resultaten lieten zien als het model. Dit laat zien dat FCMs inderdaad een veelbelovende methode is om belanghebbende en modelleurs meer bij elkaar te kunnen brengen. FCMs kunnen een gezamenlijk platform vormen dat duidelijk de verschillen en overeenkomsten in denken over het systeem in kaart brengt. Bovendien kunnen de dynamische resultaten een belangrijke rol spelen in het kwantificeren van de kwantitatieve scenario's die door de belanghebbenden zijn ontworpen. Doordat deze dynamische resultaten alleen semikwantitatief zijn moet dit echter wel zorgvuldig gebeuren en kunnen ze waarschijnlijk niet direct in het model gebruikt worden. Het hoofdstuk sluit dan ook af met een aantal aanbevelingen over hoe met deze problemen om te gaan.

In hoofdstuk 6 komt de tweede brug (de brug tussen kwalitatieve explorатieve en beleidsondersteunende scenario's) aan bod. Backcasting is een beleidsondersteunende scenario methodologie dat gebruikt word om te bekijken hoe een gewenste toekomst bereikt kan worden.
Waar exploratieve scenario's vooral kijken naar mogelijke toekomstige ontwikkelingen kijkt backcasting vooral naar wat een gewenste toekomst is en welke acties je moet nemen om die toekomst te realiseren. In dit hoofdstuk wordt een nieuwe methodologie getest waarin de beide scenario typen gecombineerd worden. Hierbij wordt gekeken hoe een gewenst toekomstig doel bereikt kan worden in de context van de verschillende exploratieve scenario's. Deze aanpak werd getest in 11 workshops, op lokale, regionale en Europese schaal. Doordat ze op verschillende schaalniveaus plaatsvonden, was het ook mogelijk om te kijken naar de overeenkomsten en relaties tussen schalen.
Hoofdstuk 6 presenteert de methodologie: eerst word een gewenst doel geformuleerd waarna, binnen de context van de 4 scenario's, gekeken wordt naar de mogelijkheden en obstakels. Aan de hand daarvan worden interim doelstellingen geformuleerd, die verder worden uitgewerkt in de vorm van concrete acties. Het belangrijkste pluspunt van deze gecombineerde aanpak is de identificatie van robuuste acties; acties die effectief zijn binnen verschillende mogelijke toekomstige ontwikkelingen als geschetst in de verschillende scenario's.
Deze aanpak wordt in dit hoofdstuk geëvalueerd op basis van enquêtes onder de deelnemers aan de workshops en een analyse van de backcasts. De resultaten lieten zien dat de scenario's inderdaad doorwerkten in de gevonden acties, maar ook dat er robuuste acties werden gevonden. Ook werd de implicaties van de robuuste acties op locale schaal op de Europese schaal duidelijk. Omdat de methode nog erg nieuw is, is meer onderzoek nodig naar methodes om de relatie tussen de backcasting en exploratieve scenario's te versterken en te monitoren.

Hoofdstuk 7, de algemene discussie en synthese, bestaat uit drie delen. Eerst worden drie aanvullende zaken gepresenteerd en bediscussieerd die helpen in het beter beantwoorden van de onderzoeksvragen: 'grensobjecten' (boundary objects), schaalniveaus en scenariokwaliteitscriteria. Het tweede deel vat te resultaten van dit proefschrift samen, wat leid tot een set aanbevelingen en conclusies.
De functie van grensobjecten ligt in hun rol van het bij elkaar brengen van verschillende groepen. Grensobjecten zijn methoden die begrijpbaar zijn voor de verschillende betrokken groepen en flexibel genoeg om om te kunnen gaan met de begrippen en concepten van beide kanten. FCMs en de robuuste acties kunnen als zulke grensobjecten functioneren door belanghebbenden en modelleurs (FCMs) en belanghebbenden en beleidsmakers (robuuste acties) met elkaar in contact te brengen. Grensobjecten kunnen ook gebruikt worden om verschillende schaalniveaus bij elkaar te brengen, wat vaak ook belangrijk is bij het ontwikkelen van scenario's. FCMs en robuuste acties kunnen daarom een belangrijke rol spelen in het ontwikkelen van scenario's die meerdere schaalniveaus beslaan, door de verschillende groepen op de verschillende schaalniveaus bij elkaar te brengen (zie figuur 3).



Figuur 3; De rol van grensobjecten in de communicatie tussen verschillende groepen op een schaal en tussen schalen onderling.

Aangezien in het tweede en derde hoofdstuk duidelijk werd dat de kwaliteitscriteria voor scenario's meer duidelijkheid behoefden, worden ze nader bestudeerd. Via een korte literatuur studie werden uiteindelijk zes criteria geïdentificeerd (geloofwaardigheid, legitimiteit, relevantie, creativiteit, structuur en duidelijkheid). Er wordt ook een overzicht gegeven hoe in de literatuur inhoud wordt gegeven aan deze criteria, als opzet voor een verdere invulling in toekomstig onderzoek.

In het tweede deel (7.3) word de rode draad van het proefschrift geschetst, wat leidt tot een kritische reflectie op de overkoepelende scenariomethodologie die in dit proefschrift werd gebruikt. Hieruit volgt een reeks aanbevelingen om de methodologie te verfijnen en aanbevelingen voor scenarioprojecten in het algemeen. De resultaten van de laatste workshop (backcasting) kunnen bijvoorbeeld meer geloofwaardig en relevant worden gemaakt door ze te kwantificeren en er moeten duidelijke indicators komen voor elk van de zes kwaliteitscriteria. Hoewel het duidelijk was dat het bouwen van bruggen tussen de scenariotypes voordelen had, zijn er ook een paar nadelen zoals als de hoeveelheid tijd die elke brug kost. Er worden een aantal aanbevelingen gegeven over hoe hiermee om te gaan.

In het laatste deel worden conclusies getrokken op basis van de onderzoeksvragen:

Hoe kunnen bruggen worden gebouwd tussen kwalitatieve en kwantitatieve explorative scenario's en tussen explorative en beleidsondersteunende scenario's?

Het gebruik van extra structurende methodes in het participatieve proces leid to beter gestructureerde uitkomsten. Meer structuur helpt om de kwalitatieve en kwantitatieve explorative scenario's beter op elkaar aan te laten sluiten. Vooral het gebruik van FCMs was succesvol, ook omdat zij nog in staat zijn een deel van de creativiteit te behouden. Het combineren van backcasting en explorative scenario's bleek ook een nuttige manier om beleidsondersteunende en explorative scenario's te koppelen. Vooral de mogelijkheid om de robuustheid van de geïdentificeerde acties te testen was een belangrijk voordeel. Aangezien het een nieuwe methode betreft dient zij verder te worden bestudeerd en te worden aangescherpt.

Hoe kunnen deze bruggen bijdragen tot een betere communicatie tussen de betrokken groepen?

FCMs kunnen gebruikt worden als communicatiemiddel tussen de belanghebbenden en modelleurs. De robuuste acties geven een belangrijke boodschap naar beleidsmakers. Beide kunnen ze gebruikt worden als grensobject, omdat ze een gezamenlijke taal vormen, die door beide groepen gebruikt kan worden om ideeën uit te wisselen. Zo kan de communicatie worden verbeterd en de uitwisseling van kennis worden vergroot, wat kan leiden tot kruisbestuiving en leereffecten.

Wat is het effect van de bruggen op de kwaliteit van de resulterende scenario's?

De brug tussen kwalitatieve en kwantitatieve scenario's vergroot de legitimiteit, creativiteit, structuur en geloofwaardigheid van de resulterende scenario's. Het gebruik van FCMs als grensobject kan bovendien zorgen dat de vooronderstellingen van de belanghebbenden en de modellen duidelijkheid worden gemaakt. De brug tussen de exploratieve en beleidsondersteunende scenario's vergroot de creativiteit van de ontwikkelde acties en de relevantie van de scenario's.
De verschillende methoden en uitkomsten kunnen bovendien gebruikt worden om de verbindingen tussen schaalniveaus duidelijker te maken. Dit kan de geloofwaardigheid, legitimiteit en relevantie van de scenario's vergroten onder de groepen op de verschillende schaalniveaus.
Om de effecten van verschillende methodes en bruggen beter in kaart te kunnen brengen is het wel nodig dat er duidelijkere indicatoren komen voor de zes kwaliteitscriteria voor scenario's

Acknowledgements

After four and half years my thesis is now ready. The road towards it was great; with lots of fun, beautiful places to visit, new friends to be made and nice bridges to be crossed, but there were also some darker parts along in which it was difficult to see where and how the journey should end. Luckily I got a lot of support from many people along the way, without whom this thesis would not be as good as it is now. I want to thank all those people.

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About the author

Curriculum Vitae

Mathijs van Vliet was born on 21 November 1979 in Bennekom. After elementary school at the Wilhelminaschool he went to secondary school (Voorbereidend Wetenschappelijk Onderwijs) at the 'Streeklyceum' in Ede. After a year that was partly spend in Canada and Sweden and partly at looking for the right study, he found that study in Wageningen. In 1999 he started with the study Landinrichtingswetenschappen (Land use planning). In the education year 2002-2003 he put his study on hold for a year to become chairman of the Daily Board of Wageningen University Sports Association Thymos. After that year he resumed his studies to work on two internships (at Pouderoyen Compagnons, a land use planning consultancy firm in Nijmegen and the Fraser Basin Council, a NGO in Vancouver, Canada) and two MSC-theses. The first MSc-thesis was written together with Hans van Bolderen and studied communicative planning processes in the city network Stedendriehoek, consisting of the municipalities of Apeldoorn, Deventer, Zutphen Brummen, Voorst and Groessen. 15 In depth interviews were conducted to study how the municipalities communicated between them during a strategic land use planning process. The second MSc-thesis was a study on Integrated Flood Management in which the flood management practices in the Netherlands and British Columbia (Canada) were compared. Recommendations were given for both the Dutch and Canadian situation. After working shortly as a land use planner at Pouderoyen Compagnons he started his PhD at the Land Dynamic group of Wageningen University at the end of 2006. His research is focused on participatory scenario development. As part of his PhD he worked in the European SCENES project.

Peer reviewed publications

Vliet, M. van; Kok, K.; Veldkamp, A. (2010) Linking stakeholders and modellers in scenario studies: The use of Fuzzy Cognitive Maps as a communication and learning tool. *Futures* 42 (1). pp. 1 - 14.

Vliet, M. van; K. Kok, T. Veldkamp and S. Sarkki, (subm.) Structure in Creativity; Effects of structuring tools on results of participatory scenario development workshops. *Regional Environmental Change*.

Vliet, M. van and K. Kok, (subm.) Backcasting as governance tool; looking for robust actions across futures and scales. *Technological Forecasting and Social Change*

Van Vliet, M.; M. Flörke; C. Varela-Ortega; E.H. Cakmak; R. Khadra; P. Esteve; D. D'Agostino; H. Dudu; I. Bärlund and K. Kok (subm.) Fuzzy Cognitive Maps as common base for linking stakeholder products and models. *Environmental Modeling & Software*.

Kok, K. and M. van Vliet (in press) Using a participatory scenario development toolbox: added values and impact on quality of scenarios. *Journal for Water and Climate Change*

Kok, K.; M. van Vliet; A. Dubel; J. Sendzimir; I. Bärlund (in press) Combining participative backcasting and exploratory scenario development: Experiences from the SCENES project. Technological Forecasting and Social Change.

PE&RC PhD Education Certificate

With the educational activities listed below the PhD candidate has complied with the educational requirements set by the C.T. de Wit Graduate School for Production Ecology and Resource Conservation (PE&RC) which comprises of a minimum total of 32 ECTS (= 22 weeks of activities)

Review of literature (6 ECTS)

- Theories on participatory methods for scenario development and conceptual modelling

Writing of project proposal (4.5 ECTS)

- Bridging the gap between storylines and models; the use of semi-quantitative methods in participatory scenario development

Post-graduate courses (6.4 ECTS)

- Scenario development training; SCENES, PE&RC (2007)
- NeWater-TIAS training course "qualitative research methods; NeWater-TIAS (2007)
- Training in systems thinking and causal loop diagramming; Centre for Systems Solutions (2008)
- NeWater-GWSP Summer School: managing change: tools and methods for adaptive river basin management; Centre for Systems Solutions, IIASA (2009)

Laboratory training and working visits (3.6ECTS)

- Participatory scenario development on a river basin scale; CIHEAM-IAMB Bari (2007)
- Use of large hydrological models (WaterGAP) in scenario development; Kassel University (2007 and 2010)
- Process related aspects of stakeholder participation in scenario development; SYKE (2008)
- Conceptual models, causal loop diagrams and system dynamics in scenario development; IIASA (2009 and 2010)

Invited review of (unpublished) journal (2 ECTS)

- Water and Climate Change: downscaling continental scale water scenarios to local visions (2010)
- Water and Climate Change: framework for analysing participatory scenario-making experiments (2010)

Deficiency, refresh, brush-up courses (8.6 ECTS)

- Spanish I (2007)
- Techniques for writing and presenting a scientific paper (2008)
- Facilitating interactive processes (2009)

Competence strengthening / skills courses (2.1 ECTS)

- Project- and time management; WGS (2007)
- PhD Competence assessment; WGS (2008)
- Stakeholder participation in scientific research; facilitation training; PE&RC (2008)

PE&RC Annual meetings, seminars and the PE&RC weekend (1.5 ECTS)

- PE&RC Introduction weekend (2007)
- PE&RC Day (2008 and 2009)

Discussion groups / local seminars / other scientific meetings (5 ECTS)

- Discussion group on stakeholder participation in scientific research; including organization (2007-2010)
- Mansholt Multidisciplinary Seminar: discourses on Dutch spatial planning (2008)
- Klimaatverandering? Leuk!?; Network Land&Water (2008)
- Environmental governance and the question of scale-the concept of landscape governance (2008)
- Getting into the right lane for 2050: from vision to strategy for a sustainable Europe; TIAS webinar (2010)

International symposia, workshops and conferences (8.6 ECTS)

- CAIWA, International Conference on A and Integrated Water Management; Basel; poster session (2007)
- Space for the River, Space for People-Dilemmas and Directions in Multifunctional River Planning and Management, Freude Am Fluss closing conference; Nijmegen; paper presentation (2008)
- IHDP Open meeting; Bonn; participate in SCENES panel, co-author on paper (2009)
- Scaling and Governance Conference; Wageningen; paper presentation (2010)
- Stockholm Futures Conference-Our Future in the Making; Stockholm; invited paper presentation and panel session (2010)

Lecturing / supervision of practical 's / tutorials (1.8 ECTS)

- Scenario development training (2007)
- Multi-functional land use; lecture en practical (2009)
- Multi-functional land use; lecture and practical (2010)

Supervision of MSc 2 students (8-10 day)

- Assessment of the participation process within a scenarios projects, SCENES
- Matching the tool to the stakeholders- an assessment of participatory tools in SCENES

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