Frames in climate change communication and decision-making: A catalogue of information tools

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dr J. de Boer[1], drs. J.A. Wardekker[2], dr. M.J. Kolkman[3], dr. J.P. van der Sluijs[2], dr. K.S. Buchanan[3], drs. A. de Jong[2], prof. dr. A. van der Veen[3]

(1) Institute for Environmental Studies (IVM), VU University Amsterdam, Amsterdam
(2) Copernicus Institute for Sustainable Development and Innovation, Utrecht University, Utrecht
(3) Water Engineering & Management Group (WEM), University of Twente, Enschede

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Inhoudsopgave

Samenvatting (in Dutch)

Voor de doelgroep van projectteams die de taak hebben beslissingen over adaptatie te nemen, wordt in het Klimaat voor Ruimteproject IC10 uitgelegd hoe de analyse van frames kan helpen bij de opzet van klimaatcommunicatie en de keuze van beslissingsstrategieën.

Frames zijn achterliggende interpretatieschema's die mensen hanteren bij denken, horen, zien en voelen. Frames bepalen wat voor verbanden iemand legt. Hoe dit kan uitwerken blijkt uit de rol van frames bij de perceptie en communicatie van risico's. Door frameverschillen kan zonder dat de betrokkenen dat beogen, een heftige controverse over een risico ontstaan die uitloopt in een "dialoog van doven". Het analyseren van frames kan verhelderend zijn in elk werkveld waar communicatie en beslissingsprocessen aan de orde komen die economische, wetenschappelijke en morele aspecten hebben.

In het samenvattend paper (Part I) komen aan de orde het morele grenzenframe (frame achter *An Inconvenient Truth*), het wetenschappelijk onzekerheidsframe (frame bij communicatie over IPCC rapporten), het economische competitiviteitframe (frame bij marketing van "*climate proof city*"), en het algemene vooruitgangsframe (frame bij "*win-win*" plannen). Vervolgens wordt beschreven hoe beslissingsstrategieën voor de aanpak van kennisvragen en beleidsvragen kunnen worden onderscheiden.

In de praktische ideeëngids (*Tool Catalogue,* zie Part II) zijn bijpassende beslissingsondersteunende methoden gesuggereerd, zoals methoden die inspiratie kunnen geven om problemen te structureren of om onzekerheden inzichtelijk te maken.

Het achterliggende denkkader over de impliciete rol van frames bij beslissingen wordt beschreven in Part III.

Summary

For the target group of members of a decision unit who have the task to make decisions on climate change adaptation, the IC 10 project aims to identify and explain the role of frames. Frames are the organizing principles of perception that shape in a "hidden" and taken-for-granted way how people develop a particular conceptualization of an issue. Science-related issues, such as climate change, are often linked to a few frames that consistently appear across different policy areas. These frames can be characterized in terms of a simple framework that highlights specific interpretations of climate issues. An additional framework clarifies the built-in frames of decision-tools. IC 10 has produced a three-part report on these topics.

The summary paper (Part I) describes a frame-based approach to situated-decision-making on climate change. Based on the multidisciplinary literature on the relationship between frames and decision-making, it argues that members of a decision unit may gain from making frames more explicit. Using Thompson's two basic dimensions of decision, it identifies the main uncertainties that should be taken into account in developing a decision strategy. The paper characterizes four types of decision strategy, focusing on (1) computation, (2) compromise, (3) judgment, or (4) inspiration, and links each strategy to the most appropriate methods and tools, as well as the most appropriate social structure.

The "Tool Catalogue" of frame-based information tools (Part II) presents characteristic examples of how various tools deal with framing. This catalogue is to serve as an "idea guide" for practitioners who are faced with framing-related issues. It synthesizes IC10 researchers' prior experiences with topics as interface tools for multi-stakeholder knowledge partnerships, communication of scientific uncertainty in the science-policy interface, and implicit framing issues. The examples demonstrate that it may be very fruitful to use more than one frame and more than one decision strategy after another.

The background paper (Part III) aims to gain a better understanding of the relationship between conventional decision support tools and novel analytical tools, such as cognitive aids and participatory tools. It provides a frame-based characterization of the various tools that are available to support climate policy

appraisals. The paper explains that debates on policy-relevant information are closely related to the ways in which appraisals are framed.

Part I Summary paper

1. Frame-based guide to situated decision-making on climate change

Joop de Boer[1]), J. Arjan Wardekker[2]), Jeroen P. van der Sluijs[2])
[1]) Institute for Environmental Studies (IVM), VU University Amsterdam
[2]) Copernicus Institute for Sustainable Development and Innovation, Utrecht University
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Abstract
The present paper describes a frame-based approach to situated-decision-making on climate change. Based on the multidisciplinary literature on the relationship between frames and decision-making, it argues that members of a decision unit may gain from making frames more explicit. Frames are the organizing principles of perception that shape in a "hidden" and taken-for-granted way how people develop a particular conceptualization of an issue. Science-related issues, such as climate change, are often linked to a few frames that consistently appear across different policy areas. Indeed, it appears that there are some very contrasting ways in which climate adaptation may be framed. These frames can be characterized in terms of a simple framework that highlights specific interpretations of climate issues. A second framework clarifies the built-in frames of decision-tools. Using Thompson's two basic dimensions of decision, it identifies the main uncertainties that should be taken into account in developing a decision strategy. The paper characterizes four types of decision strategy, focusing on (1) computation, (2) compromise, (3) judgment, or (4) inspiration, and links each strategy to the most appropriate methods and tools, as well as the most appropriate social structure. Our experiences show that the frame-based guide can work as an eye-opener for members of a decision unit, particularly where it demonstrates how to add more perspectives to the decision.

1.1. Introduction

One of the main characteristics of decision-making on climate change adaptation is that the impacts of policy options appear to be very context specific [Dempsey and Fisher, 2005; Halsnæs et

al., 2007; Kirshen et al., 2008]. This is partly due to the complexities of climate change itself, which may cause considerable uncertainty over climate change projections and its impacts [Dessai and Hulme, 2004; Lempert et al., 2004]. Also the role of other human-caused environmental changes, such as changes in regional land use patterns, can make a large difference. In particular, it is the specific combination of climate change and other environmental changes that may create the most significant impacts for society. Consequently, members of a decision unit who have the responsibility or authority to search for solutions should develop a strategy that is informed by a rich store of information and, at the same time, ensures a sufficient degree of flexibility and adaptability [Lindblom, 1990; Thompson, 2003; Thompson and Tuden, 1959]. Whether the strategy for decision-making can stand in the service of adequate action will strongly depend on the way in which the members of the decision unit and the stakeholders frame the specifics of the situation, including the time lines [Robinson et al., 2006; Schlumpf et al., 2001]. However, the actors involved in this process may not be sufficiently aware that "taken-for granted" frames, including the frames that are "built-in" in decision tools, can subtly shape the selectivity and organization of information. Therefore, based on the multidisciplinary literature about these topics, the present paper will examine how decisions may gain from making frames more explicit.

A frame-based guide to situated decision-making may be particularly helpful where thinking about climate change at a distal level has to be supplemented by thinking at a proximal level. In the recent past, uncertainty about climate change may have lead people to conceptualize it in terms of abstract and distal properties [Bord et al., 1998]. This response agrees with general patterns of differences between distal and proximal levels of thinking [Liberman and Trope, 2008; Wakslak and Trope, 2009]. Thinking at a proximal level may require, for instance, that several conditions of uncertainty have to be accepted. Instead of just focussing on the question "How can we reduce uncertainty in our estimates of future climatic conditions?" it is important to give more attention to the question "Given that there is considerable uncertainty about our future, how can we best manage this coastal area to reduce risk and increase system resilience?" Obviously, the first question can be an excuse for delaying action. In contrast, the latter question is far more action related. In fact, the two

questions are based on divergent implicit frames. It is their contrasting impact that demonstrates why situated decision-making may be facilitated by making frames and frame-based decision-strategies more explicit.

After a short explanation of frames – in particular frames that are relevant for discussions on science-related issues, such as climate change – the next sections of the paper will address some critical choices and assumptions of decision-making. One of the most important choices is selecting a decision strategy, which, in turn, may shape the choices of appropriate methods and tools, as well as the social structure that fits the process. Our approach has been developed in interaction with a number of adaptation projects at the regional level, but a description of these cases is beyond the scope of this paper.

1.2. Frames applied to science-related issues

Although there are slight differences between various definitions [Barsalou, 1999; Chong and Druckman, 2007; Graf, 2006], frames are generally conceived as organizing principles of perception that shape in a “hidden” and taken-for-granted way how people develop a particular conceptualization of an issue. Seen in this way, frames are not just personal mindsets but also cultural structures. Frames are crucial micro-mechanisms for perception, knowledge, communication and decision-making, not only at the level of individuals but also at the level of policy-making processes. They are the topic of research in such varied fields as anthropology, linguistics, cognitive psychology, social and organizational psychology, management science, sociology, communication and media studies, social movements research, policy science, science studies, and philosophy. In the literature on policy controversies [Schön and Rein, 1994], frames are depicted in terms of "underlying mental structures" of belief, perception and appreciation, which enable people to take shared or opposing political positions.

The way in which decision-makers and stakeholders think about climate change may reveal several relevant frames. Because climate change is still very much a scientific issue, it is one of the policy areas that regularly generate debates among scientists and non-scientists. Social scientists who have analyzed public discussions on science-related issues argue that these issues are often linked to a few frames that consistently appear across

different policy areas [Gamson and Modigliani, 1989; Nisbet, 2009]. For example, synthetic pesticides, such as DDT, have been framed as a blessing for humanity (before the year 1962), but also as Pandora's box (after the publication of Rachel Carson's *Silent Spring* in 1962), as a matter of specific risks and benefits to be decided on scientific evidence (with the rise of ecotoxicology as a science in the 1980s and 1990s), and as a key factor to keep certain industries competitive (along with each new pesticide regulation).

The frames that are applied to science-related issues suggest that there are some very contrasting ways in which climate adaptation may be interpreted. Based on the view that interpretations are inherently perceptual [e.g. Barsalou, 1999], two perceptual contrasts can be used to make their meaning more transparent. The two contrasts lay the ground for a simple framework that highlights specific interpretations of climate issues. The first contrast is the difference between a promotion or prevention orientation to goal-directed behaviour; the second involves taking a distal or proximal view on an object.

Generally, a promotion orientation makes the person sensitive to positive outcomes and hits that may be gained through aspirations, accomplishments, and ideals [Higgins, 1997; 2000]. In contrast, a prevention orientation makes the person sensitive to negative outcomes and errors that have to be avoided by fulfilling one's moral obligations and responsibilities. This difference is not just a matter of personal mindsets – the orientations can be associated with certain institutions, subcultures within an organization, or occupational groups. Engineers, for example, are said to be safety oriented and inclined to "overdesign" for safety [Schein, 1996].

In line with the second contrast, taking a distal (versus a proximal) view on an object may evoke broad categories to represent its general features rather than its more contextual and incidental aspects [Liberman et al., 2007]. This may include more abstract moral principles to judge the object. In contrast, a proximal view induces categories that are narrower to represent more detailed and contextualized features. A proximal view is also more constrained by concrete realities [Goldstone and Barsalou, 1998]. Again, these perceptual differences also have cultural relevance. They are closely related to differences between holistic and analytical ways of thinking, each of which may have become more

useful and more available in one culture than in another. For instance, Easterners tend to engage more in holistic perceptual processes whereas Westerners tend to engage more in analytical ones [Nisbett, 2003].

Figure 1 combines the two perceptual contrasts and presents four cells that reflect promotion or prevention orientations in combination with a distal or a proximal view. Building on that framework, Figure 2 captures the different frames that may underlie discussions on science-related issues. In addition, each cell provides an example of a matching climate-related issue.

	Promotion orientation	Prevention orientation
Distal view	Using broad categories to represent general features and focusing on gaining positive outcomes (hits)	Using broad categories to represent general features and focusing on avoiding negative outcomes (errors)
Proximal view	Using narrow categories to represent contextualized features and focusing on gaining positive outcomes (hits)	Using narrow categories to represent contextualized features and focusing on avoiding negative outcomes (errors)

Figure 1. Two perceptual contrasts combined.

The four cells in Figure 2 illustrate that there are major differences between the ways in which climate-related issues are being framed. Social actors often try to influence each others' frame by using particular communication symbols (framing devices, see Gamson and Modigliani [1989]). Important symbols are historical examples from which lessons are drawn (e.g. the most dramatic recent disaster), metaphors and visual images (e.g. picture of a polar bear). By adopting one of the frames they attempt to open certain positions in favour or against an issue.

The upper right cell of Figure 2 represents distal, moral thinking about climate change. Without going into details, it can be said that Al Gore's movie, *An Inconvenient Truth*, fits well into this pattern, calling for precaution in the face of potentially catastrophic impacts. Next, the reports by the Intergovernmental Panel on Climate

Change (IPCC) and the second Dutch Deltacommittee [2008] take a more proximal view, drawing on the latest scientific insights on, for instance, plausible upper limits of regional sea level rise (lower right cell of Figure 2). The reports' publication stimulated a lively discussion on scientific uncertainty. Both Al Gore's movie and the Deltacommittee report demonstrate the characteristics of a prevention orientation, which aims to avoid errors in dealing with the earth's atmosphere.

	Promotion orientation	Prevention orientation
Distal view	**Social progress frame** defines the issue as improving quality of life or harmony with nature **Middle way frame** puts the emphasis on finding a possible compromise position between polarized views > Plan for a tulip-shaped island	**Morality/ethics frame** defines the issue in terms of right or wrong; respecting or crossing limits **Pandora's box frame** defines the issue as a call for precaution in face of possible impacts or catastrophe > Al Gore, An inconvenient truth
Proximal view	**Economic development frame** defines the issue as investment that improves competitiveness **Conflict/strategy frame** defines the issue as a game among elites, a battle of personalities or groups > Climate Proof City	**Scientific uncertainty frame** defines the issue as a matter of what is known versus unknown **Public accountability frame** defines the issue as responsible use or abuse of science in decision-making > Report IPCC

Figure 2. Science-related frames [adapted from Nisbet, 2009] grouped into four perceptual contrasts, with examples about climate issues.

In turn, both prevention-oriented frames contrast with two promotion-oriented frames. Promotion-oriented frames highlight the possible gains that climate-related issues can entail for society. These frames may be linked to the notion of a "climate proof city", such as the city of Rotterdam, which emphasizes its competitiveness by advertising its various strengths (lower left cell of Figure 2). A more distal view is reflected by the plan for a tulip-shaped island near the Dutch coast, which can be seen as a means of reconciling the objectives of land reclamation and coastal management (upper left cell of Figure 2).

It should be emphasized that Figure 2 is meant to improve our understanding of the various ways in which climate issues may be framed. In addition, the contrasting pairs indicate that none of the frames is a stand-alone guide to an adaptive choice. Each frame

has its strengths and weaknesses in articulating the specifics of a situation. Prevention may have to be complemented with promotion (or vice versa), and the distal view of broad strategic planning needs a more implementation-oriented, proximal way of thinking about how measures can be organized. Hence, introducing a contrasting frame may be used to open-up the process of decision-making.

1.3. Frames built-in in decision tools

An additional set of frames is necessary to highlight the key elements of decision that should be taken into account in developing an adaptive decision strategy. A crucial consideration is the question whether there is a need for more scientific knowledge or for more deliberation on preferences. Following Thompson's seminal approach to strategy development, the two basic dimensions of decision are beliefs about (1) the cause/effect relations that are instrumental for what the decision might actually accomplish and (2) preferences regarding the possible outcomes of the decision [Thompson, 2003; Thompson and Tuden, 1959]. Depending on the specifics of the situation, both dimensions can take a range of values. However, for the sake of clarity of the presentation, they are often dichotomized: i.e. members of the decision unit perceive certainty or uncertainty regarding causation and certainty or uncertainty regarding outcome preferences.

Figure 3 presents the patterns of uncertainty of the two dimensions. Whether cause/effect relations are uncertain may depend on several conditions, such as the decision unit's belief that the existing knowledge is incomplete, that there is inherent uncertainty or uncertainty due to competition with rivals. Outcome preferences can become uncertain in situations where an individual or organization appears to hold opposing preferences regarding the outcomes of possible actions. An additional type of uncertainty occurs when there are external constraints that make the decision unit dependent on others who hold veto power over some possible preferences. This may happen where regional decision making is restricted by strategic planning processes that are coordinated by governmental institutions and other agencies [Few et al., 2007].

Figure 3 also provides logical links between uncertainties and strategies of decision-making. Members of the decision unit who are confronted with uncertainties regarding causation and outcome

preferences should adapt their decision strategy to these issues [Thompson & Tuden, 1959; Thompson, 2003]. Provided that there is at least a certain degree of commitment to reaching agreement, they may choose one of the four types of decision strategies.

- If there is certainty regarding both causation and outcome preferences, decision-making is relatively straightforward, although it may require a computational strategy to process voluminous data (upper left cell of Figure 3).
- If outcome preferences are clearly known and shared but cause/effect relations are uncertain or disputed, the decision unit must rely on a judgmental strategy to find a solution (lower left cell of Figure 3).
- In contrast, if cause/effect relations are certain but outcome preferences are uncertain or disputed, the decision unit needs a compromise strategy to identify a common preference (upper right cell of Figure 3).
- Finally, if both causation and outcome preferences are uncertain or disputed, the most likely action of the decision unit is to avoid any decision on the issue, unless an inspirational strategy can be introduced to create a new vision or belief (lower right cell of Figure 3).

Beliefs about cause/effect relations	Preferences regarding possible outcomes: Certain	Preferences regarding possible outcomes: Uncertain
Certain	Causation and outcome preferences are certain – data are voluminous **Computational strategy**	Uncertain due to - opposing preferences - external constraints **Compromise strategy**
Uncertain	Uncertain due to - incomplete knowledge - inherent uncertainty - competition with rival decision-makers **Judgmental strategy**	Uncertain due to - a combination of reasons **Inspirational strategy**

Figure 3. The two basic dimensions of decision combined to identify different decision strategies (after Thompson, 2003).

Each decision strategy can be elaborated to find methods and tools with built-in frames that fit the strategy. Figure 4 shows a number of options.

A computational strategy (upper left cell of Figure 4) may rely on conventional forms of decision support, such as multi-criteria analysis tools (MCA) and cost-benefit analysis (CBA). The built-in frame of these methods sees the decision situation as a problem for which an optimal solution might exist, provided that trade-offs will be accepted. The notion of trade-offs can be an argument to opt for a transparent, quantitative evaluation of the options. CBA can identify the most advantageous solution or at least those options for which benefits are greater than the costs, because it may attach a monetary value to every aspect considered relevant to society. In fact, this monetarisation is framed as aggregating independent individual choices in a market context. However, CBA is not adapted to long time horizons (> 25 years) and may generate questions about the ethics of interest rates and long-term discounting [Stern, 2007; Turner, 2007].

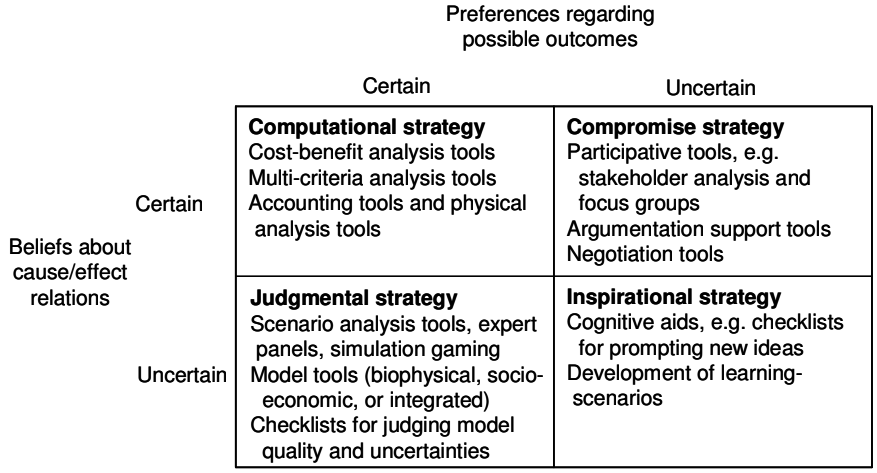

Figure 4. Methods and tools that are relevant for the decision strategies.

Alternatively, the decision situation may be framed as a problem whose solution should satisfy a wide set of constraints (upper right cell of Figure 4). Following a compromise strategy, the decision unit may want a course of action that is acceptable to all kinds of stakeholders. To find a common preference, participatory tools can be applied, such as community planning tools, which can be framed as building on deliberative democratic forums. Such a frame involves some form of open, goal-directed conversation or "dialogue" between decision-makers, experts and other stakeholders, which may create favourable conditions for the exchange of diverging arguments. It should be noted, however,

that people with diverging arguments can only communicate meaningfully if their frames overlap to a certain degree [Brockriede, 1992].

Where outcome preferences are clearly known and shared but cause/effect relations are uncertain or disputed, the decision unit must rely on a judgmental strategy to clarify matters (lower left cell of Figure 4). It is in particular the nature and the relevance of scientific uncertainty that can lead to difficult discussions between decision-makers and experts, as well as between experts among themselves [Dessai and Hulme, 2004; Lempert et al., 2004]. Insight into the strengths and weaknesses of advanced tools such as influence diagrams (including Bayesian Belief Networks) and dynamic models (including computable general equilibrium models) will require an analysis of critical choices and assumptions. Uncertainty about the impacts of the behaviour of other people on the decision's outcomes may require a game theoretic approach.

Finally, an inspirational strategy may include tools to stimulate creativity, such as the development of learning-scenarios (lower right cell of Figure 4). In fact, there are two diverging frames of creativity. Some persons tend to emphasize the value of spontaneous insight and the magical "Aha!" moment that occurs when a long-sought idea suddenly appears at the conscious level. Other persons emphasize systematic approaches to exploring problems and potential solutions. The occurrence of insight is often associated with restructuring or reframing a problem space, for example, from a broader perspective. Both approaches should be supported by good preparation and the participation of people who have good knowledge about a particular domain and who are able to think flexibly and synthetically.

A closely related strategic consideration is the notion that institutions and groups have organized themselves differently to address different kinds of decision-making problems [Thompson, 2003; Thompson and Tuden, 1959]. Hence, when members of the decision unit want to adapt their decision strategy to the uncertainties regarding causation and outcome preferences, they also have to consider the social structures that are appropriate for the issues. Figure 5 displays the most appropriate social structures for each of the strategies.

A computational strategy that is based on cost-benefit analysis, for example, should take into account that this tool can only be applied meaningfully under specific conditions. Compliance with certain rules and conventions regarding the choice of discount rates is crucial to provide comparative insights into the financial costs and benefits of the options. Accordingly, the most appropriate setting for the use of cost-benefit analysis may be a bureaucratic structure that guaranties that every issue is routed to the appropriate specialist (upper left cell of Figure 5).

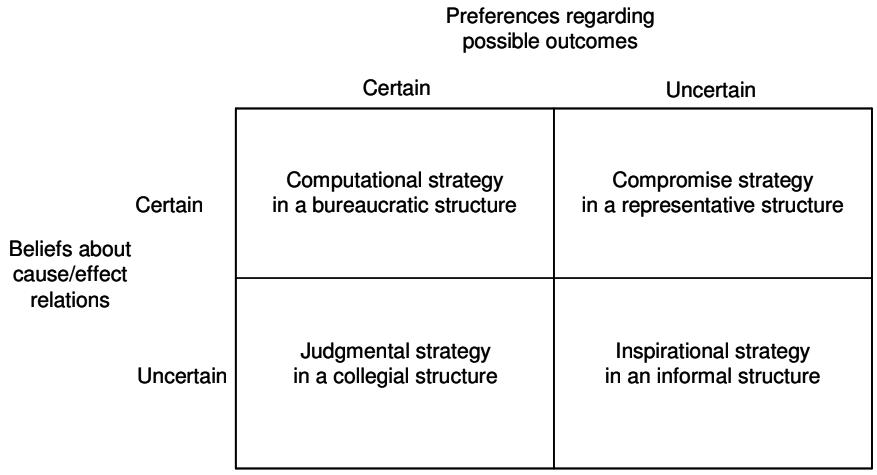

Figure 5. Different social structures that fit the decision strategies.

A compromise strategy has to be developed if there is agreement by all parties regarding the expected consequences of the available alternatives but lack of consensus over preferences. The most appropriate setting to handle compromise types of issues economically and efficiently is a representative structure of intermediate size that facilitates detailed and subtle exploration of the several preferences (upper right cell of Figure 5).

A judgmental strategy is called for if causation is uncertain or disputed; this may require a collegial structure, such as a self-governing voluntary group that is competent by virtue of their expertise to make a judgment (lower left cell of Figure 5). If none of the experts has indisputable and complete evidence, no member should be allowed to outvote or override the judgment made by other members and a majority judgment may be necessary.

The fourth type of issue is one in which both causation and outcome preferences are uncertain or disputed (lower right cell of

Figure 5). In fact, these conditions make it difficult for all parties to prevent disintegrating tendencies, such as loss of contact or decreasing commitment to reaching agreement. Therefore, the decision unit may try to avoid any decision on the issue, unless a new vision or belief can be developed [Thompson and Tuden, 1959]. Harnessing the inspirational aspects of a decision strategy may require an informal setting that offers incentives for collective problem solving. Such a creative kind of activity may be stimulated by charismatic leaders or successful models of new visions.

Generally, the notion that there should be a match between decision strategy and social structure implicates that a decision unit may not be in a position to change its strategy. For example, a decision unit that operates in the context of a bureaucratic structure may not have room for another type of strategy than a computational one. If an organization, such as a planning bureau, adopts one of the four decision strategies as its dominant strategy, it may have to cooperate with other organizations to exercise a different kind of strategy. Alternatively, it may be necessary to create a novel decision unit to address issues for which traditional structures are ill suited.

A final strategic consideration is the relationship between the science-related frames and the decision strategies. Figure 6 illustrates that there may be a loose coupling between the various elements of decision-making. For example, an economic competitiveness frame may give rise to a computational strategy to check the optimum. Similarly, a morality frame may lead to a compromise strategy in order to check the constraints of a morally acceptable solution. A scientific uncertainty frame may require a judgmental strategy to clarify what is known versus unknown. And a social progress frame that aims to reconcile opposing policy objectives may have to be fleshed out by an inspirational strategy. However, these linkages are not the only possibilities and Figure 6 can be seen as a heuristic device.

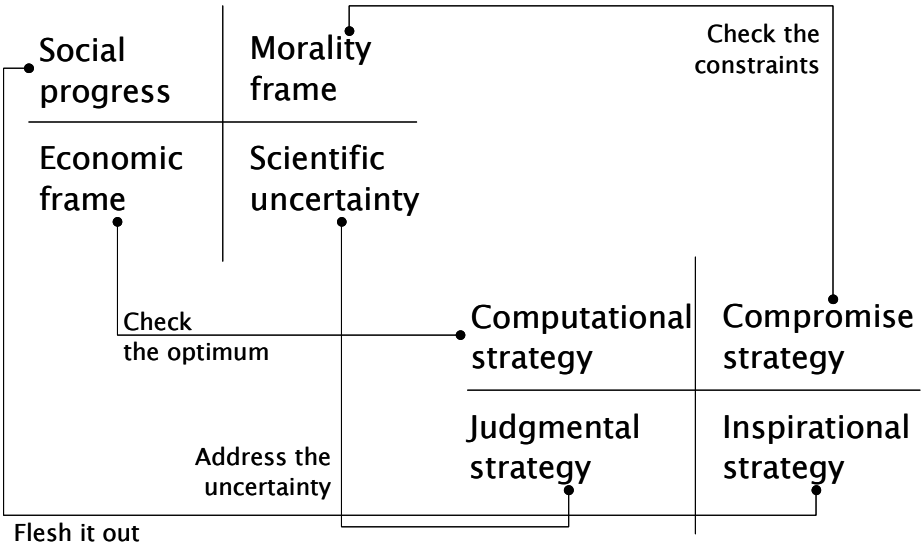

Figure 6. Loose coupling between science-related frames and decision strategies.

Our interaction with a number of adaptation projects at the regional level showed that the information that is summarized in Figure 6 works as an eye-opener for members of decision units. This relates in particular to the exposé of contrasting frames and the way in which they may open-up decision-making. Based on these experiences we have written a tool catalogue in which we present characteristic examples of how various tools mentioned in Figure 4 deal with framing [Wardekker et al., 2009]. The examples are meant to demonstrate that it may be very fruitful to use more than one frame and more than one strategy after another. Obviously, strategy development has to be responsive to cues that crucial circumstances are changing or that a strategy is failing. More generally, however, the members of a decision unit should repeatedly ask themselves whether they are still on the right track, as long as the decision process has not been successfully completed.

1.4. Discussion and conclusions

This paper has discussed several crucial aspects of frames. Frames can particularly be of help in adding new perspectives to a decision process and in checking whether the participants are able to understand each other. Taken together, the insights on the relationship between science-related frames, uncertainties, decision strategies and social settings may contribute to a more in-depth understanding of the information tools that can be used to

support situated decision-making. A careful consideration of frames in their role of organizing principles may create a better match between supply and demand of information among all the people involved, i.e. knowledge producers, members of a decision unit and stakeholders.

A crucial point is that people can only communicate meaningfully if their frames overlap to a certain degree. If the frames of two persons share too little, they will be unable to co-operate in the same process. For example, due to the technical nature of computational tools, this decision support tool may become counterproductive if its outcomes cannot be shared with members of a decision unit and stakeholders who see themselves as problem owners. If members of a decision unit and stakeholders do not recognize how their input has been incorporated in the analysis, they will loose their trust in the method.

One limitation of the paper is that we did not address the issue of managing the decision process. Thompson and Tuden [1959] already referred to confusion of issues, structural constraints, inappropriate decision units and expansion tendencies in decision issues. As a group changes its beliefs about cause-and-effect relations, for example, types of issues that at one time are identified as appropriate for a judgment strategy may at another time be defined as computational problems, or vice versa. Also, different members of a decision unit may respond to the same situation in different ways, some seeing it as a matter for computation, others as a judgment matter, and still others as requiring bargaining.

If the issue to be decided is linked to serious pre-existing conflicts, strategy development should first create a more neutral starting point. Even then, however, both a judgmental and a compromise strategy may fail due to increasing tendencies of polarization. The heat of debate can lead experts who endorse a particular solution to overstate their case, discount missing information and refer to moral justification for the solution they prefer. When this occurs, the issue is no longer one of judgment but one of compromise. Similarly, an issue that seems fit for a compromise strategy may generate difficulties in the identification of causation. Next, proponents may discount causation theories endorsed by their opponents and dismiss the corresponding “facts”. As a result of

this polarization, all parties may start to threaten each other with trouble on unrelated matters [Thompson and Tuden, 1959].

Reframing can play an important role in opening-up processes of decision-making [Schön and Rein, 1994]. A crucial way to reframe a situation may result from changes in people's mental models of a topic. For example, it may be helpful to put climate change adaptation and mitigation in the context of a higher-level objective, such as sustainable development [Robinson et al., 2006]. Emphasizing the functional relationship with sustainable development makes it easier to combine the impacts of adaptation and mitigation with those of other environmental changes. Placing a particular issue in a larger context is not only relevant to handle bargaining issues, but it can also help to crystallize consensus about preferences if the parties involved are unaware of the similarities of their preferences.

Our experiences demonstrate that presenting more than one frame may work as an eye-opener for members of decision units. One of the main drawbacks of a stand-alone frame is that it tends to induce a passive acceptance of the information given. Hence, contrasting frames may be used to stimulate more active participation in decision-making. Because each frame may have its strengths and weaknesses in articulating the specifics of a situation, it may be fruitful for a decision unit to use more than one frame after another. In sum, decision-making may gain from making frames more transparent.

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1. Introduction

In the perception, knowledge production and policymaking on complex issues ('wicked problems'), such as climate change, frames and framing play an important but often hidden role. Frames relate to one's 'schemas of interpretation'; the conceptual images, values, starting points, and mental models that one may have of an issue. This can include, for instance, one's problem definition, perceptions of the cause-effect relationships in an issue, one's primary goals, perception of one's and others' roles and responsibilities relating to the issue, and views on suitable strategies and interaction with (other) stakeholders [cf. Dewulf et al., 2005].

Differences in frames can lead to miscommunication and conflicts. For example, a knowledge producer could produce information that the decision maker finds of little relevance, if their problem definitions and boundaries are different. The knowledge may be credible and legitimate, but not salient to the user's needs, i.e. not an answer to the decision maker's question/problem. Frame differences can also be used to arrive at a more complete picture of the issue at hand. In managing complex problems, actors have only a partial view of the situation. Bringing together the frames of a diverse group of people, with various backgrounds, interests, and values, can improve the comprehensiveness of a management strategy.

In order to limit miscommunication and enhance beneficial interaction between stakeholders, it is important to take framing into account. Various tools can be used for this purpose, but the suitability of each tool depends on the situation. Two important criteria for selecting tools are: (1) whether there is a clear understanding of the cause-effect relations and (2) whether there is consensus regarding the desired policy goal/outcome (Table 1). E.g. when there is controversy on both knowledge base and policy goal, a tool that straightforwardly calculates 'the answer' is unlikely to provide input that is acceptable to policymakers and stakeholders. The four decision strategies in Table 1 provide some guidance on tool selection. However, keep in mind that selecting such a strategy is a matter of framing in itself.

Table 1. Types of decision issues [source: Thompson, 2003].

Beliefs about cause-effect relations	Preferences regarding possible outcomes	
	Certainty	Uncertainty
Certain	Computational strategy	Compromise strategy
Uncertain	Judgmental strategy	Inspirational strategy

Intended audience and scope
This tool catalogue is intended as an idea-guide and eye-opener for organisations who are confronted with framing-related issues and who want to take these into account when developing knowledge, policy, or viewpoints.

This document has been developed in the context of the Dutch national research programme 'Climate changes Spatial Planning' (CcSP; 'Klimaat voor Ruimte' (KvR) in Dutch). Some sections will explicitly or implicitly refer to this context of climate change, climate change adaptation, and spatial planning. However, the catalogue can be used for a much broader range of topics.

The catalogue does not aim to give a complete list of methods. Rather, it will present a number of characteristic examples of how various tools deal with framing. Some suggestions will be given on the situations for which these approaches are most suitable. For more extensive overviews of participatory methods, refer to the various stakeholder participation guidelines and catalogues that are available (several references have been included in the present document).

Reading guide
The tool catalogue will start with a short theoretical introduction on framing and frame-based information tools (Chapter 2). Following, the document will present examples of frame-based tools (Chapter 3). They are categorized into the decision strategy (Table 1) they are most suitable for. Per strategy, several full descriptions will be presented, plus a number of short descriptions intended for comparison and as eye-opener.

References in full tool-descriptions are listed directly below the description; all other references are listed in Chapter 4.

2. Frame-based approach to decision-making

2.1. Overview of the approach

Climate change raises a lot of questions about the decisions that have to be taken. The present section provides an overview of a frame-based approach to situated-decision-making on these issues. More particularly, it will explain how decision-making may gain from making frames more explicit. One of the crucial points is that there are some very contrasting ways in which climate change may be framed. These frames are directly relevant for identifying the main uncertainties that should be taken into account in developing a decision strategy. Based on these uncertainties, four types of decision strategy will be characterized. Each strategy can be elaborated to find the most appropriate methods and tools, as well as the most appropriate social structure for the strategy. As this section is devoted to an overview of the approach, details are presented in separate boxes.

Rationale

The central characters of this section are members of a decision unit who have the responsibility, or authority or power to choose for an organization or a broader social system. The nature of their position often calls for decision-making that is highly sensitive to the specifics of a situation and that can stand in the service of adequate action. However, guides to decision-making generally ignore the specifics, focusing largely on methods and tools that abstract information out of situations without any reflection on the context. That might be one of the reasons why there has recently been a certain backlash against the analytical, quantitative and information technology-driven approach to decision-making [Burgess et al., 2007]. Hence, a fresh approach to decision-making is necessary that fruitfully combines various methods and tools.

Situated decision-making requires strategies that enable a decision unit to be informed by a rich store of information and, at the same time, ensure a degree of flexibility and adaptability [Lindblom, 1990; Thompson, 2003; Thompson and Tuden, 1959]. However, awareness of strategy use is something that conventional approaches to decision support often neglect. The point is that developing a strategy for this type of decision-making strongly depends on the way in which members of the decision unit and all stakeholders frame the specifics of the situation. As the following

two questions demonstrate, discussions about climate change may frame the problem in different ways.

- The first question is “How can we reduce uncertainty in our estimates of future climatic conditions and how climate change will impact us?”
- The second question is “Given that there is considerable uncertainty about our future, how can we best manage this coastal area to reduce risk and increase system resilience?”

Obviously, the first question can be an excuse for delaying action. In contrast, the latter question is far more action related. It is the contrasting impact of these questions that explains why situated decision-making may gain by making frames more explicit.

Frames

Frames are generally conceived as organizing principles that enable a person to predict and qualify the continuous changes in his or her environment as a basis for action [Chong and Druckman, 2007; Graf, 2006]. Frames are not just personal mindsets but mainly cultural structures that shape in a “hidden” and taken-for-granted way how social actors interact with other actors and take shared or opposing positions regarding an issue [Schön and Rein, 1994]. Given the dominant role of scientists in discussions on climate change, this topic may be framed as a science-related issue.

Interestingly, science-related issues are often linked to a few frames that consistently appear across different policy areas [Gamson and Modigliani, 1989; Nisbet, 2009]. Pesticides, for example, have been framed as a blessing for humanity, but also as Pandora's box, a matter of responsible use or abuse of science in decision-making and a key factor to keep certain industries competitive. At a more general level, these frames can be characterized in terms of two dimensions, namely promotion versus prevention and holistic versus analytical orientations. Figure 1 presents the two dimensions and the four cells that indicate how climate change may be framed.

The four cells in Figure 1 illustrate that there are major differences between the ways in which climate-related issues are being framed. Without going into details, it can be said that Al Gore’s movie, *An Inconvenient Truth*, reflects holistic and moral thinking

about climate change, calling for precaution in the face of potentially catastrophic impacts. In the Netherlands, the report by the second Deltacommittee takes a more analytical approach, drawing on the latest scientific insights on plausible upper limits of regional sea level rise.

	Promotion orientation	Prevention orientation
Holistic approach	**Social progress frame** defines the issue as improving quality of life or harmony with nature **Middle way frame** puts the emphasis on finding a possible compromise position between polarized views > Plan for a tulip-shaped island	**Morality/ethics frame** defines the issue in terms of right or wrong; respecting or crossing limits **Pandora's box frame** defines the issue as a call for precaution in face of possible impacts or catastrophe > Al Gore, An inconvenient truth
Analytical approach	**Economic development frame** defines the issue as investment that improves competitiveness **Conflict/strategy frame** defines the issue as a game among elites, a battle of personalities or groups > Climate Proof City	**Scientific uncertainty frame** defines the issue as a matter of what is known versus unknown **Public accountability frame** defines the issue as responsible use or abuse of science in decision-making > Report Second Deltacommittee

Figure 1. Science-related frames applied to climate change.

In turn, both prevention-oriented frames contrast with two promotion-oriented frames. These frames may be linked to the notion of a "climate proof city", such as the city of Rotterdam, which emphasizes its competitiveness by advertising its various strengths. A more holistic example is the plan for a tulip-shaped island near the Dutch coast, as a means of reconciling the objectives of land reclamation and coastal management.

It should be emphasized that Figure 1 is meant to improve our understanding of the various ways in which climate change may be framed. There is no reason to claim that a certain frame is always better than the others. Each frame may have its strengths and weaknesses in articulating the specifics of a situation. For a decision unit, therefore, it may be fruitful to use more than one frame after another.

Decision strategies

The four combinations of the two dimensions do not only generate diverging representations of climate-related issues, but they also suggest appropriate ways to deal with them. That is, decision-making can be made more sensitive to the specifics of a situation

by taking into account the frames that accentuate promotion and prevention orientations combined with holistic and analytical approaches. This can be specified as follows.

- Examining promotion and prevention orientations may reveal opposing preferences regarding the possible outcomes of a decision; these preferences may be reconciled, for example, by a middle way frame to find a compromise solution.
- Examining holistic and analytical approaches may show diverging beliefs about the cause/effect relations that are instrumental for what the decision might actually accomplish; these beliefs may be reviewed, for example, using a scientific uncertainty frame to distinguish what is known from what is not known in science.

These examples demonstrate that there is an important link between the various frames and the development of a decision strategy. Beliefs about the cause/effect relations that are instrumental for what the decision might actually accomplish and preferences regarding the possible outcomes of the decision are the two basic dimensions of decision that should be considered in the development of a decision strategy [Thompson, 2003; Thompson and Tuden, 1959]. Depending on the specifics of the situation, both dimensions can take a range of values. However, for the sake of clarity of the presentation, they are often dichotomized: members of the decision unit perceive certainty or uncertainty regarding causation and certainty or uncertainty regarding outcome preferences.

Figure 2 presents the patterns of uncertainty of the two dimensions. Whether cause/effect relations are uncertain may depend on several conditions, such as the decision unit's belief that the existing knowledge is incomplete, that there is inherent uncertainty or uncertainty due to competition with rivals. Outcome preferences can become uncertain in situations where an individual or organization appears to hold opposing preferences regarding the outcomes of possible actions. An additional type of uncertainty may occur when there are external constraints. This means that the decision unit is dependent on others who hold veto power over some possible preferences. This is an important aspect of climate-related issues, because they will become manifest at a variety of spatial scales and political levels.

Figure 2 also provides logical links between uncertainties and strategies of decision-making. Members of the decision unit who are confronted with uncertainties regarding causation and outcome preferences should adapt their decision strategy to these issues [Thompson, 2003; Thompson and Tuden, 1959]. Provided that there is at least a certain degree of commitment to reaching agreement, they may choose one of the four types of decision strategies (see Figure 2.

- If there is certainty regarding both causation and outcome preferences, decision-making is relatively straightforward, although it may require a computational strategy to process voluminous data.
- If outcome preferences are clearly known and shared but cause/effect relations are uncertain or disputed, the decision unit must rely on a judgmental strategy to find a solution.
- In contrast, if cause/effect relations are certain but outcome preferences are uncertain or disputed, the decision unit needs a compromise strategy to identify a common preference.
- Finally, if both causation and outcome preferences are uncertain or disputed, the most likely action of the decision unit is to avoid any decision on the issue, unless an inspirational strategy can be introduced to create a new vision or belief.

		Preferences regarding possible outcomes: Certain	Preferences regarding possible outcomes: Uncertain
Beliefs about cause/effect relations: Certain		Causation and outcome preferences are certain – data are voluminous **Computational strategy**	Uncertain due to - opposing preferences - external constraints **Compromise strategy**
Beliefs about cause/effect relations: Uncertain		Uncertain due to - incomplete knowledge - inherent uncertainty - competition with rival decision-makers **Judgmental strategy**	Uncertain due to - a combination of reasons **Inspirational strategy**

Figure 2. The two basic dimensions of decision combined to identify different decision strategies [after Thompson, 2003].

Methods and tools

Each decision strategy can be elaborated to find the most appropriate methods and tools. Figure 3 provides a number of methods and tools that are relevant for each of the strategies. A computational strategy can be based on well-known tools such as cost-benefit analysis tools. Relatively novel tools, such as checklist for judging model quality and uncertainties, may support a judgmental strategy. In the context of a compromise strategy, negotiation tools can be applied to find a common preference. Finally, an inspirational strategy may include the development of learning-scenarios. It should be noted that each of the methods and tools has built-in frames that fit the strategies (see Chapter 3).

Beliefs about cause/effect relations	Preferences regarding possible outcomes: Certain	Preferences regarding possible outcomes: Uncertain
Certain	**Computational strategy** Cost-benefit analysis tools Multi-criteria analysis tools Accounting tools and physical analysis tools	**Compromise strategy** Participative tools, e.g. stakeholder analysis and focus groups Argumentation support tools Negotiation tools
Uncertain	**Judgmental strategy** Scenario analysis tools, expert panels, simulation gaming Model tools (biophysical, socio-economic, or integrated) Checklists for judging model quality and uncertainties	**Inspirational strategy** Cognitive aids, e.g. checklists for prompting new ideas Development of learning-scenarios

Figure 3. Methods and tools that are relevant for the decision strategies.

Social settings

When members of the decision unit want to adapt their decision strategy to the uncertainties regarding causation and outcome preferences, they also have to consider the social structures that are appropriate for the issues [Thompson, 2003; Thompson and Tuden, 1959]. For example, a computational strategy that is based on cost-benefit analysis should take into account that this tool can only be applied meaningfully under specific conditions. Compliance with certain rules and conventions regarding the choice of discount rates is crucial to provide comparative insights into the financial costs and benefits of the options. Accordingly, the most appropriate setting for the use of cost-benefit analysis may be a bureaucratic structure that guaranties that every issue is routed to the appropriate specialist.

Figure 4 displays the most appropriate social structures for each of the strategies. If causation is uncertain or disputed, a judgmental strategy is called for; this may require a collegial structure, such as a self-governing voluntary group that is competent by virtue of their expertise to make a judgment. If none of the experts has indisputable and complete evidence, no member should be allowed to outvote or override the judgment made by other members and a majority judgment may be necessary.

If there is agreement by all parties regarding the expected consequences of the available alternatives but lack of consensus over preferences, a compromise strategy has to be developed. The most appropriate setting to handle compromise types of issues economically and efficiently is a representative structure of intermediate size that facilitates detailed and subtle exploration of the several preferences.

The fourth type of issue is one in which both causation and outcome preferences are uncertain or disputed. These conditions make it difficult for all parties to prevent disintegrating tendencies, such as loss of contact or decreasing commitment to reaching agreement. Therefore, the decision unit may try to avoid any decision on the issue, unless a new vision or belief can be developed. Harnessing the inspirational aspects of a decision strategy may require an informal setting that offers incentives for collective problem solving. Such a creative kind of activity may be stimulated by charismatic leaders or successful models of new visions.

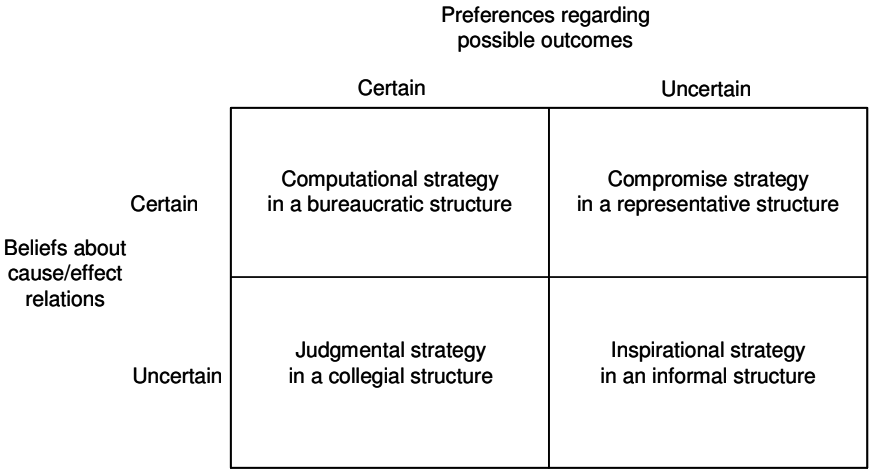


Figure 4. Different social structures that fit the decision strategies.

Generally, the notion that there should be a match between decision strategy and social structure implicates that a decision unit may not be in a position to change its strategy. For example, a decision unit that operates in the context of a bureaucratic structure may not have room for another type of strategy than a computational one. If an organization, such as a planning bureau, adopts one of the four decision strategies as its dominant strategy, it may have to cooperate with other organizations to exercise a different kind of strategy. Alternatively, it may be necessary to create a novel decision unit to address issues for which traditional structures are ill suited.

Combining multiple approaches
Taken together, the insights on the relationship between frames, uncertainties, decision strategies and social settings may contribute to a more in-depth understanding of the information tools that can be used to support situated decision-making. This may create a better match between supply and demand of information among all the people involved, i.e. knowledge producers, decision-makers and stakeholders.

Managing the decision process may significantly facilitate decisions. As long as the decision process has not been successfully completed, the members of a decision unit should repeatedly ask themselves whether they are still on the right track. There are a variety of reasons why adjustments may be appropriate. Obviously, strategy development has to be responsive to cues that crucial circumstances are changing or that a strategy is failing.

As a group changes its beliefs about cause-and-effect relations, for example, types of issues that at one time are identified as appropriate for a judgment strategy may at another time be defined as computational problems, or vice versa. If the competence of a single expert becomes doubted, issues may be defined as calling for judgment rather than computation.

Also, different members of a decision unit may respond to the same situation in different ways, some seeing it as a matter for computation, others as a judgment matter, and still others as requiring bargaining. During the process, they may also change their frames and strategies. This does not have to be a problem as long as they are aware of what they are doing. Generally, it may be

very fruitful to use more than one frame and more than one strategy after another.

Reframing can play an important role in opening-up processes of decision-making [Schön and Rein, 1994]. Presenting alternative formulations of the same situation to the people involved can make different aspects of it salient. Creating a different storyline is the rhetorical beginning of reframing. If a project has to undergo a mid-term evaluation, for example, strategic reframing may be used in talking up or talking down of expectations about the project's outcomes. In other cases, it may be necessary to reframe an issue in order to evoke a different way of thinking. Many failures in problem solving result not from the lack of appropriate knowledge but from the inability to recognize when that knowledge is appropriate to a new situation.

2.2. More details about strategy development

The present Guide uses a frame-based approach to structure the development of various decision-making strategies. It also considers the built-in frames of methods and tools that fit these strategies and provides a catalogue of relevant options. To start with, two overarching considerations should be mentioned, because they can have large impacts on strategy development. The first one refers to the time dimension, the second to pre-existing conflicts.

Time dimension

Where a time dimension is not clearly implied by the nature of the issue to be decided, the role of decision support is to specify such a dimension. In cases related to climate change, both short-term and long-term views are relevant. A really long-term view is necessary to capture the possibilities of extreme changes in climate and land use. However, a long-term perspective that goes far beyond the conventional planning horizon exceeds the capabilities of the available decision-support tools. Members of a decision unit may have to be enabled to flexibly move up and down the "time ladder", for example, to explore whether or not it is allowed to attend a set of problems in a sequential fashion.

Pre-existing conflicts

If the issue to be decided is linked to serious pre-existing conflicts, strategy development should first create a more neutral starting point. If there is a heated controversy, some groups are better able

to cope than others and science, in particular, should not become the servant of one set of interests. Accordingly, the first step should address the main factors that forecast trouble among decision units and stakeholder groups in succeeding steps. This might be done “informally” and it might include the choice as to whether to tackle an issue at all. The crucial point to be achieved is a certain level of commitment to reaching agreement.

Next steps

Decisions do not result from a linear process and they are seldom made at a single point. Yet, for reasons of presentation they are often framed in such a way. Figure 5 gives an outline of the development of a decision-making strategy to support decision units and stakeholder groups. Regarding an issue to be decided, Figure 5 shows a number of key questions for strategy development. The figure also indicates specific considerations that are explained in separate boxes.

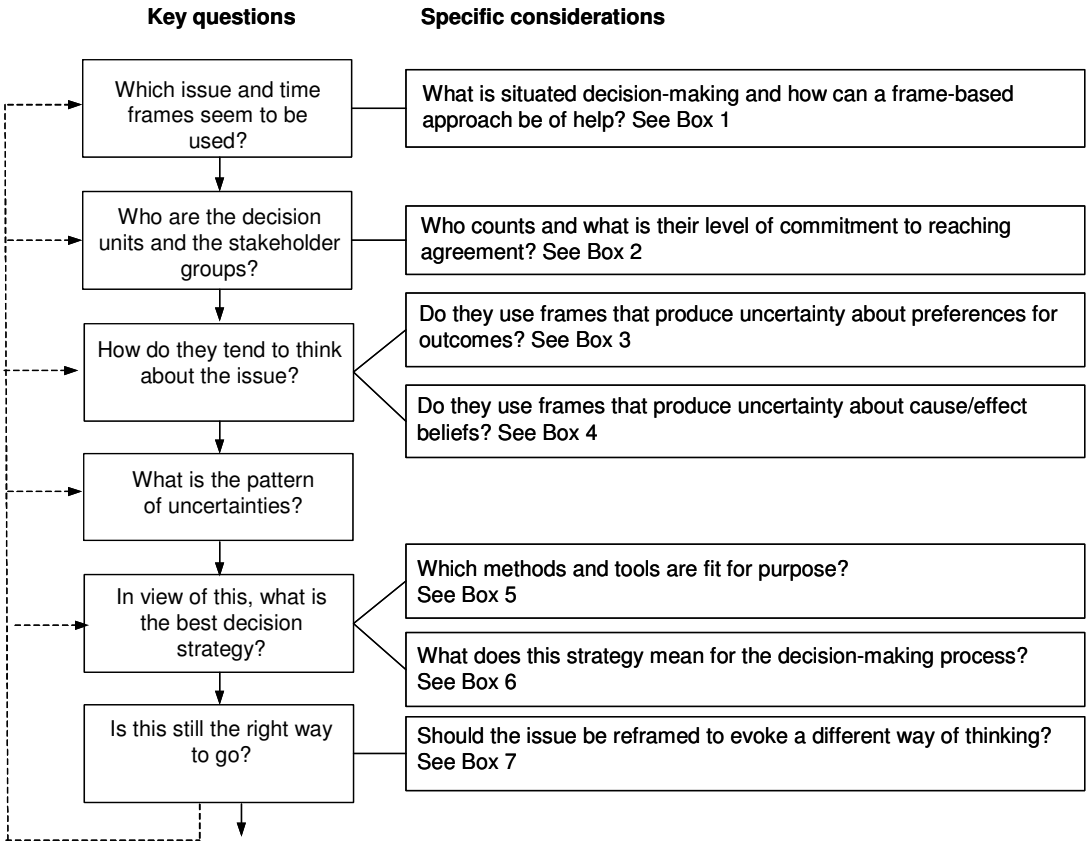


Figure 5. Key questions and specific considerations for strategy development.

The key questions in Figure 5 are meant to summarize the items that have been mentioned briefly in Section 2.1 and will be elaborated in Boxes 1 to 6. Building on the four quadrants of Figure 2, the questions focus on the uncertainties regarding causation and outcome preferences that characterize the decision situation at a certain moment.

The boxes provide more background information on situated decision-making, the role of a frame-based approach, the inclusion of stakeholders, frames that produce uncertainty about preferences for outcomes, frames that produce uncertainty about cause/effect beliefs, the methods and tools that are fit for purpose, the decision-making process, and some ways to reframe a decision situation.

Guided by the answers to the key questions, the reader can choose a strategy and consider some of the tools that have been presented in Figure 3. A number of these tools are introduced in Chapters 3 (inspirational tools), 4 (compromise tools), 5 (judgmental tools) and 6 (computational tools). Each chapter describes some appropriate tools, explains how they take framing into account, and indicates when and how they can best be used.

Box 1. What is situated decision-making and how can a frame-based approach be of help?

Situated decision-making is decision-making that is highly sensitive to the specifics of a situation. It differs from other types of decision-making, which generally ignore the specifics and tend to abstract information out of situations without any reflection on the context. In contrast, situated decision-making is strongly dependent on the way in which members of the decision unit and the stakeholders, including scientists and the public at large, perceive the specifics of the situation. The crucial impact of perceptions may clarify why creating more transparency on the role of frames can support situated decision-making.

Many debates on policy-relevant information are closely related to the ways in which situations are framed. In technical terms, frames are perceptual coordinate systems that align data from memory and data from the environment near to the person. To illustrate this role of frames, Figure 6 shows the processing of information by a person who is exposed to environmental sounds. In processing the sound signals the person will automatically apply speech-frames that classify the sounds, for example, as the voice of a woman (Frame 1) and as English speech (Frame N). Next, it is the combination of these frames that generates the perception of an English-speaking woman.

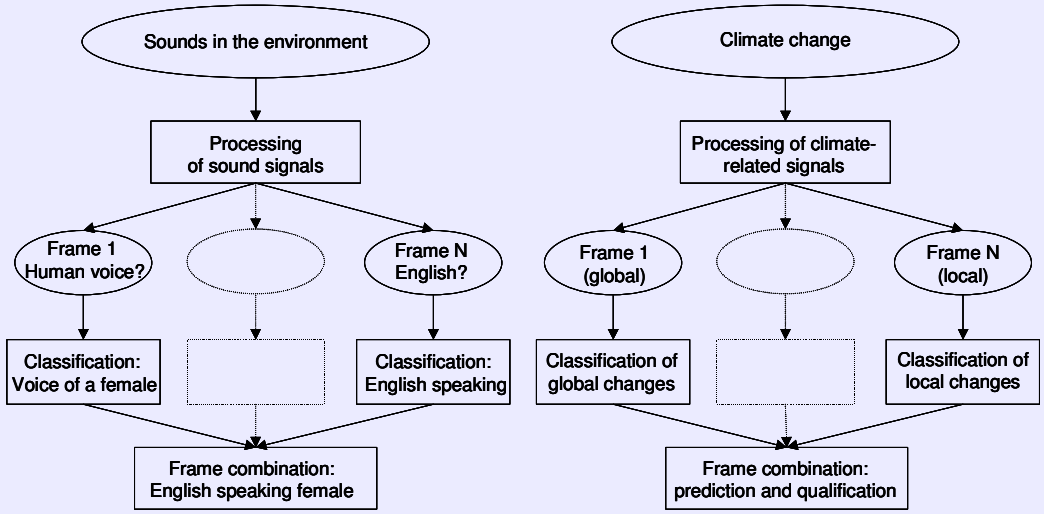


Figure 6. A person's processing of sound signals (left) compared with the processing of climate-related signals (right) to illustrate frame combination.

In the same way, the perception of climate change is also based on the combination of frames (Figure 6). Simply put, the very notion of climate change requires frames to classify global features (e.g. melting ice caps), frames to classify local features (e.g. sea level observation), and ways to combine the frames (e.g. linking changes in sea level to melting ice). In the scientific literature on the physical and biological impacts of anthropogenic climate change this way of combining frames is known as the “joint attribution approach”, which involves a meta-analysis of changes in physical and biological systems [Rosenzweig et al., 2008].

Frames for abstract information processing are storylines and mental models, which demonstrate the relevance of causal thinking for frames and frame combinations. People assume and prefer a common-cause structure regarding "natural" categories. An example is the idea that living things, such as dogs, have an essence that works as a common-cause of all the different dog-like phenomena. In contrast, common-effect models often relate to ideas about artefacts that have been assembled, such as a table; its different constituting elements produce the table-like function as their common effect. Common-cause models, such as the “joint attribution approach” mentioned above, are relatively easy to understand and can flexibly be extended or reduced [Kinchin et al., 2000]. In contrast, common-effect models require more knowledge about the constituting elements and their mutual relationships.

The common-cause model may help people to become aware of the many ways in which climate change can become manifest, such as by changes at the North pole, in the Alps, in sea level and in patterns of rainfall. This may happen even if their understanding of these issues is not completely in line with established scientific knowledge. In contrast, making a country climate proof by adaptation and mitigation measures requires a completely different mental model. Climate proofing should be driven by opportunities for technological, institutional and societal innovations, rather than purely by fear of the negative effects of climate change [Kabat et al., 2005]. Therefore, climate proofing is a common effect of different constituting elements that have to be balanced carefully. The contrast between the two mental models is illustrated in Figure 7.

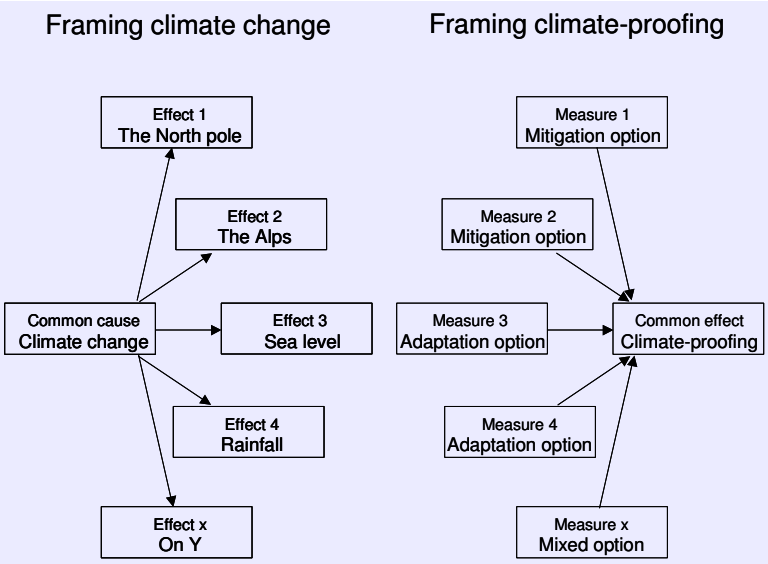


Figure 7. Climate change is a common cause; climate proofing is a common effect.

A better understanding of causal relationships may put a policy issue in a different frame, for example, in relation to common causes or common effects. What is needed for such a conceptual change is, basically, a different interpretation of observations. This is a crucial point because the impacts of policy options on climate change adaptation and mitigation appear to be very context specific [Halsnæs et al., 2007]. In particular, the role of other human-caused environmental changes, such as changes in regional land use patterns, should be taken into account. It is the specific combination of climate change and other environmental changes that may create the most significant impacts for society (i.e. a common-effect model). Consequently, it is extremely difficult, also for skilled decision-makers, to determine the main priorities and avoid short-sighted solutions.

In the case of policy controversies, conflicts of interests have been triggered that may partly be rooted in the frames of the parties involved [Schön and Rein, 1994]. Because divergent frames may have shaped the conflicting policy-positions, it makes sense to reflect on the frames and the ways in which they are combined. Moreover, frames are not only relevant for an understanding of the conflict itself, but also for insight into the type of negotiation that might end it.

An important example is the difference between Eastern and Western approaches to negotiation [Nisbett, 2003]. This difference

can be summarized as follows:

1. Westerners prefer an analytical approach to negotiations based on clear ideas about acceptable deals; negotiations should be short and to the point, because it is the results that count.
- Easterners are more concerned with long-term relationships between the various parties involved; they also tend to emphasize the complex and intertwined nature of the objects of negotiation.

This contrast between Eastern and Western views is part of a pattern of different approaches to the world, which can be illustrated by the typical preferences for grouping revealed by Figure 8. If Westerners are asked to look at Figure 8 and to place two of the three objects together, they tend to choose the chicken and the cow. This response shows a preference for grouping by common category membership (i.e. animals). In contrast, Easterners tend to link the cow and the grass, which reveals their preference for grouping on the basis of thematic relationships (i.e. the cow eats the grass). These different approaches to the world are reflected by the way in which Westerners and Easterners frame negotiations. The differences are not invariant, but they often occur by default.

Figure 8 illustrates that frames include subtle and implicit practices that people often cannot report because they are using them in a taken-for-granted way. Although there are some simple tests to disclose differences in frames among actors, the multitude of frames and frame combinations cannot be measured by standardized tests or self-report inventories. In addition, it should be mentioned that the development of a decision strategy would not gain by making all frames more explicit.

Figure 8. Preference for grouping: Which two go together and are different from the third? [Nisbett, 2003, p. 141].

A frame-based approach

To support decision-making, a reasonable strategy is to use some relatively broad patterns of frames that can represent different approaches to the world. These patterns are associated with the issue at hand and the distinctive way in which members of the decision unit and stakeholders interpret the issue.

Issue and time frames refer to the taken-for-granted interpretation that bears on a particular issue, problem or set of events. For instance, an issue may generally be seen in terms of short-term or long-term environmental policy-making. Accordingly, the question "which issue and time frames seem to be used?" may be relatively easy to answer.

The distinctive way in which members of the decision unit and stakeholders interpret the issue may be less easily recognized. It may require an in-depth understanding of certain patterns. The patterns of frames that may become particularly relevant include differences between promotion and prevention orientations (i.e. systems of motivation) and between analytical and holistic approaches (i.e. systems of thought). These patterns can significantly contribute to at least one type of uncertainty in the decision-making process, mentioned in Figure 2. Moreover, their presumed impact can be supported by evidence from empirical research. The special role of these frames will be highlighted in Boxes 3 and 4.

Box 2. Who counts?

Stakeholders are persons, groups and organizations who have a stake in the issue at hand, as they are affected by the decision's outcomes. What is at stake may be their demand to be consulted on the relevant issues or their position in a conflict of interests. In environmental decision-making the stakeholders may include competing research groups, small or large businesses, environmental organizations, the general public and even nation states. Although stakeholders may disagree on all kinds of issues, the crucial point for strategy development is that they show at least a certain degree of commitment to reaching agreement.

In a frame-based approach, stakeholders are particularly important because they may bring in patterns of frames that provide an additional perspective on the issue. One of the drawbacks of a single perspective is that it tends to induce passive acceptance of the information given [Kahneman, 2003]. A relatively novel strategy is to involve experts from disciplines that are closely linked to different perspectives, such as economists, ecologists and political scientists. A similar strategy is to include stakeholders from the appropriate sectors of society, such as industry, NGOs and citizen groups.

Clearly, there are also reasons not to include too many stakeholders in the decision-making process. One way to prevent overload is to focus on stakeholder groups instead of separate individuals. The decision strategy may aim to include those groups who can potentially put forward arguments based on legitimate (local) concerns, credible (local) knowledge and/or an additional perspective on the issue. Table 2 can be used to summarize these considerations for each group.

Table 2. Matrix to summarize reasons for the inclusion of stakeholder groups.

Stakeholder group		**Contribution adds**	
	Legitimate (local) concerns	Credible (local) knowledge	Additional perspective
Group 1 (…) Group N			

The role that stakeholders may play in the decision-making process depends on their impact on uncertainty about preferences for outcomes (Box 3) and cause/effect beliefs (Box 4). The pattern of uncertainty is relevant for the choice of a decision strategy and the further selection of the appropriate tools (Box 5) and an institutional structure (Box 6).

Box 3 Do they use frames that produce uncertainty about preferences for outcomes?

The way in which decision-makers and stakeholders think about the issue may reveal certain patterns of relevant frames. Two relatively independent patterns of frames involve a promotion or prevention orientation to goal-directed behaviour [Higgins, 1997; 2000]. Generally, a promotion orientation makes the person sensitive to positive outcomes and hits that may be gained through aspirations, accomplishments, and ideals. In contrast, a prevention orientation makes the person sensitive to negative outcomes and errors that have to be avoided by fulfilling one's moral obligations and responsibilities. This difference is not just a matter of personal mindsets – the orientations can be associated with certain institutions, subcultures within an organization, or occupational groups. Engineers, for example, are said to be safety oriented and inclined to "overdesign" for safety [Schein, 1996].

If promotion oriented and prevention oriented groups participate in the same decision-making process, they may create uncertainty about preferences for outcomes. For example, one group may emphasize opportunities to improve the natural quality of a coastal area and the other groups may fear that this plan will hamper future safety measures. It should be emphasized that there is nothing wrong with the fact that there are opposing preferences. The only point for the present discussion is that these opposing tendencies should be taken into account in the development of a decision strategy.

Table 3 specifies a number of linkages between promotion or prevention orientation and types of uncertainty. The input for the table is based on theoretical and empirical research into differences between the two orientations; the specific links with types of uncertainty are based on interpretations of the findings, made for the purpose of this table.

Promotion orientation and prevention orientation may not just accentuate opposing preferences but also opposing decision rules. A promotion oriented decision rule will focus on choosing the best alternatives from the choice set; a prevention oriented decision rule tends to focus on rejecting unacceptable alternatives from the choice set. There may also be a link with external constraint, as prevention orientation articulates moral obligations and

responsibilities.

In addition, promotion orientation and prevention orientation may create uncertainty about cause/effect beliefs. The two orientations may accentuate opposing ways of coping with risks. For instance, prevention orientation makes a person vigilant to avoid errors, such as decision-making under incomplete knowledge. A promotion orientation may be relevant for competition with other decision-makers.

Table 3. Linkages between promotion or prevention orientation and types of uncertainty.

	Promotion orientation ("ideal or gain frame")	**Prevention orientation ("ought or loss frame")**
Main characteristics*)	Makes the person sensitive to positive outcomes that may be gained through aspirations, accomplishments, and ideals Sustained by eagerness and doing extra things	Makes the person sensitive to negative outcomes that have to be avoided by fulfilling one's moral obligations and responsibilities Sustained by vigilance and being careful
Link with uncertainty due to opposing preferences	Promotion orientation and prevention orientation may accentuate opposing preferences and opposing decision rules	
	Promotion orientation is focused on choosing the best alternatives from the choice set	Prevention orientation is focused on rejecting unacceptable alternatives from the choice set
Link with uncertainty due to external constraints		Prevention orientation articulates moral obligations and responsibilities, which may work as external constraints
Link with uncertainty due to incomplete knowledge	Promotion orientation and prevention orientation may accentuate opposing ways of coping with risks	

	Promotion orientation makes person eager to accept risks (including the risk caused by incomplete knowledge)	Prevention orientation makes person vigilant to avoid errors, such as decision-making under incomplete knowledge
Link with uncertainty due to system dynamics		
Link with uncertainty due to competition with other decision-makers	Promotion orientation articulates aspirations and accomplishments, which can make the person feel eager for competition	

*) See Higgins [1997; 2000; Higgins et al., 2003].

Box 4. Do they use frames that produce uncertainty about cause/effect beliefs?

Two other relatively independent patterns of frames involve analytical and holistic approaches to the world [Nisbett, 2003]. An analytical approach views the universe as composed of independent objects; a holistic approach assumes that every element in the world is somehow interconnected. Again, this difference is not just a matter of personal mindsets or separate cultures. These approaches can be conceptualized as two systems of thinking, each of which may have become more useful and more available in one culture than in another. Therefore, the approaches may be associated with certain institutions, subcultures within an organization, or occupational groups. Engineers, for example, are said to be pragmatic perfectionists who prefer "people free" solutions (designing humans out of the systems rather than into them) based on linear, simple cause-and-effect, quantitative thinking [Schein, 1996].

If analytical and holistic oriented groups participate in the same decision-making process, they may create uncertainty about cause/effect beliefs. For example, groups with either analytical or holistic approaches have different notions of causal relationships and will fill in incomplete data in different ways. When predicting future events, an analytical thinking person tends to abstract from existing patterns of change or stability that have been displayed in the past and chooses a linear perspective. In contrast, a holistic thinking person tends to choose a cyclical view that assumes constant fluctuations because of the complex pattern of interactions among the elements.

Table 4 specifies a number of linkages between analytical or holistic approaches and types of uncertainty. The input for the table is based on theoretical and empirical research into differences between the two approaches; the specific links with types of uncertainty are based on interpretations of the findings, made for the purpose of this table.

Analytical and holistic approaches may not just accentuate different notions of causal relationships, but also different ways of dealing with opposing preferences. For instance, an analytical approach to negotiations will be based on clear ideas about acceptable deals. This approach tends to focus on opposite

preferences and wants non-contradictory arguments in favour or against them. In contrast, a holistic approach is more concerned with long-term relationships between the various parties involved. This approach tends to pursue compromises and may accept apparently opposite propositions because one of them may be eventually transformed into the other. The holistic approach may also identify more external constraints that have to be incorporated.

Table 4. Linkages between analytical or holistic approaches and types of uncertainty.

	Analytical approach	**Holistic approach**
Main characteristics*)	Views the universe as composed of independent objects Sees individual parts with more ease than "the whole picture"	Assumes that every element in the world is somehow interconnected Sees "the whole picture" with more ease than individual parts
Link with uncertainty due to incomplete knowledge	Analytical and holistic approaches have different notions of causal relationships and will fill in incomplete data in different ways	
	Tends to abstract from similar patterns of change or stability that have been displayed in the past; chooses a linear perspective when predicting future events	Tends to choose a cyclical view that assumes constant fluctuations because of the complex pattern of interactions among the elements
Link with uncertainty due to system dynamics	Is less willing to accept inherent uncertainty if it reduces the predictability of an object	Is more willing to accept inherent uncertainty due to complex causalities
Link with uncertainty due to competition with other decision-makers	Tends to expect a game-theoretic approach	
Link with uncertainty due to opposing preferences	Analytical and holistic approaches will consider patterns of existing preferences in different ways	

	Has clear ideas about acceptable deals; tends to focus on opposite preferences and wants non-contradictory arguments in favour or against them	Is concerned with long-term relationships; tends to pursue compromises and may accept apparently opposite propositions because one of them may be eventually transformed into the other
Link with uncertainty due to external constraints	Sees less external constraints	Sees more external constraints

*) See Nisbett [2003].

Box 5. Which methods and tools are fit for purpose?

The way in which members of the decision unit and stakeholders interpret the issue at hand may have been framed by promotion or prevention orientations and analytical or holistic approaches. Figure 9 provides some examples of combined frames, which suggest that engineers may typically combine an analytical approach with a prevention orientation. Although this is in line with the engineers' image in the literature [Schein, 1996], it should be emphasized that the examples in Figure 9 are meant for illustrative purposes only. The examples show large differences in framing between "issue sellers" (who want to draw key decision-makers' attention to a particular issue), big picture planners, engineers and conservationists. Yet, the crucial point for strategy development is their joint impact on the pattern of uncertainties.

	Analytical approach	Holistic approach
Promotion orientation	Is sensitive to positive outcomes that may be gained. Sees individual parts with more ease than "the whole picture" e.g. issue sellers	Is sensitive to positive outcomes that may be gained. Sees "the whole picture" with more ease than individual parts e.g. big picture planners
Prevention orientation	Is sensitive to negative outcomes that have to be avoided. Sees individual parts with more ease than "the whole picture" e.g. engineers	Is sensitive to negative outcomes that have to be avoided. Sees "the whole picture" with more ease than individual parts e.g. conservationists

Figure 9. Examples of combined frames (made for illustrative purposes).

Members of the decision unit who are confronted with uncertainties regarding causation and outcome preferences should adapt their decision strategy to these issues [Thompson, 2003; Thompson and Tuden, 1959]. Provided that there is at least a certain degree of commitment to reaching agreement, they may choose one of the four types of decision strategies (see Figure 10).

- If there is certainty regarding both causation and outcome preferences, decision-making is relatively straightforward, although it may require a computational strategy to process voluminous data.
- If outcome preferences are clearly known and shared but cause/effect relations are uncertain or disputed, the decision

unit must rely on a judgmental strategy to find a solution.

- In contrast, if cause/effect relations are certain but outcome references are uncertain or disputed, the decision unit needs a compromise strategy to identify a common preference.
- Finally, if both causation and outcome preferences are uncertain or disputed, the most likely action of the decision unit is to avoid any decision on the issue, unless an inspirational strategy can be introduced to create a new vision or belief.

Beliefs about cause/effect relations	Preferences regarding possible outcomes: Certain	Preferences regarding possible outcomes: Uncertain
Certain	Causation and outcome preferences are certain – data are voluminous **Computational strategy**	Uncertain due to - opposing preferences - external constraints **Compromise strategy**
Uncertain	Uncertain due to - incomplete knowledge - inherent uncertainty - competition with rival decision-makers **Judgmental strategy**	Uncertain due to - a combination of reasons **Inspirational strategy**

Figure 10. The four decision strategies that address the various uncertainties.

Each decision strategy can be elaborated to find the most appropriate methods and tools. Figure 11 provides a number of methods and tools that are relevant for each of the strategies. A computational strategy can be based on well-known tools such as cost-benefit analysis tools. Relatively novel tools, such as checklist for judging model quality and uncertainties, may support a judgmental strategy. In the context of a compromise strategy, negotiation tools can be applied to find a common preference. Finally, an inspirational strategy may include the development of learning-scenarios.

Beliefs about cause/effect relations	Preferences regarding possible outcomes: Certain	Preferences regarding possible outcomes: Uncertain
Certain	**Computational strategy** Cost-benefit analysis tools Multi-criteria analysis tools Accounting tools and physical analysis tools	**Compromise strategy** Participative tools, e.g. stakeholder analysis and focus groups Argumentation support tools Negotiation tools
Uncertain	**Judgmental strategy** Scenario analysis tools, expert panels, simulation gaming Model tools (biophysical, socio-economic, or integrated) Checklists for judging model quality and uncertainties	**Inspirational strategy** Cognitive aids, e.g. checklists for prompting new ideas Development of learning-scenarios

Figure 11. Methods and tools that are relevant for the decision strategies.

Box 6. What does this strategy mean for the decision-making process?

Institutions and groups have organized themselves differently to address different kinds of decision-making problems [Thompson, 2003; Thompson and Tuden, 1959]. Therefore, when members of the decision unit adapt their decision strategy to the uncertainties regarding causation and outcome preferences, they also have to consider the social structures that are appropriate for the issues. For example, a computational strategy that is based on cost-benefit analysis should take into account that this tool can only be applied meaningfully under specific conditions. Compliance with certain rules and conventions regarding the choice of discount rates is crucial to provide comparative insights into the financial costs and benefits of the options. Accordingly, the most appropriate setting for the use of these tools may be a bureaucratic structure that guaranties that every issue is routed to the appropriate specialist.

Figure 12 displays the most appropriate social structures for each of the strategies. If causation is uncertain or disputed, a judgmental strategy is called for; this may require a collegial structure, such as a self-governing voluntary group that is competent by virtue of their expertise to make a judgment. If none of the experts has indisputable and complete evidence, no member should be allowed to outvote or override the judgment made by other members and a majority judgment may be necessary.

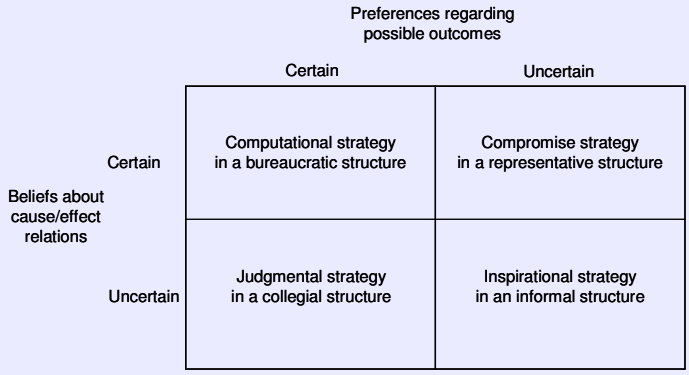


Figure 12. The different social structures that fit the decision strategies.

If there is agreement by all parties regarding the expected consequences of the available alternatives but lack of consensus over preferences, a compromise strategy has to be developed.

The most appropriate setting to handle compromise types of issues economically and efficiently is a representative structure of intermediate size that facilitates detailed and subtle exploration of the several preferences.

The fourth type of issue is one in which both causation and outcome preferences are uncertain or disputed. These conditions make it difficult for all parties to prevent disintegrating tendencies, such as loss of contact or decreasing commitment to reaching agreement. Therefore, the decision unit may try to avoid any decision on the issue, unless a new vision or belief can be developed. Harnessing the inspirational aspects of a decision strategy may require an informal setting that offers incentives for collective problem solving. Such a creative kind of activity may be stimulated by charismatic leaders or successful models of new visions.

Generally, the notion that there should be a match between decision strategy and social structure implicates that a decision unit may not be in a position to change its strategy. For example, a decision unit that operates in the context of a bureaucratic structure may not have room for another type of strategy than a computational one. If an organization, such as a planning bureau, adopts one of the four decision strategies as its dominant strategy, it may have to cooperate with other organizations to exercise a different kind of strategy. Alternatively, it may be necessary to create a novel decision unit to address issues for which traditional structures are ill suited.

Box 7. Should the issue be reframed to evoke a different way of thinking?

Managing the decision process may significantly facilitate decisions. As long as the decision process has not been successfully completed, the members of a decision unit should repeatedly ask themselves whether they are still on the right track. There are a variety of reasons why adjustments may be appropriate. Thompson and Tuden [1959] already referred to confusion of issues, structural constraints, inappropriate decision units and expansion tendencies in decision issues. Obviously, strategy development has to be responsive to cues that crucial circumstances are changing or that a strategy is failing.

As a group changes its beliefs about cause-and-effect relations, types of issues that at one time are identified as appropriate for a judgment strategy may at another time be defined as computational problems, or vice versa. The latter may occur if the competence of a single expert becomes doubted and issues are defined as calling for judgment rather than computation. Also, different members of a decision unit may respond to the same situation in different ways, some seeing it as a matter for computation, others as a judgment matter, and still others as requiring bargaining.

In addition, both a judgmental and a compromise strategy may fail due to increasing tendencies of polarization The heat of debate can lead experts who endorse a particular solution to overstate their case, discount missing information and refer to moral justification for the solution they prefer. When this occurs, the issue is no longer one of judgment but one of compromise.

Similarly, an issue that seems fit for bargaining may generate difficulties in the identification and exploration of causation. In this context, proponents may discount causation theories endorsed by their opponents and dismiss the corresponding “facts”. As a result of this polarization, all parties may start to threaten each other with trouble on unrelated matters.

Reframing can play an important role in opening-up processes of decision-making [Schön and Rein, 1994]. Presenting alternative formulations of the same situation to the people involved can make different aspects of it salient. Creating a different storyline is the

rhetorical beginning of reframing. If a project has to undergo a mid-term evaluation, for example, strategic reframing may be used in talking up or talking down of expectations about the project's outcomes. In other cases, it may be necessary to reframe an issue in order to evoke a different way of thinking. Many failures in problem solving result not from the lack of appropriate knowledge but from the inability to recognize when that knowledge is appropriate to a new situation.

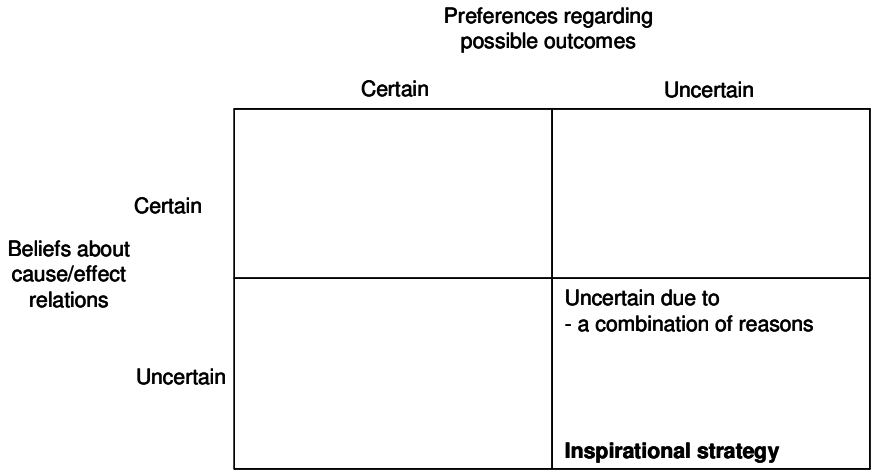
Two substantive ways to reframe a decision situation are connected with mental models and goal hierarchies. A crucial way to reframe a situation may result from changes in people's mental models of a topic, such as implicit causal beliefs concerning interrelationships in nature. Given the relevance of causal thinking for concept formation, a better understanding of causal relationships may put an issue in a different frame, for example, in relation to time and space.

Another way of reframing is to consider a higher level in the hierarchy of goals. For example, it may be helpful to put climate change adaptation and mitigation in the context of a higher-level objective, such as sustainable development. Emphasizing the functional relationship with sustainable development makes it easier to combine the impacts of adaptation and mitigation with those of other environmental changes. Placing a particular issue in a larger context is not only relevant to handle bargaining issues, but it can also help to crystallize consensus about preferences if the parties involved are unaware of the similarities of their preferences.

Members of a decision unit should be enabled to flexibly move up and down the levels in the hierarchy of goals. Just focussing on long-term goals may frustrate the decision-making process. When they face an important and complicated issue, it may become necessary to redefine this issue into a series of smaller issues that can each be addressed by an appropriate strategy.

3. Examples of inspirational tools

Starting with a description of decision support that fits into an inspirational strategy, this chapter provides a number of examples of frame-based tools. An inspirational strategy is appropriate if the members of a decision unit are confronted with uncertainties regarding both the cause/effect relations that are instrumental for what the decision might actually accomplish and preferences regarding the possible outcomes of the decision. The strategy aims to create a new vision or belief.



Most relevant tools

- Cognitive aids for problem structuring, e.g. checklists for prompting new ideas
- Goal-hierarchical reframing

Most appropriate setting

- Informal structure (collective problem-solving stimulated by charismatic leader)

The notion of creativity may be an important ingredient of inspirational tools. Hence, it should be mentioned that there are diverging views on creativity. Some people tend to emphasize the value of spontaneous insight and the magical “Aha!” moment that occurs when a long-sought idea suddenly appears at the conscious level. Other people emphasize systematic approaches to exploring problems and potential solutions.

This Guide is based on the idea that the two approaches do not have to be incongruent. The occurrence of insight is often associated with restructuring or reframing a problem space, for example, from a broader perspective (e.g. see Section 3.2). In fact, both approaches should be supported by good preparation and the participation of people who have good knowledge about a

particular domain and who are able to think flexibly and synthetically.

3.1. Cognitive aids for problem structuring

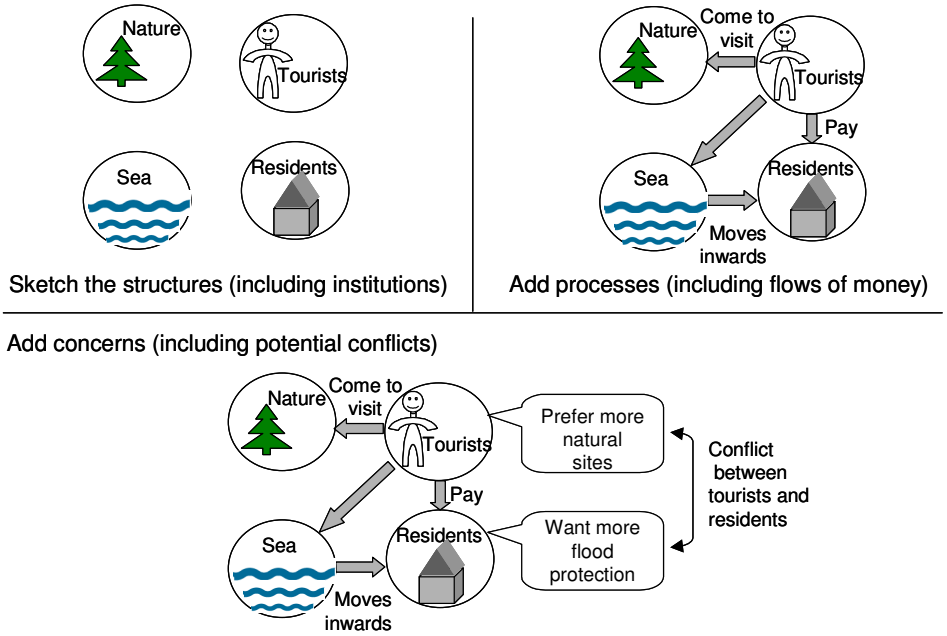
1. Short description
A variety of cognitive aids for problem structuring has been developed to support individuals or groups at the beginning of the decision-making process. The aids include tools, such as lists, maps, and pictures, which are used to gain a preliminary understanding of the problem to be solved and some innovative ideas about potential solutions. The aids also include the family of soft Operation Research (OR) tools that apply modelling approaches to address messy or wicked problems. Depending on the field in which the aids are applied, they may be bound by specific conventions, but it is not possible to set out all those details here.

2. How do the aids take framing into account?
By their very nature, cognitive aids are strongly dependent on the potential of frames to organize information processing. Basically, the aids stimulate thinking by creating a tentative representation of the problem, so that various elements can be identified, grouped and criticised. The aids can be divided into those that:

- Look for connectivity, storylines, networks (i.e. horizontal relationships);
- Develop part-whole relationships and hierarchies (i.e. vertical relationships);
- Seek perspectives or contrasts (i.e. matched opposites)
- Provide context-dependent prompts (i.e. theoretically-grounded checklists).

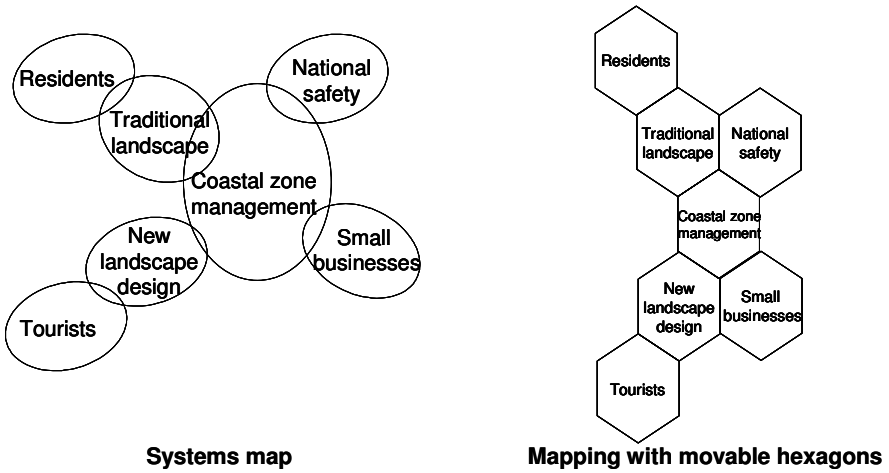
Pictures and maps
Several tools may stimulate a person to think thoroughly about the nature of a complex situation by specifying connections between diverging elements. The idea of using sketches or "*rich pictures*" (see drawing) is, in particular, linked to Checkland's Soft Systems Methodology [Checkland, 2000[. The pictures are drawn to explore which parts of the situation should best be regarded as structure and which as process. The first step is to look for the parts of the situation that change relatively slowly over time and are relatively stable (e.g. institutions). The next step is to seek things that are in a state of change, such as the activities that are going on. Then additional elements are included, such as stakeholders' concerns that indicate how the structure and the processes interact. This

may give the analyst more insight into the quality of the situation, such as the potential for conflicts.



Rich picture

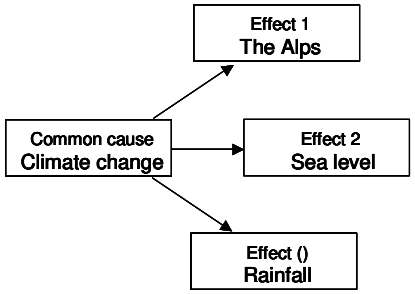
Pictures and maps can become rather complicated. From a philosophical perspective, it may even be necessary to include the analyst in the picture as someone who is not just a bystander but a person with perceptions and concerns. Alternatively, a relatively free form approach is drawing a "*systems map*" to visualize all kinds of associations regarding an issue and the way it is related to other issues (see drawing). A comparable type of visual facilitation uses *movable hexagon cards* for creative thinking about key issues [Hodgson, 1992; see drawing].



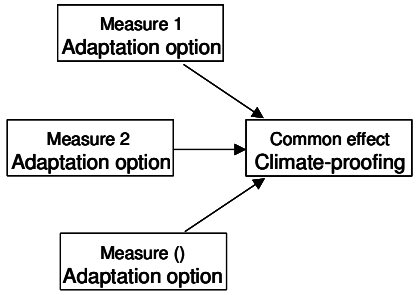
Systems map

Mapping with movable hexagons

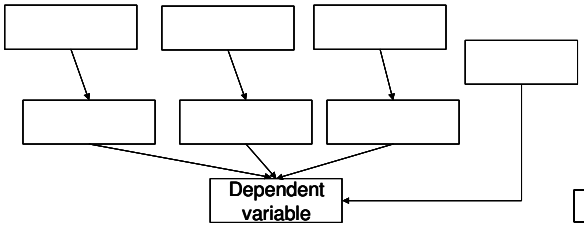
Ordered diagrams
Various types of ordered diagrams can be used as a framework to sketch the characteristics of a concept or the relationships between concepts. The diagrams are often based on implicit causal models of the relevant phenomena. *Common-cause models* and *common-effect models* (see drawing) are important frames for abstract information processing about a concept.



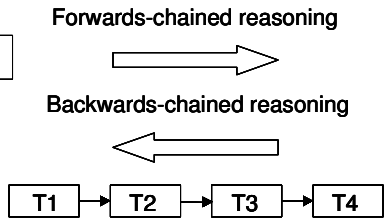
Common cause model



Common effect model



Influence diagram



Storyline of a scenario

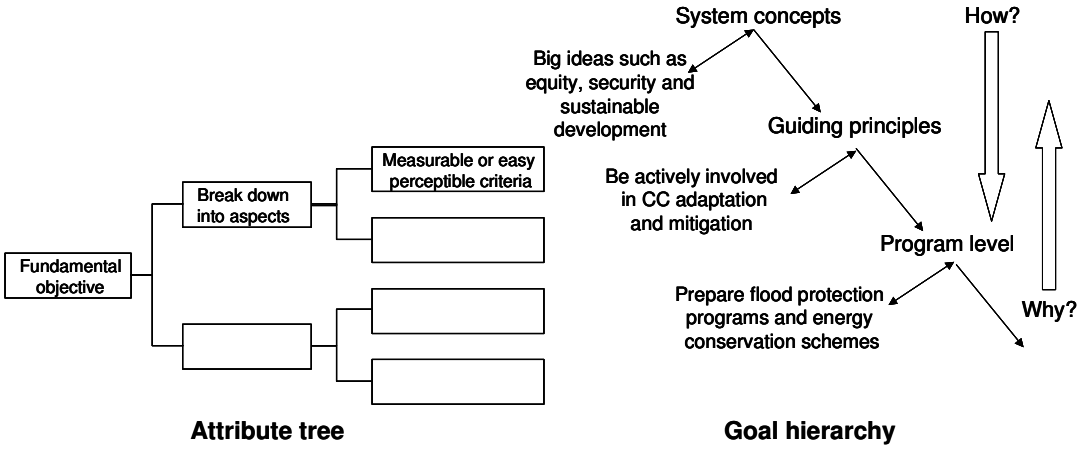
A more elaborated causal chain is the *influence diagram* (see drawing). This diagram may just be meant to visualize the direction and the structure of causal impacts on a dependent variable. However, it may also become the starting point of modelling tools, such as Bayesian Belief Networks [e.g. Lyman et al., 2007; and Section 3.3.3c on Group Model Building].

Another type of ordered diagrams is the *storyline* (see drawing). A storyline is a frame that lays the ground for the development of a scenario, which can further be elaborated using assumptions that give a consistent description of the impact of certain driving forces over time. The story-building strategy mentally simulates the events; it may start at T1 and use forward-chained reasoning, i.e. from existing conditions, or start at T4 and use backward-chained reasoning, i.e. from desirable end-states. It should be emphasized

that single stand-alone scenario projects do not very often lead to "blinding insights" on what to do [Van der Heijden, 2004]. At least two scenarios are necessary to create a heuristic device and they should be built into an iterative process with feedback sessions.

Trees and hierarchies
The framework of a tree is often used to characterize part-whole relationships, such as attribute trees or goal hierarchies. The *attribute tree* (see drawing) may provide a pictorial breakdown of an overall policy objective (or societal value) into its main aspects and a set of measurable criteria that can indicate whether the objective has been achieved. The frame can be used in combination with Keeney's Value Focused Thinking approach [Keeney, 1992] at the pre-analysis stage. Keeney's approach uses simple models of values, which ask the decision unit and the stakeholders to reflect on the main objectives that are relevant for the situation and that can be operationalized in terms of easy perceptible criteria.

Constructing an attribute tree may provide a fruitful basis for developing a common language and a better mutual understanding of the way in which the achievement of the objectives can be proved. This may support latter stages of negotiating and decision-making, such as the identification of decision opportunities and the creation of better alternatives [e.g. Arvai et al., 2001]. The attribute tree can also be used as a starting point for multi-criteria analysis tools (e.g. Section 6.1).



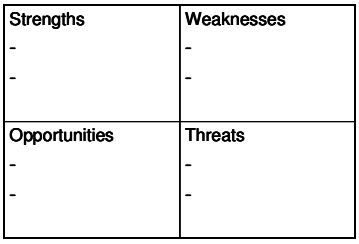
A closely related part-whole model is the *goal hierarchy* with big ideas on top and more concrete action programmes at a lower level (see drawing). The goal hierarchy can describe a decision

situation in terms of different functional levels of control, informed by laddering down “how” questions and laddering up “why” questions. This tool may be used as a basis for reframing (e.g. Section 3.2).

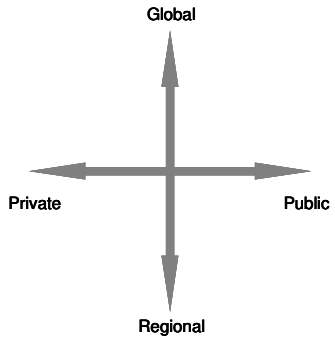
Perspectives and contrasts
An important reason to examine complex issues from multiple perspectives is the notion that any decision on an individual action may be nested within a broader set of objectives. If the members of the decision unit agree on the legitimacy and perceived value of considering the situation from different perspectives, an obvious approach is to include stakeholders who bring in divergent frames, such as experts from backgrounds that are closely linked to different perspectives.

An approach that aims to increase divergent thinking can be supported by additional aids, such as checklists and graphics with built-in contrasts. Checklists are lists of well-chosen keywords that focus on generic aspects of an issue so that a person can give specific thoughts on these aspects. A famous example is the SWOT (Strengths, Weakness, Opportunities and Threats) approach, which is a *list with built-in contrasts* (see drawing). The contrasts involve positive versus negative items, and current versus future situation. A similar but not bi-polar approach is PEST (political, economic, social and technical perspectives).

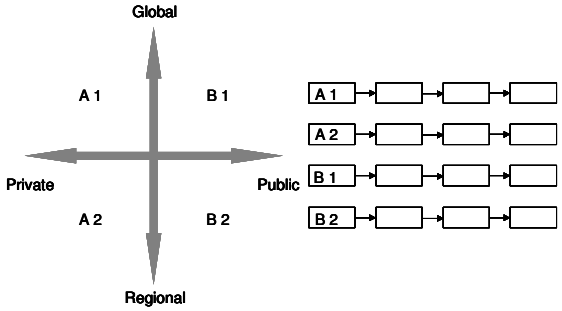
Graphical tools can support thinking in terms of contrasts. Drawing two axes with tentatively defined dimensions can be of help to locate a few key aspects, such as public versus private ways of organizing society, in order to encourage a wide exploration of relevant issues. The *two-dimensional plot* (see drawing) is often presented with axes ordered from negative to positive, but it does not always make sense that features are assigned negative values. Instead, the axes may be ordered from weak to strong or from open to closed.



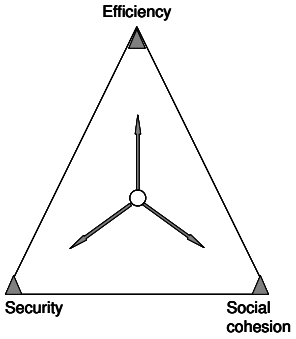
List with built-in contrasts: SWOT



Two-dimensional plot



Axis approach to scenarios



Trilemma

The frame with two axes can also be used as the basis of four storylines, each describing an internally consistent pathway into the future that is characteristic for one of the quadrants. This *axis approach* (see drawing) may be helpful as a heuristic device to create very different visions of the future, which can be used to assess the potential impacts of a hypothetical disturbance ("shock") or a strategic plan under these contrasting conditions (e.g. Section 3.3.4). Because the stories should be internally consistent, however, they are not specifically meant to indicate how the world could shift from one quadrant to another.

A relatively new strategic tool looks at the interplay between essential forces and between the contrasted ways in which different groups can pursue their objectives [Hector et al., 2009; Shell, 2005]. The "triple-dilemma" or *trilemma* (see drawing) is based on the notion that decision-makers often have to deal with conflicting choices or pathways. For example, they cannot simultaneously maintain the three policy objectives of "security", "efficiency" and "social cohesion". If they want to keep "security", they have to choose between "efficiency" and "social cohesion". Generally, the tool should identify three forces that have a natural tendency to act in opposing directions. Also, it may be thought

provoking to introduce a hypothetical disturbance to the forces that are at play. The question how the trilemma will be resolved may be a starting point for further exploration.

Context-dependent prompts
Cognitive aids, such as pictures and diagrams, serve as prompting cues that are independent of the context in which they are applied. Tailoring of the context-independent prompts to the specific problem at hand may be of help to elicit more issue-specific information. The method of tailoring can also be used as a way to take theoretical insights into account. The resulting context-dependent prompts include checklists, questioning schemes, or focusing methods [Browne et al., 1997].

In the context of decision-making on climate change adaptation and spatial planning, for instance, a theoretically grounded *checklist* (see below) about the general principles of resilience can be used to develop a set of directed questions that may help spatial planners in their understanding of a climate proof city (e.g. "what can our town planners learn from the principle of redundancy?"). A similar checklist approach has been designed as a judgmental tool for uncertainty assessment and communication (see Section 5.1).

Checklist: Six general principles of resilience*)

- Homeostasis (multiple feedback loops stabilize the system);
- Omnivory (external shock mitigated by diversification of resources and means);
- High flux (a fast rate of movement of resources through the system ensures fast mobilisation of these resources to cope with perturbation);
- Flatness (hierarchical level relative to base should not be top-heavy, overly hierarchical systems are less flexible and hence less able to cope with surprise and adjust behaviour);
- Buffering (systems with a capacity in excess of its need are more resilient);
- Redundancy (overlapping functions, if one fails, others can take over).

***)** Dessai & van der Sluijs, 2007.

Questioning schemes may become particularly useful if they are based on practical reasoning and take people's cognitive limitations into account (e.g. "can you summarize the features necessary for a successful system?"). Prompts that utilize a counterargument strategy (e.g. "can you think of any reason why the system would fail or malfunction?") will increase the number of

associations in the person's memory and force him or her to consider different or unique viewpoints [Pitts and Browne, 2007].

3. When and how can the aids best be used?
The tools mentioned above can be used at the beginning of any decision-making process. In combination with their role as problem structuring methods, the aids may be applied as a preliminary research model (e.g. influence diagrams) and as a starting point for negotiations (e.g. attribute trees). Apart from the cognitive aids several organizational conditions may be of help for an inspirational strategy, such as an informal setting and a "warming-up" to stimulate the participants. In addition, two potential pitfalls should be avoided. The pitfalls may result from a lack of overlapping frames and a lack of problem ownership.

Ensuring overlapping frames
Even if the members of the decision unit agree on the perceived value of considering the situation from different perspectives, bringing in persons with divergent frames may create misunderstandings or negative reactions. The point is that people can only communicate meaningfully if their frames overlap to a certain degree. If the frames of two persons share too little, they will be unable to contribute to the same discussion. To ensure divergent but also overlapping frames, it may be advisable to include persons who are involved in "boundary work" carried out at the interface between different communities, such as communities of experts and communities of decision makers [e.g. Cash et al., 2003].

Ensuring problem ownership
Decision support may become counterproductive if the outcomes of the methods cannot be shared with the persons who should see themselves as problem owners. For example, a decision analyst may want to develop an attribute tree that organizes values and measurable criteria for a multi-criteria analysis (see Section 6.1). The analyst may start by asking members of a decision unit and stakeholders to make value judgments. If the analyst then rearranges their answers in a way that improves the logical structure of the attribute tree, the participants may not recognize how their input has been incorporated in the analysis. As a result, they will loose their trust in the method. Ensuring ownership of the problem can be promoted by keeping as much as possible the words and phrases of the persons involved.

4. References

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3.2. Goal-hierarchical reframing

1. Short description

When designing a policy strategy, or another type of plan, the scope/broadness of one's objectives has a strong influence on the design of the plan. Having narrow aims, such as the protection of an area against some specific level of flooding, may contribute to a decision-making process that is adequate and efficient. However, if a broader context, e.g. climate change, is taken into account, it may appear that having a narrow aim also contributes to a tunnel vision or "group think" [Janis and Mann, 1977], which misses solutions that are really more sustainable. Overlap and interaction with other issues may be overlooked and, as a result, goals may not be reached or the strategy may have important negative side-effects in other policy areas. The broadness of goals can be described in a hierarchy, from broad umbrella concepts to specific programmes. Table 5 presents the three top levels of control. Considering a higher level in the 'hierarchy of goals' is a crucial way to open-up and reframe a situation.

Table 5. Levels in the hierarchy of goals [De Boer, 2008, adapted from Carver and Schreier, 1998].

Functional level of control	Key question	Examples
System concepts	Why?	Big ideas such as security, equity, and sustainable development
Guiding principles	How?	Be actively involved in climate change adaptation and mitigation
Programmes	Another how?	Prepare regional flood protection programmes and energy conservation schemes

This reframing to a broader goal can be done interactively, in a small group of colleagues, clients or stakeholders. It can also be used as an argumentative tool for critically evaluating 'current practice' in a presentation or document. Four steps need to be taken, as shown in Table 6: (1) assessing current practice (in an interactive setting: either with the participants or prior to the workshop), (2) assessing the broader goal that policies should serve, (3) reflecting on current practice from this new frame, and

(4) adjusting the strategies or options if the original goal indeed proves to be too narrow.

2. How does it take framing into account?
Goal-hierarchical reframing intends to draw participants, listeners, or readers out of their existing frames – the lines of thinking and assumptions that are rooted in participants' everyday practice (i.e. the policy programs and approaches that they are used to working with). They are called to take a 'step back' from those frames, and reframe the issue, taking its broader context into account. From this new position, one can reflect on the original thoughts and assumptions, allowing for a new and more open minded look at an issue.

Table 6. Steps in applying goal-hierarchical reframing in practice.

1. Assess current options/strategies	**2. Refocus: 'take a step back'**
Option A Option B	Higher goal – e.g. creating a sustainable city Refocus: but what is the 'higher goal' of these options? Option A Option B
3. Reflection on the current situation	**4. Modify strategies/options**
Higher goal – e.g. creating a sustainable city Reflection: but do the initial options contribute to this? Are these the only ones, or can we think of more? Option A Option B	Higher goal – e.g. creating a sustainable city Option A Option B If not, then… Option A Option C (new) *(option B discarded)*

3. When and how can it best be used?
This tool can be useful when participants have been working on an issue for a long time, and strong views/frames have already formed. People tend to fit (new) information to their existing frames and positions. Rather than using only the parts of knowledge that are useful for continuing 'business-as-usual', this tool can help

practitioners gain a fresh look and stimulate creativity and make better use of the available knowledge. It requires that participants are willing to reflect on their positions and, in a participatory setting, can agree on one or more higher 'levels of control' (e.g. 'higher goals'). The latter can be difficult. In practice, participants may come up with a list of overlapping points that will need to be reformulated, grouped, discarded, etc. Working with a set of higher goals, rather than a single one, or one goal with several subgoals can help to make this objective more tangible and practical. Furthermore, one could categorize existing proposals/ideas to these subgoals to determine whether current measures really address all goals.

4. References

Examples of this tool applied in practice:

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3.3. Short descriptions

3.3.1. Free brainstorms and group decision support brainstorms

In free brainstorms, a central question, problem, or task is posed, on which participants are asked to freely generate ideas. This can take the simple form of a whiteboard or post-its, or a more advanced approach using a group decision support system [Turban and Aronson, 1998; Hage and Leroy, 2008], both complemented with normal discussion. The first approach has the advantage of being easy to use and low-cost. The latter has the advantage of all participants being able to submit input at the same time. This approach is often part of a larger workshop (e.g. a future workshop, guided workshop, etc.). Participants respond from a variety of frames, depending on their background. These frames are implicitly present in their answers. This tool aims to collect these different perspectives and provide a synthesis (either a 'spread of ideas' or consensus view). A group decision support brainstorm aims to cross-fertilize frames as well: participants can see and respond to others' input, and continue to submit answers (which may be influenced by others' input). This tool is useful when a variety of frames exist and progress may be achieved by confronting, synthesising and/or cross-fertilizing them. It is particularly helpful when individual frames are only 'half-formed' and can benefit from the interaction.

Figure 1. Workshop on particulate matter using a group decision support system, Utrecht 2005 (photos: Penny Kloprogge).

3.3.2. Future workshops or (en)visioning workshops

Future workshops aim to create creative solutions and new perspectives. The process starts with a set of scenarios concerning a particular issue/problem/challenge. Participants are first asked to criticise the presented scenarios and to give their own views on the issue. The second phase is to develop desired 'visions' of the future (as individual and/or group), without regard for practical considerations; the 'utopia phase'. Some approaches

to creating visions[1]: storylines/essays, collages or drawings of things associated with the vision, conceptual innovative designs/maps of for instance a pilot area or a future city or region, and 'messages from the future' in the form of a fictive future newspaper headline/article or a letter. The third phase is to return to reality and discuss what can be realised and how; the barriers and possible plans for action. This tool aims to create new frames (visions) on both the future and the way to get there. Individual visions can be collected, and/or a synthesised group vision can be created. This tool is useful when there is a lack of existing frames and ideas in general, or when participants are 'trapped' in a status quo and new perspectives need to be generated. More information: Hage and Leroy [2008], Raadgever and Mostert [2005], Apel [2004], and Jungk and Mullert [1987].

3.3.3. Guidance documents and Guided workshops

Guidance documents, guided workshops, checklists for prompting new ideas, and similar tools function as cognitive aids. They can be structured along a central frame, intending to guide participants/users into this way of thinking, or they can be more generic and support the participant/user in developing a frame or making it explicit. They can introduce participants/users to a new way of thinking, structure the thinking process, point users to issues that are important, stimulate explicit reasoning, ask guiding (intentionally 'leading') questions, and offer tools, tips, and examples. Depending on the way such a tool is set up, it can be useful for situations where frames exist and participants are (at least) willing to complement these with a new frame (the one central to the tool) or situations where suitable frames are (self-perceived to be) lacking.

[1] One could also imagine performing a similar, but more open or specifically problem-oriented visions exercise during the scenario phase. Particularly, the 'newspaper headline' is quick enough to be suitable.

3.3.4. Worldview approach

A worldview approach communicates information based on a limited set of contrasting perspectives (see also Section 3.1 on frames with built-in contrasts). These perspectives intend to cover the spread of possible views (the 'plurality of frames'). As such, worldviews perform a function similar to scenarios. These worldviews are generally strongly different, often stereotypical views, based on different beliefs on e.g. nature, economy, and freedom of choice.

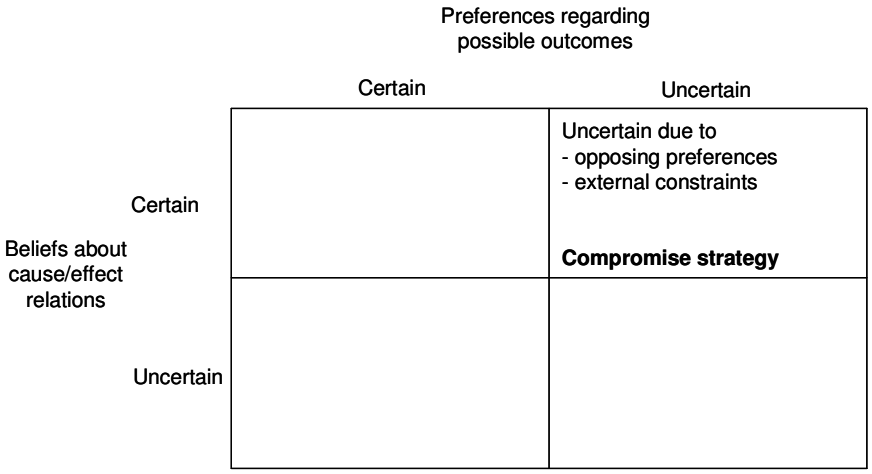
Figure 2. Worldviews regarding sustainability [MNP, 2004].

Examples include the archetypes from Cultural Theory (egalitarian, hierarchist, individualist, fatalist) [Douglas and Wildavsky, 1983; Schwartz and Thompson, 1990], the Netherlands Environmental Assessment Agency's worldviews for sustainability assessment (global market, global solidarity, caring region, safe region) [MNP, 2004; Petersen et al., 2006; Wardekker and Van der Sluijs, 2006], stereotypical political positions, and stereotypical corporate vs. environmentalist views. These perspectives can be used to reveal where different lines of reasoning lead: what are preferred policy directions, management structures, etc. Storylines can be developed for a report, showing different policy directions and tradeoffs. Alternatively, a software tool (decision support system) can be created to allow people to explore the consequences/implications of these different lines of reasoning.

Applying a worldview approach in a participatory setting is more difficult, as participants quickly feel themselves being placed in 'boxes'. Since the views are stereotypes, people feel these 'boxes' do not fully apply to them. A worldview approach can be useful when one is interested in diversity in perspectives (e.g. future visions, policy preferences, etc.), for instance when exploring the robustness of a policy strategy.

4 Examples of compromise tools

An important consideration in decision-making is the question whether there is a need for more scientific knowledge or for more deliberation on preferences. If cause/effect relations are certain but outcome preferences are uncertain or disputed, the decision unit should choose a compromise strategy to identify a common preference. Strategies to achieve a compromise may focus on the basic idea of a decision or on a detailed list of disputed elements. That is, the decision situation may be framed as a problem whose solution should satisfy a wide set of constraints. For example, the decision unit may want a course of action that is acceptable to all kinds of stakeholders. As mentioned before, bringing in stakeholder groups with divergent frames might create misunderstandings or negative reactions, unless the frames do overlap to a certain degree.



Most relevant tools

- Reasoning and dispute elicitation
- Awareness of Frames, Framing, & Reframing
- Visual Representation of Discourse & Frames
- Community based auditing

Most appropriate setting

- Representative structure (each stakeholder group should be represented)

A compromise strategy may include participatory tools, such as community planning tools, which can be framed as building on deliberative democratic forums. This frame involves some form of open, goal-directed conversation or “dialogue” between decision-makers, experts and other stakeholders, which should create favourable conditions for the exchange of diverging arguments. In

the context of climate change adaptation, however, stakeholder participation is often restricted by strategic planning processes coordinated by governmental institutions and other agencies. The tensions that may arise between the planning agency and the local stakeholders can seriously hamper any open-minded conversation. These tensions might be less if a planning agency is explicit from the outset about the true scope of the purpose, external constraints and expected outcomes of stakeholder participation.

4.1. Reasoning and dispute elicitation

1. What is it?
This tool produces a detailed list of disputed elements that are present in a decision making issue. It organises this list in a matrix with regard to the institutional and personal motivations behind the elements for each stakeholder. The cells of the matrix represent frame related differences in world view with regard to specific problem situation issues. This tool also produces mental model maps of individual stakeholders, and by analyzing these maps surfaces different chains of reasoning attributed to the different stakeholders involved. The information elicited in the tool application process allows the production of a causal decision explanation model. The tool discusses matrix and mental models in a stakeholder group with the aim of producing a combined mental model map for the group.

Information is collected by document analysis, semi-structured interviews and group discussions. Interviews etc. can be recorded, or directly taken down in summarized form. Text analysis can be done in an editor (ms-Word) or spreadsheet, or with help of dedicated software (e.g. NVivo). Mental model maps can be drawn on flip-over sheets, or by special software (for example CMapTools).

The method is flexible and can be adapted to a specific situation. The full method (including transcription and mental model building of each interview) is rather time consuming. Shortcuts are available to accelerate the analysis process. A “low-budget” variant consists of a “quick & dirty” application of the method by the project leader. The level of detail can be varied by adding more or less detailed mental model maps, and omitting the combined mental model map building in the stakeholder group.

2. How does it take framing into account?
The method elicits the frames-in-action for each stakeholder. The cells in the matrix indicate specific instances of framing the issue. The mental model map explicitly reveals a stakeholder’s frame and the specific knowledge used in his chain of argumentation. Further on these frames are confronted with their owners, and subsequently with other stakeholders to reveal frame differences.
Frames and frame differences can be used to discuss what knowledge is considered to be relevant or to be excluded, and how

knowledge elements can be interpreted differently (from different stakeholder points of view). This process of building “the larger picture” does not implicate a consensus on a common frame; it merely surfaces existing knowledge and interpretation.

The method should, in principle, also be usable to guide stakeholders into a new, common frame (this has not been put into practice yet). The approach aims to support interactions between stakeholders. Discussion of the elicited mental model maps and matrix of disputed elements stimulates communication and learning between individuals and their organisations involved in a case. Construction of a common mental model map of the problem situation allows the structuring of conflicting elements of diverse argumentation chains without immediately resolving the controversies, and surfaces assumptions, interpretations and uncertainties involved. The approach offers a better understand of how data, information and knowledge are acquired and manipulated during processes of decision-making. The nature of controversies and their rooting in institutional and personal contexts can be discussed.

The method starts with implicitly addressing the frame-in-action, by talking about relevant issues and knowledge elements connected. This focus on mental models has the advantage, above the direct focus on frames, that institutional and normative position of the actors are unchallenged, because mental model mapping does not doubt the validity of an actor’s frame, but merely wants it illuminate it by focusing on the information used within the frame. Focusing on the mental model respects and allows the decision maker or stakeholder to be responsible for his/her own valuation of the information in the context of his specific situation. Of course, this can be the starting point of a learning process or critical dispute. The analysis of mental models, later on, makes frame differences explicit by pinpointing conflicting elements and different chains of reasoning.

The method provokes discussion about the knowledge hidden behind conflicting elements.

3. When and how can it best be used?
The method can be used at different moments of the policy/problem cycle. In the beginning to establish major issues and responsibilities, further on to analyse details of the stakeholder discussions and frame positions, and afterwards to analyse the decision argumentation.

Representative stakeholders from the different institutions and organisational levels involved in the case are needed in order to cover the full range of frame perspectives and mental models.

A full benefit of the method will require a willingness to break through institutional communication patterns and distributions of responsibilities, which presents new responsibilities for the stakeholders involved.

The interviews with case informants have an open character to stimulate the person interviewed to give his own facts, views and opinions. The interviews try not to impose a particular structure on the elicited information, but allow the structure to arise from informants' responses. A list of focal points and probing questions can be used to guide the interviews. This list can be based on a literature study, and can be subsequently adapted using the results of a focus group session with experts on the specific problem field, possibly augmented by interviews with experts on specific aspects of the case.

4. More information
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4.2. Awareness of Frames, Framing, & Reframing (AFFR)

1. Short description
This is an interactive introduction to the ideas of frames and framing for the layperson (the non-climatologist, non-spatial planner) who is being confronted with new information in the realm of climate change and spatial planning. It gives a way in to realising how we all use frames and framing processes in daily life. The tool therefore develops an awareness of: a. how we are already using frames and framing to think about climate change issues and b. how our existing mindset, which we can recognise has been formed over time, then responds to new and different issues. This tool is for use at the start of any climate change and spatial planning workshop or client discussion to make participants/clients aware of the concept of framing through recognition of their own use of frames. Participants also can become aware of what the communication process they are engaged in is aiming to do. For instance: a. impart new information, b. change their minds, c. influence their behaviour and their decisions. If this reflexivity is developed then their involvement in the process is active and critical rather than passive or defensive due to their new self-consciousness. In the context of the project in which this Tool Catalogue has been developed, the key question is to what extent citizens in The Netherlands are understanding, conceptualising (using mind mapping) and responding to the new and emerging spectrum of framings of spatial planning policy in relation to Climate Change?

2. How does it take framing into account?
This tool places frames and framing at the forefront of the knowledge dissemination process. The intention of AFFR is that each individual participant starts the main workshop discussion primed with clear consciousness of: a. what a frame and the framing process are, b. how they use frames to interpret new information *i.e.* a re-framing through self-reflection on their own learning process, c. how they can re-frame their own thinking *if they so wish* in the light of fresh knowledge, and d. through listening to other people's frames an awareness of how other participants' frames, and all their processes of framing and re-framing, relate to and influence their own, and finally, e. how to bridge the differences between their frames by re-framing again.

3. When and how can it best be used?
This tool can be used at any stage in the spatial planning process where new information is introduced by knowledge institutes for climate change science and policy. Ideally this short exercise precedes the presentation of fresh data. It prepares the people who are being given this information by giving them a short time to reflect on their thinking up to that point by analysing their approach to Climate Change-related spatial planning in terms of the frames they currently use. They can explore how the frames they use influence their perception, interpretation, and degree of reception of new information on Climate Change-related spatial planning. This helps people to move from a position of being aware of the framing process to re-framing in light of the new knowledge communicated to them by Climate Change scientists, spatial planners, and decision-makers. The intention is to create a more open-minded and creative approach and working environment within which both mixed and homogeneous groups reflect on and assimilate new information.

Using mind-mapping approaches, people can sketch out the frames they think of as they uncover them. They can be asked to reflect on how these frames shape how they think and how they approach new information and develop new ways of thinking. Using flip-charts or A3 sheets of paper, participants draw out their frames in the form of mind-maps [see Wates, 1999]. This AFFR tool is designed to allow the development of self-awareness and reflexivity with regard to their personal, individual frames to emerge within a guided structure.

This same technique can work both at a general and a more specific level, and with a couple of people as well as a larger group, depending on the subject of the main workshop or discussion. It is possible to move up from the individual level to the collective level using a clustering of personal perspectives so that the differences within the group can be brought into the open at an early stage. The facilitator can use this as an opportunity to confront any conflicts *e.g.* of a temporal nature in terms of the degree of urgency of adaptation action or the immediacy of the threat of Climate Change, or *e.g.* between a selection of one of the four KNMI scenarios and those of other climate institutes. Using a guided process *e.g.* Future Search Conference (see Weisbord and Janoff, 2000), a selected multi-stakeholder group can explore their

shared knowledge, aims, and interests and work towards resolving fundamental differences and conflicts over time.

This exercise can work well at quite a fundamental stage in the spatial planning process to expose any differences in the frames held and used by key stakeholders, thus providing an opportunity to address any conflicts that act as obstacles to organisations and institutions working together from the outset as well as at each subsequent step of the process. For instance, fundamental framing differences may exist between the public and private sectors, between the various professional and academic groupings involved, as well as between the political actors whose interests shape and are shaped by ideological frames. In this case a reflection on the goals and objectives of the spatial planning project that can focus all the stakeholders on their common purpose is followed by a mediation of conflicts, part of which is a process of re-framing can help build a shared frame within which to continue working together (compare with Section *3.3.3 Future workshops or (en)visioning workshops*, which deals with developing a common view, and Section *3.2. Goal-hierarchical reframing*, which deals with reframing to overall goals).

4. More information

Wates, N. 1999. "*The community planning handbook*". Earthscan, London.

Weisbord M., S. Janoff, 2000. "*Future Search: An Action Guide to Finding Common Ground in Organizations and Communities*". 2nd edition. Berrett-Koehler, San Francisco.

A 'Future Search' conference is a method of getting a whole range of stakeholders involved in an area of work to explore a 'system' and to develop a shared vision and way forward toward an agreed goal. See http://www.futuresearch.net/ a site that reflects the origins of future search in the USA but gives excellent contacts for planning events and useful examples of the technique in practice.

4.3. Visual Representation of Discourse & Frames (VRDF)

1. Short description
This tool is for analysing and representing the frame-making and re-framing process over time *i.e.* a longitudinal study of the process of using discourses for communicating and understanding the need for changes to spatial planning approaches in the light of ever-evolving climate change scientific scenarios. The idea behind using the visual medium for the exploration of discourses, frames and framing draws on the discipline of critical visual anthropology as a way of using visual technologies to document and analyse the world and for communicating knowledge about the stakeholders' use of discourses, frames and (re-)framing in a specific socio-political location *e.g. KvR* hotspot area. This approach explores the use of the visual as a new perspective on discourses, frames, and (re-)framing processes and provides a tool for the re-thinking of existing communication mechanisms by exploring what happens if, instead of writing and reading discourse and (re-)framing, we start seeing, showing, hearing and feeling it.

2. How does it take framing into account?
The thesis of this combined approach is that the fundamentals of discourse and framing - ideas and models - are one and the same, so that making these explicit aids self-examination of one's own ideas and the premises upon which they have been based. We also see that going in through the route of discourses *e.g.* climate change, flooding, that people can recognise, helps them to see their own individual mental models and personal frames which have their imprint on the way they receive and think about new forms of knowledge through the process of re-framing.

As the context of this project is about the mobilisation of change in the way that Dutch people think and feel about the risks and opportunities of climate change and the implications for spatial planning it is relevant to draw upon parallel uses of discourses and re-framing processes. Frame analysis is used, for instance in New Social Movement studies to analyse the discourses employed by members of the movements and their ability to mobilise people. Within this project frame analysis can also be applied to the reflexive study of the climate change movement within contemporary society and how its social and institutional actors have adopted collective discourses of *e.g.* climate change risk or

adaptation for themselves as individual frames and applied these in the context of public policy-making *e.g.* for spatial planning. This tool creates a documentary which visually represents the long-term process of stakeholders being mobilised and bringing about change by using discourses, frames, and (re-)framing process in a case study area *e.g. KvR* Hot spot. By using the visual medium as opposed to writing, the focus is on aiding a creative and self-reflexive process of examination of the discourse-based ideas and premises upon which stakeholders developed their own frames.

3. When and how can it best be used?
One method is to give cameras to informants *e.g.* key stakeholders in the decision-making process such as Project Committee members, for them to capture visual representations of their discourses and frames on Project climate change risks and opportunities. They can be asked to shoot a one shot sequence with a narrative that tells a story of their own experiences within the camera frame. They can then be interviewed and asked to describe the intentions behind what they have filmed. This allows the documenting of people's frames to explore a range of topics including the economic, political, and socio-cultural aspects of climate change, perhaps even the roots of environmental and climate injustice, or the role of environmental education and ethics in solving Climate Change and justice issues.

Authoritative climate science now points to the need for a radical rethinking of the ways in which spatial planning responds to climate change if societies worldwide are to remain in their existing territories. A significant influence on spatial planning policy in The Netherlands, as elsewhere, is how climatic futures or scenarios, including their perceived risks and opportunities, are conceptualised by the general public. Using this filming tool to record the use of discourses and frames in particular areas allows the documentation of how these have emerged and changed over time. So it is possible to explore the experience, ideas, and feelings of ordinary stakeholders who live within the changing and dynamic water landscape. The output can be used to communicate these aspects with other stakeholders to facilitate an exchange of views on their own experiences of discourses, frames and re-framing, and how these have effected change for them.

Inter-related areas as subject matter for filming, documenting and communicating:

1. What are the dominant climate science and policy discourses and frames for understanding historic and current climate change and spatial planning debates?

2. How are the Dutch public(s) understanding, conceptualising, and responding to the new and emerging spectrum of climate scenarios (*e.g. KNMI's*)? What risks and opportunities do they perceive, who do they trust, and what other factors do they see as important in the acceptance of new and different spatial planning policies and practices?

3. To what extent does spatial proximity to areas more at risk from climate change-induced events *e.g.* flooding from rivers, the sea, modify the ways in which climate change issues and key frames are interpreted by social groups in these areas?

4. To what extent do people recognise, buy into, value, and make trade-offs between alternative visions for new climatic futures, particularly over time *e.g.* during a long-term spatial planning process to implement socio-politically acceptable development that changes the landscape?

4. More information

Shrum, W., R. Duque, T. Brown, 2005. "Digital Video as Research Practice: Methodology for the Millennium". *Journal of Research Practice*, vol. 1, no. 1, article no. M4.

Oxford Academy of Documentary Film-making. http://www.oadf.co.uk

4.4. Community based auditing

1. Short description

Management decisions concerning the natural environment can lead to widespread discontent and conflict among stakeholders in the area of interest because of concerns about adverse environmental and social effects. These decisions can be based on a false claim of certainty regarding the scientific background and impacts of the implemented measures. However, citizens who want to raise objections or take part in the decision making procedure face numerous difficulties. Community Based Auditing (CBA) is a tool for empowering citizens to undertake disciplined inquiry into issues relating to natural resource planning and management [Tattersall, 2003]. Furthermore, an appropriate manner of dealing with scientific uncertainty is included. CBA is a method of auditing, based in part on internationally recognised standard systems such as ISO 14001.

The CBA audit process occurs on three levels:

1. An audit is performed of the management a proponent intends to use. Auditors, together with their experts, try to unravel the prescriptions and science behind the management plan, including the (risk) assessments which are accomplished in support of the proposed practices. The aim is to examine the validity of the planning assumptions and their application to the case in question.
2. An audit of the site the management plan will be applied to. The aim is to assess the validity and completeness of the application of the management prescriptions. In this stage, data is collected and measurements are made in order to evaluate the soundness claimed by the proponent.
3. Members of the CBA process create a publicly available text of their inquiry. In this publication, the results of the audit process are revealed and they implications of any mismatches of the management plan are shown.

It is important to consider is that the aim of the audit procedure is not only the provision and evaluation of ‘hard science’, in order to evaluate the proposed management plan and expose any false claims to certainty regarding its scientific background and impacts. The tool also aims to support of the growth and development of participants and facilitators. Figure 15 visualises the interrelations among the components of those two aims. The process guiding

participant engagement is known as action research [Reason, 1994].

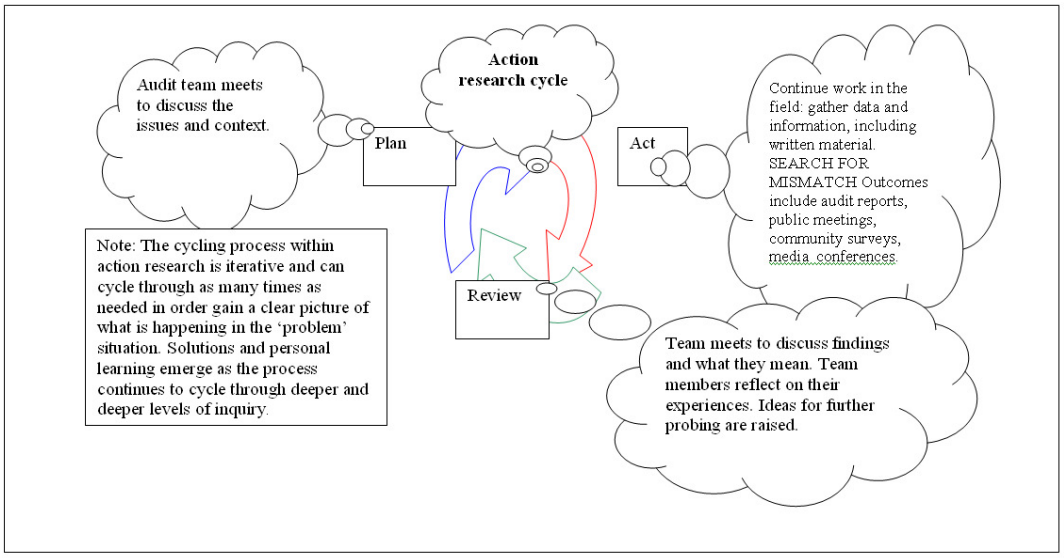


Figure 15. Relationships among the processes within CBA methodology [source: Tattersall, 2007, 2008].

2. How does it take framing into account?

Management plans, advice and decisions are sometimes based on an idea of certainty. They expect and assume that (applied) science ultimately leads to certain and true results. However, citizens who want to object to management plans, often share the same paradigm. CBA approaches the concept of certainty in a different manner, while using the same instruments. Key in CBA is to initiate a process which scrutinises the 'facts', uncertainties, claims, and reasoning behind the management plan. In doing so, this tool uncovers and scrutinizes the (explicit and implicit) frames in the management plan, and the assumptions underlying these. It also helps citizens in making their own frames/perceptions explicit and supporting them with arguments. This could be described as a process of counter-framing. That is, it allows the citizens to create a viable alternative way of sense-making of the decision problem. This creates a more level playing field in the decision making procedure.

3. When and how can it best be used?

This tool can be useful for citizens that are put aside in decision making processes, or have difficulty in motivating their concerns regarding the impact of (natural resource) management plans due to the soundness and certainty claimed by the plans' proponents.

CBA provides both for scientific data as well as practical understanding in order to prove the legitimacy of the citizens' concern. In addition, it is inherent to the CBA process to unite a community as a relevant stakeholder in the decision making process. CBA as a tool can be commenced any moment due to the fact that it is independent of the proponents' actions. However, it is recommended to start a CBA as soon as possible, in order to maximise its influence in the decision making process. It is not necessary to wait until a proponent's management plan and supporting risk assessments are finished, because participants collect their own data, which can be cross-examined with proponents' information at any point. It is recommended that experts are recruited, to play a role as members and mentors during the whole auditing process.

4. More information
Comparable tools:
Fischer, C., Leydesdorff, L., Schophaus, M. 2004. Science Shops in Europe: The public as stakeholder. Science and Public Policy, 31, p. 199-211.

Literature sources:
Reason, P. 1994. Three approaches to participative inquiry. In: N.K. Denzin, Y. Lincoln (eds.), *Handbook of Qualitative Research*. Sage Publications, Thousand Oaks, p. 324-329.

Tattersall, P.J. 2003. Community based auditing: empowering the community to take charge – pathways to a just and sustainable society. In: R. Worthington (ed.), *Proceedings of the Community Research Network, 6th Annual Conference,* Sandstone Minnesota, USA. The Loka Institute, Washington, DC. www.loka.org/conf2003/2003_conference.htm

Tattersall, P.J. 2007. What is Community Based Auditing and How Does it Work?. *Upper Catchment Issues Tasmania*, (ISSN 1444-9560), vol. 4, no. 2. Tasmanian Community Resource Auditors Inc. http://www.resource-publications.com.au/uppercatchment/

Tattersall, P.J. 2008. The Case for a New Form of Community Involvement in Resource Planning and Management In Tasmania. *Upper Catchment Issues Tasmania*, (ISSN 1444-9560), vol. 4, no. 3. Tasmanian Community Resource Auditors Inc. http://www.resource-publications.com.au/uppercatchment/

4.5. Short descriptions

4.5.1. Consensus conference

Figure 3. Experts are queried on a controversial subject by participants. GvRM/NVRB/UU University Day on Risk Management 2007, Utrecht (photo: Fleur Janssen).

A consensus conference is a public inquiry by a group of citizens (or broader: non-experts) on a socially controversial subject. The group assesses the subject by directing questions and concerns to a panel of experts, and by discussing and negotiating amongst themselves. The final product is an advice/statement directed at decision makers and the general public. A consensus conference aims to jointly generate frames on the problem, solutions, etc., in a group with diverse value frames, and arrive at a consensus view. Optionally, organisers can allow some room for disagreement. This tool is useful in controversial, value-laden situations, where decision makers are in need of negotiated evaluations that take a broad range of value positions/frames into account. More information: Elliot et al. [2005].

4.5.2. Focus group, round-table conference, and world café

Various formats for group discussion exist, each with a slightly different setup. In focus groups, small groups of participants discuss a defined topic in a structured way, assisted by a moderator. They are used to collect, exchange and discuss opinions and information. They are often used to study people's preferences and values. Round-table conferences are similar, but focus more on allowing participants to garner insight in each others' views and frames (rather than allowing researchers to understand the views of participants), and on exploring options for reframing.. In a 'world café', multiple discussion groups are set up around several tables, each with a specific topic. Participants move from one table to another at regular intervals, while a table host remains and summarizes the previous participants' input for the new group. These tools explore frames in a free manner. They are useful for problem identification, idea generation, and evaluation, in situations that are not highly controversial and where participants are open towards others' views. More information: Elliot et al. [2005], Raadgever and Mostert [2005], Hage and Leroy [2008].

4.5.3. Role-playing or 'multi-actor behavioural simulation'

Role-playing involves participants in a scenario (a situation that could occur in reality, e.g. a negotiation scenario concerning a particular problem in a region) with multiple actors, each with predefined knowledge, values, interests, and resources (i.e. frames). Participants are each assigned the 'role' one of these actors – different from their actual professional role – and act out the scenario. The exercise allows participants to remove themselves from their existing frames and explore a different perspective. It intends to create awareness and appreciation of others' frames, the differences, and the reasons behind those differences. It helps them understand the choices that other stakeholders may face. This can improve discussion, communication and collaboration. Role-playing explores the plurality of frames. It can be a useful tool when there is little personal interaction between stakeholders and considerable, but not insurmountable, differences in frames. More information: Raadgever and Mostert [2005].

4.5.4. Tension field approach

A tension field reveals a 'choice space' in which various frames can position themselves. A tension field is a set of goals or values that are considered important, but which may not always be possible to satisfy equally. They may require tradeoffs. A well-known example is 'people, planet, profit', another is 'efficiency, security, social cohesion' – Shell's 'Trilemma Triangle' [Shell, 2005]. A tension field help users to keep these fundamental goals in mind, and assists them in making more explicitly argued choices, while developing strategies for the future. The approach starts with a set of reasons behind frame differences: the multiple goals/values involved, which can be weighted differently by various people. From this position, the 'plurality of frames' can be explored. This tool can be used in a participatory setting, e.g. with an organisation's strategy department, by an individual user as a thinking aid, and as an argumentation device in a report or presentation. It can be a useful tool when no strong frames have yet formed, or when people have (unintentionally) formed frames that pay attention to one goal/value in the tension field, but neglects others.

5. Examples of judgmental tools

If outcome preferences are clearly known and shared but cause/effect relations are uncertain or disputed, the decision unit must rely on a judgmental strategy to clarify the decision issue. The nature and the relevance of scientific uncertainty is one of the topics that can lead to difficult discussions between decision-makers and experts, as well as between experts among themselves. Insight into the main strengths and weaknesses of advanced tools such as influence diagrams (including Bayesian Belief Networks) and dynamic models (including computable general equilibrium models) will require an analysis of critical choices and assumptions. Several tools are available for such an analysis and one of their characteristics is that they are all based on some kind of peer review.

		Preferences regarding possible outcomes: Certain	Preferences regarding possible outcomes: Uncertain
Beliefs about cause/effect relations: Certain			
Beliefs about cause/effect relations: Uncertain		Uncertain due to - incomplete knowledge - inherent uncertainty - competition with rival decision-makers **Judgmental strategy**	

Most relevant tools

- Guidance for uncertainty assessment and communication
- Expert panels
- Group Model Building

Most appropriate setting

- Collegial structure (self-governing voluntary group)

5.1 Guidance uncertainty assessment and communication

1. Short description
The Guidance for Uncertainty Assessment and Communication (MNP/UU, 2003; Janssen et al., 2005) aims to facilitate the process of dealing with uncertainties throughout the whole scientific assessment process (see Table 7). It explicitly addresses institutional aspects of knowledge development, openly deals with indeterminacy, ignorance, assumptions and value loadings. It thereby facilitates a profound societal debate and a negotiated management of risks. The Guidance is not set up as a protocol. Instead, it provides a heuristic that encourages self-evaluative systematic critical reflection in order to become aware of pitfalls in knowledge production and use. It also provides diagnostic help as to where uncertainty may occur and why. This can contribute to more conscious, explicit, argued, and well-documented choices.

Following a checklist approach inspired by Risbey et al. (2005), the Guidance consists of a layered set of instruments (Mini-Checklist, Quickscan, Detailed Guidance, Tool Catalogue) with increasing level of detail and sophistication. It can be used by practitioners as a (self-)elicitation instrument or by project managers as a guiding instrument in problem framing and project design. Using the Mini-Checklist and Quickscan Questionnaire, the analyst can flag key issues that need further consideration. Depending on what is flagged, the analyst is referred to specific sections in a separate Hints & Actions document and in the Detailed Guidance. Since the number of cross-references between the documents of the Guidance is large, an interactive web application has been implemented. The foci depicted in Table 7 provide the structure of the Mini-Checklist and Quickscan. Below, they are briefly described:

Problem framing relates to the inclusion and exclusion of different viewpoints on the policy problem and the connections the policy analysis should make to other policy problems. Decisions on problem framing influence, for instance, the choice of models (what domains should they cover, which processes should be included, et cetera).

Table 7. Foci and key issues in uncertainty assessment and communication [MNP/UU, 2003].

Foci	Key issues
1. Problem framing	Other problem views; interwovenness with other problems; system boundaries; role of results in policy process; relation to previous assessments
2. Involvement of stakeholders	Identifying stakeholders; their views and roles; controversies; mode of involvement
3. Selection of indicators	Adequate backing for selection; alternative indicators; support for selection in science, society, and politics
4. Appraisal of knowledge base	Quality required; bottlenecks in available knowledge and methods; impact of bottlenecks on quality of results
5. Mapping and assessing relevant uncertainties	Identification and prioritization of key uncertainties; choice of methods to assess these; assessing robustness of conclusions
6. Reporting uncertainty information	Context of reporting; robustness and clarity of main messages; policy implications of uncertainty; balanced and consistent representation in progressive disclosure of uncertainty information; traceability and adequate backing

Involvement of stakeholders concerns the identification of the relevant stakeholders and their views on the problem, including disagreements among them. There are several ways in which stakeholders can be involved in the assessment. They can either be involved directly or, alternatively, analysts can try to incorporate their perspectives.

Selection of indicators for scientific policy advice inevitably involves choices with respect to output processing and interpretation: decisions are taken on what indicators are calculated and included in the study. One should realize that alternative choices can always be made and that sometimes alternatives are brought forward and advocated by participants in the societal and political debate. The uncertainties associated with indicators may differ depending on the indicators chosen, and indicators may be more or less representative of a problem.

Appraisal of knowledge base addresses issues such as what quality of information is needed for answering the questions posed, which depends on the required quality of the answers. Gaps and quality issues in the knowledge and methods which are needed for the assessment need be identified and decisions to pursue further research may be taken in the case of deficiencies. Often, however, it will not be possible to reduce the uncertainty.

Mapping and assessment of relevant uncertainties in the available scientific evidence applies an uncertainty typology in the form of a matrix (Section 5.2.4 and Appendix A). The matrix is used to create an overview of where one expects the most important (policy-relevant) uncertainties to be located. Uncertainty is classified along several dimensions: its 'location' (where it occurs), its 'level' (whether it can best be characterized as statistical uncertainty, scenario uncertainty or recognized ignorance) and its 'nature' (whether it primarily stems from knowledge imperfection or is a direct consequence of inherent variability). The typology also distinguishes the dimensions 'qualification of knowledge base' (what are weak and strong parts in the assessment) and 'value-ladenness of choices' (what biases may shape the assessment). The matrix can be used to identify areas where more elaborate uncertainty assessment is required. The different cells in the matrix are linked to uncertainty assessment tools (in the Tool Catalogue) suitable for tackling that particular uncertainty type.

Reporting of uncertainty information addresses issues regarding how to adequately communicate uncertainty, mainly through formulating messages that are robust with respect to these uncertainties – that is, the strength of the policy-relevant statements made is tailored to the reliability of the underlying evidence.

2. Hoe does it take framing into account?
The checklist helps to systematically reflect on frames and provides a structured way of thinking about uncertainty in complex issues. The first three foci directly address framing issues. The uncertainty matrix (fifth focus) can help in making explicit different framings regarding uncertainty, for instance, different beliefs regarding the relative importance of statistical uncertainty, scenario uncertainty and recognized ignorance in a given assessment.

3. When and how can it best be used?
The Guidance is a reflective approach to uncertainty that is especially useful in the assessment of complex problems where decisions are urgent, stakes high, uncertainties high, and values in dispute. The uncertainty guidance can be used before, during and after an assessment. Use before and during is preferred over use after. It is a flexible instrument that can be applied at different levels of sophistication varying form a 'back of the envelope' exercise to an in-depth application. In its easiest form, the Mini-checklist is used as a tool to systematically inspire discussions and structured thinking in project teams working on complex issues.

4. More information
MNP/UU, 2003. "*Guidance on Uncertainty Assessment and Communication*" series. RIVM/MNP and Utrecht University, Bilthoven/Utrecht. http://www.nusap.net/guidance/

Van der Sluijs, J.P., A.C. Petersen, P.H.M. Janssen, J.S. Risbey and J.R. Ravetz, 2008. "Exploring the quality of evidence for complex and contested policy decisions". *Environmental Research Letters*, vol. 3, no. 2, article no. 024008. http://dx.doi.org/10.1088/1748-9326/3/2/024008

Janssen, P.H.M., A.C. Petersen, J.P. van der Sluijs, J.S. Risbey, J.R. Ravetz, 2005. "A guidance for assessing and communicating uncertainties". *Water Science & Technology*, vol. 52, no. 6, p. 125-131.

Risbey, J.S., J.P van der Sluijs, P. Kloprogge, J.R. Ravetz, S.O. Funtowicz, S. Corral Quintana, 2005. "Application of a Checklist for Quality Assistance in Environmental Modelling to an Energy Model". *Environmental Modeling & Assessment*, vol. 10, no. 1, p. 63-79.

5.2. Short descriptions

5.2.1. Expert panel

Expert panels aim to collect and synthesise the knowledge of a group of experts, who can be scientists, professionals or local stakeholders and citizens, in order to judge a particular issue. The panels often seek to make explicit and utilizable the unpublished, implicit knowledge and insight that experts have, based on their experience and expertise. Alternatively, they could seek to exchange, compare and synthesise published knowledge. A variety of techniques can be used, e.g. Delphi, group model building, scenario analysis, card sorting, and hexagon method. The tool collects different implicit frames, confronts and explores them, and distils a synthesis view (not necessarily a consensus view). Expert panels are useful when relevant frames are implicit, unpublished, and incomplete. More information: Slottje et al. [2008], Raadgever and Mostert [2005], Elliot et al. [2005], and Hage and Leroy [2008].

Figure 4. Expert panel on uncertainty communication, Utrecht, 2004 (photos: Jeroen van der Sluijs).

5.2.2. Extended peer review

Extended peer review is the involvement of stakeholders in the quality assurance of a study. The knowledge and perspectives of the stakeholders can bring in valuable new views and relevant information on the problem. Stakeholders can contribute to the quality of knowledge in a number of ways. These include improvement of the problem formulation and research questions; the contribution of knowledge on local conditions which may help determine which data are strong and relevant or which response options are feasible; providing personal observations which may lead to new research foci addressing dimensions of the problem that were previously overlooked; criticism of scientists' assumptions, which may lead to assumptions that better match real-life conditions; and, creative thinking of mechanisms and scenarios through which projected changes may affect different sectors of society (De Marchi, 2003). The main strength of extended peer review is that it allows the use of extra knowledge

from non-scientific sources. Key limitations lie in the difficulty for stakeholders to understand the sometimes complex and abstract concepts, to ensure representativeness of the selected stakeholders and in the power asymmetries that may be reproduced.

This tool aims to supplement the (limited) frames present in the research team or scientific community with those present in society, in order to check whether important matters may have been overlooked. It is particularly useful when studying ill-structured, complex and socially controversial topics.

5.2.3. Group Model Building or participatory modelling

In group model building, a group of participants, assisted by a facilitator, develops a conceptual model of a particular problem /issue. Such models can be influence diagrams (arrows; what influences what component), causal models (positive/negative influences), qualitative computational models (e.g. Quasta; based on qualitative probabilistic networks), Bayesian belief networks, or elaborate system dynamics models (mathematical relationships).

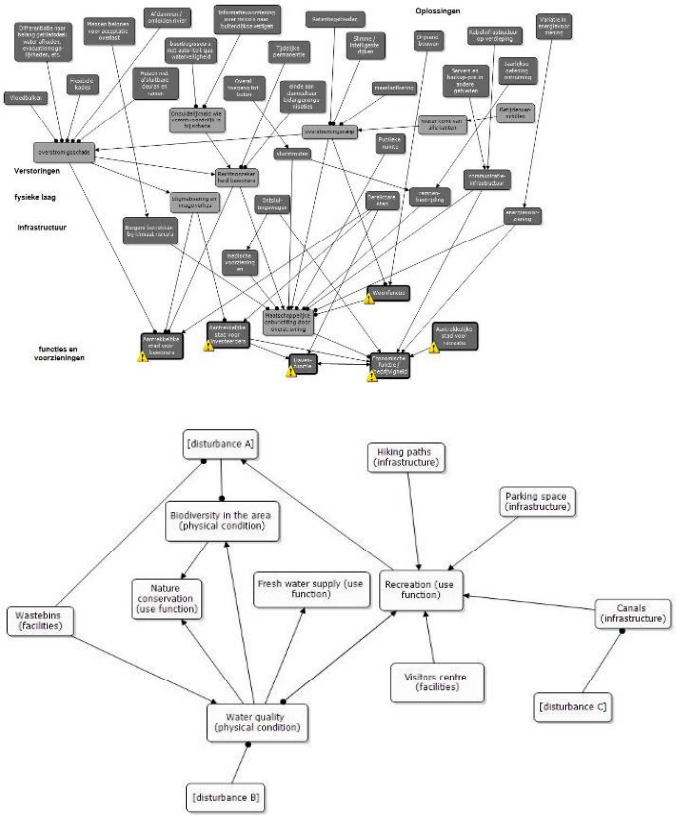


Figure 5. Top: example group model [Wardekker et al., 2008]. Bottom: example of a simple conceptual model.

The process consists of several steps: formulating the problem and/or goal, structuring it by creating causal chains (what causes/trends lead to what changes, effecting the problem/goal in what way), adding feedbacks, and optionally, generating options. Participants may have various views on the issue, and knowledge on different aspects of the system that is studied. E.g., a water manager has knowledge on managing water levels and what impacts these, a farmer has knowledge on the effects of different water levels on his crops, etc. This tool combines these different frames to construct a more complete image of the issue; a common frame. This could be a consensus view, but it could also visualize different lines of thinking. Additionally, the process can uncover aspects on which a lack of knowledge exists.

This tool is particularly useful when participants have either not yet formed strong frames (and information from others maybe helpful) or have very fragmented and incomplete frames, e.g. due to a lack of interaction between relevant stakeholders. Openness towards others' views is required. More information: Hage and Leroy [2008], Hare [2003], Vennix [1996, 1999], Andersen and Richardson [1997]; Van Kouwen [2007].

5.2.4. Uncertainty matrix

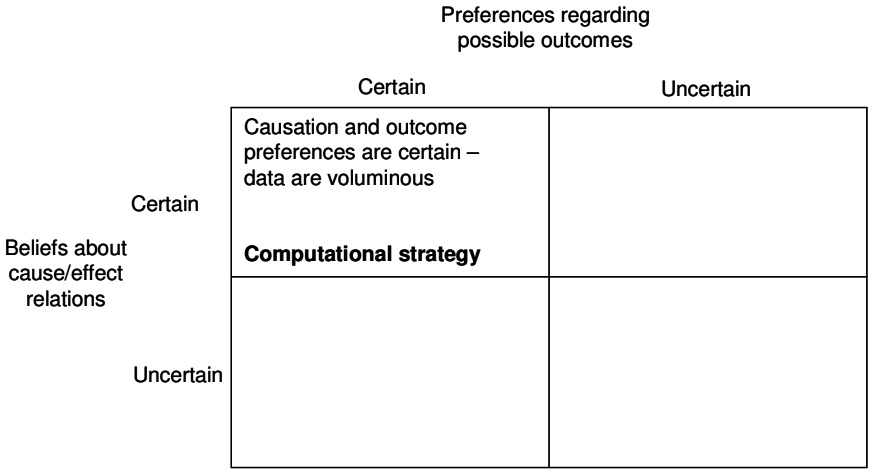
The uncertainty matrix [Walker et al., 2003; Janssen et al., 2003] can be used to identify and prioritise the most important uncertainties in a given study. See Appendix A for the matrix plus an example. For a specific application the different sources of uncertainty are listed in the rows. The type of uncertainty associated to each source is noted and characterised (quantitatively or qualitatively). The importance of each source may then be characterised, by weighting depending on its impact on the study in question, and the sum of uncertainties may be assessed.

It may not be possible to identify all sources of uncertainty and/or assigning correct weightings from the project start. The matrix can be reassessed at later stages, as more insight into the system is gained. An uncertainty matrix used interactively during the study supports the identification and prioritisation of all relevant sources of uncertainty. It also provides a framework to keep track of all sources of uncertainty during the study, so that sources identified early in the study are not forgotten at the end. Its main limitation is that it strongly relies on expert judgement and mainly yields

qualitative insight. This tool uses a central frame to structure analysis and discussion. This supports the thinking process and provides a basis for common understanding and judgment. Such a tool is useful when dealing with complex, multi-faceted issues when actors are likely to overlook parts of the issue and discussion can be hampered by a lack of common understanding.

6. Examples of computational tools

If there is certainty regarding both causation and outcome preferences, decision-making is relatively straightforward, although it may require a computational strategy to process voluminous data. This strategy may rely on conventional forms of decision support, such as multi-criteria analysis tools (MCA) and cost-benefit analysis (CBA). The built-in frame of these methods sees the decision situation as a problem for which an optimal solution might exist. Simply put, the ideal is an option that would be preferred to all other options in an imaginary decision space.



Most relevant tools

- Multi-criteria analysis tools
- Cost-benefit analysis tools

Most appropriate setting

- Bureaucratic structure (every issue should be routed to the appropriate specialist)

If there is a problem for which an optimal solution might exists, conventional decision tools such as CBA are indispensable. CBA can identify the most advantageous solution or at least those options for which benefits are greater than the costs. It should be noted that some kind of computational tool can also be used in the context of an inspirational or compromise strategy with the aim of making a quick scan of the possible options. Also, there may be a particular “fit” between, on the one hand CBA or MCA, and, on the other hand, model tools that allow for optimization of policy options. In addition, new evaluation methods seek to combine the conventional tools with different value-laden perspectives to assess what the optimal solution will be under various assumptions about stakeholder positions.

Due to the technical nature of computational tools, however, they may become counterproductive if their outcomes cannot be shared with members of a decision unit and stakeholders who see themselves as problem owners. This may already create a barrier at the beginning of a decision-making process, for example, when an analyst develops an attribute tree that organizes values and measurable criteria for a multi-criteria analysis (see Section 6.1). If members of a decision unit and stakeholders do not recognize how their input has been incorporated in the analysis, they will loose their trust in the method.

6.1. Multi-criteria analysis

1. Short description
Multi-criteria analysis (MCA), or multi-criteria decision analysis, compares alternative options or programmes using a set of criteria. Various MCA techniques available differ in the way they combine data, and are appropriate for different situations depending on e.g. the type of decision and available time and data. MCA assesses the performance of the programmes on each of the criteria. The criteria can have different units (euros, tonnes, square kilometres, qualitative descriptors, etc.). Compared to common sense judgement, this approach has the advantage that it is open, explicit, and traceable/auditable. This allows it to be an analysis framework as well as a useful tool for communication within the decision unit and to the wider community of stakeholders.

The MCA process combines a value-focused approach, which includes the development of an attribute tree (see Section 3.1), an engineering approach, focusing on the design of alternatives, and a mathematical approach, which may include an extended sensitivity analysis. It takes several steps:

1. A set of objectives is defined. To assess the extent to which these objectives are achieved, measurable criteria are established, based on an attribute tree.
2. A set of promising alternatives (programmes, options, etc.) is defined.
3. A performance matrix is created; see Table 8. This matrix lists the performance of each alternative against each criterion. In its simplest form, the MCA could end at an evaluation of this matrix. Some selection may already be possible at this point.
4. Alternatives are assigned a standardised score on each criterion, e.g. on a 0-1 or 0-100 scale, reflecting the 'strength of preference'[2]. Several standardisation procedures are available [DTLR, 2000]. Results can be plotted; see Figure 19.
5. The different criteria are weighted to correct for range differences in a way that agrees with their relative importance to the decision maker.

[2] Note that scaling needs not be linear. E.g., if size=800 is optimal, 900 is not 4.5 times as preferred as 200.

6. An evaluation is performed, based on the combined scores and weights. Many procedures are available, suitable for various situations [Hoppe et al., 1998; DTLR, 2000]. E.g., weighted summation (good scores compensate bad ones), satisficing (scores good on all criteria), minimax (best alternative on important low-scoring criteria), maximax (best alternative on important high-scoring criteria), outranking (averagely best alternative on sufficient criteria and not significantly worse than others on any other criterion), and multi-attribute utility theory.
7. Optionally, a sensitivity analysis can be carried out.

Table 8. Example performance matrix ('reserving an area for water storage during floods').

Alternatives	**Criteria**			
	Price per unit of land	Area size	Societal resistance	Potential for multi-functional use
Potential inundation area 1	5000	900	Medium	****
Potential inundation area 2	10000	200	Strong	*****
Potential inundation area 3	5000	10	Strong	*
Potential inundation area 4	7500	550	Low	***

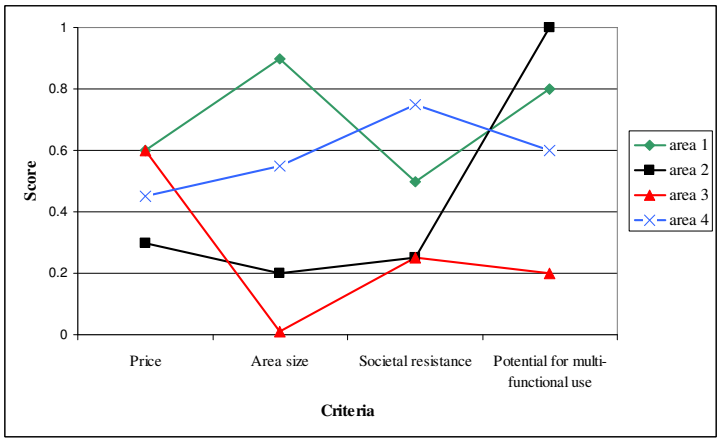


Figure 19. Example plot of standardised scores for each alternative (note that e.g. a low societal resistance results in a high score for this criterion).

2. How does it take framing into account?
MCA aims to make decision makers' normally implicit or vague frames ('perspectives') and value judgements explicit. These could be frames on e.g.: what are or goals and criteria, what optimal performance is on any criterion ('how much better is area size x compared to area size y?'), and what is the relative impact of various criteria ('how important is cost relative to societal resistance?').

Making these frames explicit helps the decision maker in his/her judgement process by providing structure and overview of the various choices that need to be made. In addition, the tool uses the frames themselves as (an important part of) the analysis framework, allowing for a formal analysis of the consequences of the frames for the judgement. It also assists users of the analysis and stakeholders in the decision process, as normally implicit frames are now open to analysis, discussion, critique, and, if deemed inappropriate, amendment.

A potential downside is that, as the selection of criteria and the weighting and scoring are fully based on the analyst's or decision maker's frames, stakeholders can not always recognize themselves in the analysis, and consequently may not support it.

3. When and how can it best be used?
This tool is most useful when there is a relatively clear view on the merits of the alternatives, the preferences and the decision rule (standardisation, weights, combined scores) – at least within the decision unit. The method usually requires providing a single value as input for scores and weights. Differences in these would require a full additional analysis. Some MCA techniques can however handle absence of data (e.g. outranking) or uncertainty (e.g. multi-attribute utility theory and fuzzy set methods), and combination with techniques such as sensitivity and Monte Carlo analysis may be feasible as well, although these could require considerable additional effort. Considerable consensus on goals and criteria is required. MCA studies using different goals and criteria are difficult to compare since they evaluate different things.

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6.2. Short descriptions

6.2.1. Cost-benefit and cost-effectiveness analysis

Cost-benefit analysis aims to evaluate the effects of policy programmes, based on their relative costs and benefits. I.e. do the benefits of a proposal or investment outweigh the costs? This can be assessed for the investor or for society as a whole (societal cost-benefit analysis). Costs and benefits are usually expressed in a single unit, money, which allows for easy comparison between costs, benefits, options, programmes, and various policy fields. Where monetary values cannot be derived from market values, various methods exist to determine prices. Examples include consumer preferences, specifically the 'willingness to pay', or (historical) policy preferences.

This implies a built-in frame that all costs and benefits can be valued in terms of money, and that the derived values are representative for society's preferences. Similar built-in frames apply to the discount rate, valuing benefits received soon less than the same benefits received later, particularly in long-term societal cost-benefit analyses where the costs aren't born by the same people that receive the benefits. These frames can lead to significant controversy concerning the analysis' results. There is also a risk of ignoring costs and benefits that are difficult to monetise, while these may be highly important for the policy choices (e.g. equity and other ethical considerations).

When monetisation of the benefits is difficult or controversial, cost-*effectiveness* analysis is a useful approach. It evaluates which policy option produces the desired effects at the lowest costs – the benefits are not monetised but taken as a 'given' goal. These tools (implicitly) synthesise society's frames on the costs and benefits of proposals into a single number, to allow for easy comparison. They are most useful when there is limited controversy on these numbers, few value judgements involved, and limited differences in the distribution of costs and benefits over various social groups. More information: Rossi et al. [2004], Eijgenraam et al. [2000], and Fischer [1997].

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Note: references in full tool-descriptions are listed directly below the description.

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Appendices

Appendix A: Uncertainty matrix

Source of uncertainty		Taxonomy (types of uncertainty)				Nature	
		Statistical uncertainty	Scenario uncertainty	Qualitative uncertainty	Recognised ignorance	Epistemic uncertainty	Stochastic uncertainty
Context	Natural, technological, economic, social, political						
Inputs	System data						
	Driving forces						
Model	Model structure						
	Technical						
	Parameters						
Model outputs							

Figure 20. Empty uncertainty matrix [modified from Walker et al., 2003].

Source of uncertainty	Type of uncertainty				Importance	
	Statistical uncertainty	Scenario uncertainty	Qualitative uncertainty	Recognised ignorance	Weighting	(Uncertainty × weight)
Problem context						
– Future agricultural practice		Medium	Medium	Medium	Large	Medium
– Future climate		Medium	Medium	Large	Medium	Medium
Input data						
– Catchment data	Medium			Small	Large	Medium
– Nitrate load from agriculture	Small			Small	Large	Small
Parameter uncertainty						
– Water quantity	Small			Small	Medium	Small
– Water quality	Medium			Medium	Medium	Small
Model structure (conceptual)						
– Geology		Large	Large	Medium	Large	Large
– Nitrate reduction in underground		Medium	Medium	Large	Large	Large
Model technical uncertainty						
– Numerical approximation	Small			Small	Medium	Small
– Bugs in software				Medium	Medium	Small
					SUM:	

Figure 21. Example of use of the uncertainty matrix (adapted version) for an initial assessment of sources of uncertainty and their importance in a specific project context (source: Refsgaard et al., 2007).

Appendix B: Details of the reasoning and dispute elicitation tool

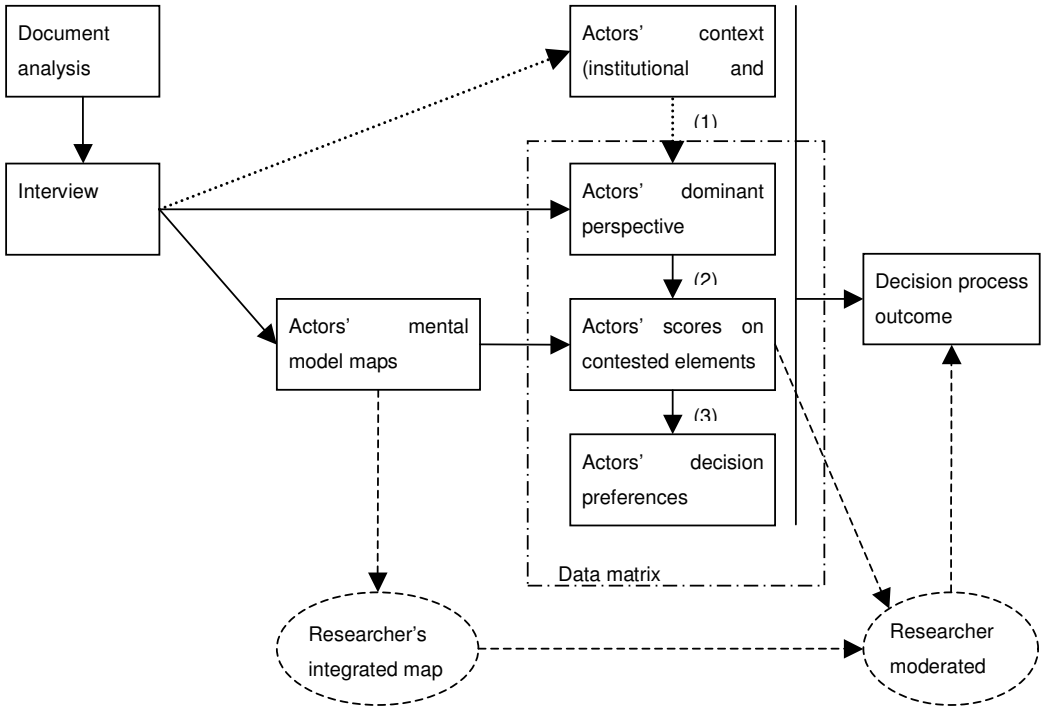

Figure 22. The basic principle of analysis for the ex-post case study example (Kolkman 2007). The arrows indicate the sequence of data production. The numbered arrows indicate the sequence of explanation. The dotted arrows have not been fully investigated, and could be included in an extended data matrix. The numbered arrows explain an actor's decision preference. The dashed circles and arrows denote possible future use of the method in ex-ante, action oriented research.

The consequent steps of our method for construction and analysis of mental models are discussed below. These steps are visualized in Figure 22.

1. A transcription of the interview sound recording was made.
2. The transcription was structured by setting apart text fragments that deal with a single subject into the cells of a table. Next the important words and passages wore highlighted, and key words were marked in bold. On the same row of the column, in the adjacent cell, the text fragment was commented and the most important passages were copied into this cell to facilitate the production of the summary. All actions were performed with the Microsoft Word software.

3. Subsequently a long summary was produced, based on the previous selected text passages. Next the long summary was further compressed into a short summary.
4. Based on the long summaries mental model maps were produced (see Figure 24 for an example), using the CmapTools software package [Cañas 2004]. Subsequently the short summaries were used to add structure to the map.
5. The mental model maps were subsequently analysed on model elements that conflicted with the maps of other informants, with the purpose of revealing controversies between informants. These specific elements were indicated in the map with ellipses. Conflicting elements were identified by different values on system parameters, different interpretations or opinions on the issue at hand. Also specific opposition against other informants or the general opinion advocated in the EIA report was noted.
6. In our study we are searching for barriers in the information flows between actors, and expect that these will become visible in the conflicting elements. In fact, we are searching for those parts of the maps that are not shared between all informants, or on which opinions differ. Removing the shared elements from the maps would result in a set of maps that have minimal overlap, from which we intend to explain the course of the decision process in this case. In stead of performing the above operations in the maps, we collected all conflicting elements in a table, the data matrix, which makes them easier to process. The elements have been written down as bi-polar (or more) statements where possible (a method we copied from the cognitive mapping method). This makes their meaning more clearly compared to the mono-polar notation. Every pole represents a value that this specific element can take. Every time the analysis of the interview produced a new conflicting element, or a new value of an already existing conflicting element, its value was included in the list. The data matrix keeps track of which informant uses which value of the conflicting element by writing down an indicator for the value in the table column of the specific informant. In this way, for each conflicting element the table shows the opinion of every informant on that subject. Table 9 presents an example of the data matrix taken from the case study described.

Table 9. Example rows of the analysis data-matrix, showing some selected concepts with their stakeholder scores. The selection represents the main themes of dispute in the case. The scores can be related to a stakeholders' dominant frame perspective type in the top of the table. The stakeholders interviewed are listed across the header of the table with a code number (1-14).

Informant no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Initial frame perspective type (TOPEA)	O	T	T	E	C	T	T	P	C	T	T	O	O	E
Responding frame perspective type (TOPEA)	E	E	-	C	P	C	E	P	P	E	O	P	P	T
Disputes observed in interviews (below)														
Must be physically **C**losed …vs… can have an **O**pen discharge canal on condition that the safety norm remains guaranteed.	C	O	C	C	C	C	C	C			C, O	C	C	C
Province must **D**issociate and limit to assessing the reasonability of the EIA report contents …vs… can fully **P**articipate on contents aspects also from the start of the project	D	P	D	P	P	D		D	D		P		D	
Discharge peaks from the river Vecht and the Sallandse Weteringen do **N**ot coincide …vs… in the past the discharge peaks were always observed to **C**oincide		C		-	C	D	C		D	C				C
The barrier increases the safety of the Zwolle city: **a**) Yes, **b**) Also at high Weteringen discharge, **c**) At low Weteringen discharge only, **d**) Never		d	c	a	-	a	d			d	d		a	d

The method described above to transcribe each interview is rather time consuming. In the course of our interview analysis we therefore devised a way to accelerate the analysis process without negatively influencing the intended final results. These shortcuts are mainly based on the

researcher's gradually growing knowledge of and insight in the case situation. This allowed us to progressively accelerate the analysis by gradually skipping steps, starting from step 5 downwards to previous steps. The progressive simplification enables us to efficiently produce a list of conflicting elements and accompanying opinions. These simplifications are described below, and illustrated in Figure 23.

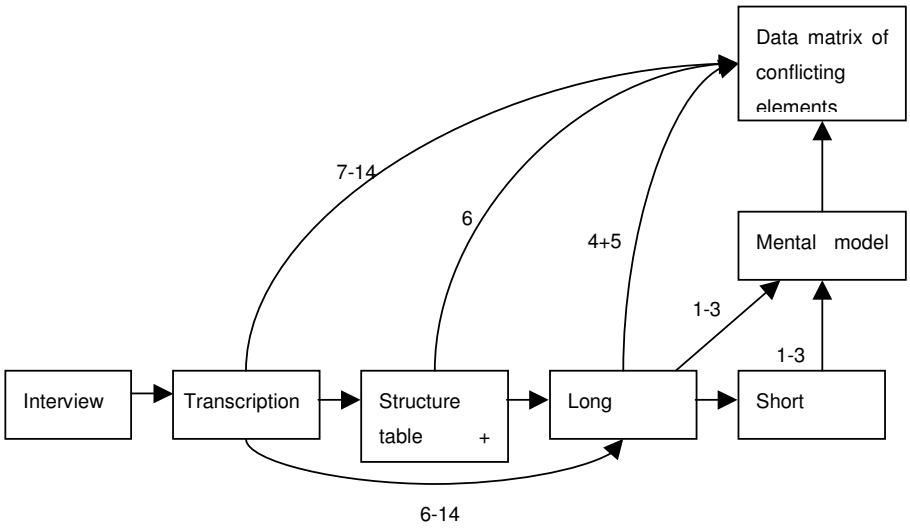

Figure 23. The procedure followed for the analysis of mental models. For successive informants (which are indicated by their numbers) shortcuts on the full procedure were used.

Steps in the progressive simplification:

1. The first transcriptions represented the recorded interview text in full extent. This created in the researcher a detailed picture of the problem situation in the specific case. Using this detailed picture, later interviews were only transcribed with regard to new information, the other part of the recordings were summarized by means of keyword and sentences. The idea behind this approach was that, starting from a certain moment; subsequent interviews would not produce new information any more. This appeared not to be the case in our interviews. Although the parts of the interviews did indeed contain the same information, every informant appeared to produce original elements. The number of new elements, however, gradually decreased.
2. Mental model maps have been produced for the first three informants only. From these maps we concluded that informants mention many overlapping elements, which resulted in large correspondences

between maps. Because our study focuses on map differences, we omitted the production of mental model maps starting from the fourth informant. For the 4th and 5th informant the conflicting elements were identified from the summaries that previously served the production of mental model maps.

3. After the fifth informant the list op conflicting elements appeared to grow less quickly, indicating that our list gradually became more complete. For this reason, starting from the 6th informant the production of summaries was also omitted, and conflicting elements and their scores ware determined directly from the structuring table and added to the list.
4. Starting from the 7th informant, also the structuring table was omitted, and the gained experience of the researcher now allowed the identification of conflicting elements directly from the interview transcription. In stead of in the structuring table, key passages, key words and comments have now been marked directly in the existing transcriptions, to facilitate the production of summaries.

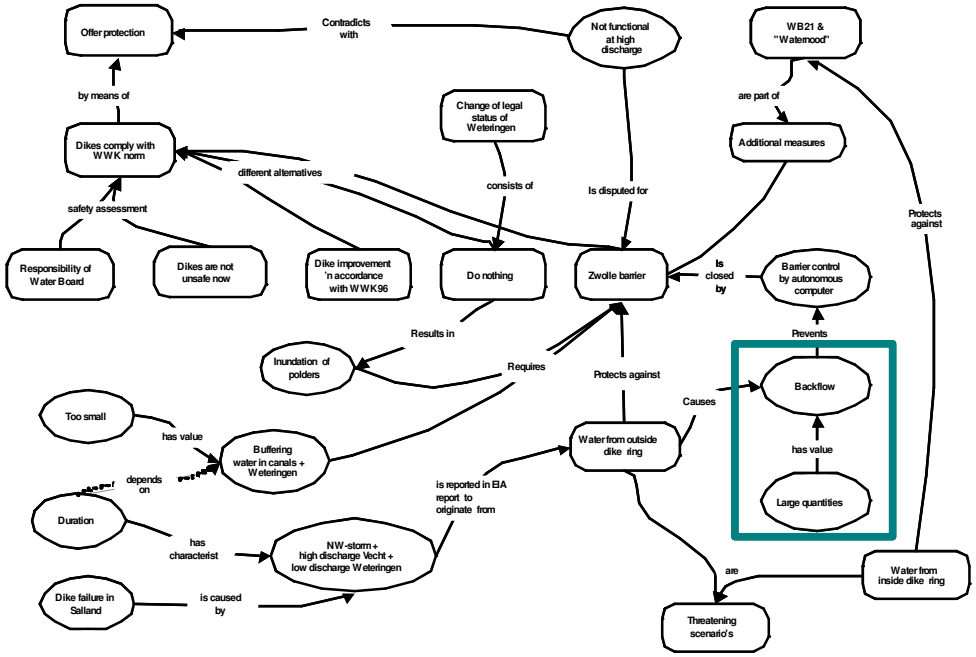

Figure 24. Example of an actor's mental map. Ovals represent elements disputed by one or more other actors. The elements in the square are disputed between stakeholders.

Part III Basic framework

1. Frame-based information tools on climate change

Joop de Boer
Institute for Environmental Studies (IVM), VU University Amsterdam
Amsterdam, March 2008

1.1. Introduction

In the years to come many new tools will have to be developed for communication and learning on climate change and, in particular, the options that can make a society more climate-proof (i.e. adaptation and mitigation). Taking the role of framing into account may significantly add to these tools and support skilled decision-makers in appraising the expected outcomes of their decisions. Skilled decision-makers are people with professional experience in the decision-making domain who tend to know what types of actions are typically appropriate and successful in a certain case [Lipshitz et al., 2001]. Their skills include the ability to detect and prioritize problems, and the ability to learn from experience. In cases related to climate change, however, they have to face various challenges that may tax their conventional problem-solving techniques, decision support tools, and the frames on which these are based. Against this background, the aim of this paper is to gain a better understanding of the relationship between conventional and novel analytical tools, such as cognitive aids and participatory tools.

A new approach is needed because climate issues are rather extreme examples of what the Operations Research community calls "wicked problems" [Mingers and Rosenhead, 2004]. This refers to situations that do not come in disciplinary-shaped boxes and that can be characterized by:

- multiple actors (at multinational, national, regional, community, sectoral, technology, firm, project level),
- differing perspectives (short-term, long-term, very long-term),
- significant but hard to define or to measure effects (well-being, equity within and between generations),
- partially conflicting interests (impacts of mitigation and adaptation measures dependent on context), and
- key uncertainties (plus discipline-based cultures of uncertainty management).

These situations are notoriously difficult to tackle. The conventional forms of decision support, such as cost-benefit analysis (CBA) and multi-criteria assessment (MCA), are important tools [Pearce, 1998] but can

have serious limitations when applied to wicked problems, such as climate change mitigation, adaptation and knowledge acquisition. Although economists are aware of the limitations of CBA [Toth, 2000; Turner, 2007], debates on policy-relevant information have added to an increasing polarization between competing forms of decision support, such as "normal" and "post-normal" science [Ravetz, 1999], or "technical" and "deliberative" approaches [Burgess and Chilvers, 2006; Owens et al., 2004]. In a recent Danish consensus conference, for example, environmental economists were "put on trial" and had to defend the way in which their field is used as a policy tool [Blok, 2007]. Clearly, more polarization may be rather unproductive and will seriously hamper the development of tools to get experts, decision-makers and the wider public involved with climate and sustainability issues [Burgess et al., 2007; Welp et al., 2006].

The debates on policy-relevant information are closely related to the ways in which appraisals are framed. Two contrasting examples are depicted in Figure 1. The first example frames appraisal as a control problem. This means that a measured process variable, such as total greenhouse gas emissions, is compared to a target level in estimating whether certain emission-reducing actions will satisfyingly reduce the distance to the target (e.g. keep concentrations of greenhouse gases below 550 ppm CO_2 equivalent). This approach may be indispensable to produce some rough calculations of the impacts of policy options. Two well-known variants are the Safe Landing Analysis (SLA) and the Tolerable Windows Approach [TWA, e.g. Bruckner et al., 2003]. These appraisals presume an appropriate understanding of process variables, target levels, manipulated variables and the decision rule for determining whether the appraisal can be finalized.

In contrast, appraisals framed as a learning process explicitly acknowledge that process variables, target levels, manipulative variables and decision rules are not well understood. At the start of such an appraisal, a preliminary understanding of what is going on is crucial for ways of representing the problem, for example in terms of enhancing social resilience to climate change [Nelson et al., 2007]. This lays the ground for extracting and structuring policy options that make a difference between futures for society. The next step in the appraisal is to generate predictions that approximate the relevant futures with and without the policy options. Finally, the differences between these futures have to be integrated and evaluated to bring the appraisal to a conclusion. The outcomes can be used to deepen the understanding of

the issues at hand and to inform sequential decision-making under uncertainty and learning.

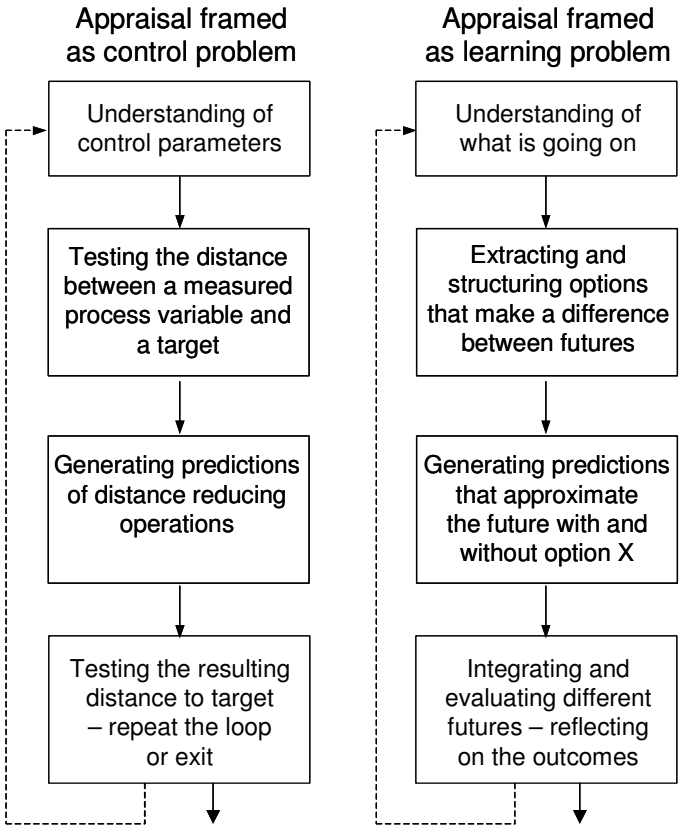

Figure 1. Two contrasting ways to frame a policy appraisal.

The analytical framework of this paper will focus on the pattern of critical choices and assumptions that have to be made in any climate policy appraisal. However, policy controversies may create a complex and value-laden context for appraisal. In the multidisciplinary literature on the conditions that spur policy-makers to seek help from experts and other stakeholders, Haas [1992] has identified two contrasting schools of thought.

Firstly, those authors applying the *political* literature presume that policy-makers will only comply with scientific advice that enables them to pursue pre-existing ends and to expand political coalitions [e.g. Schön and Rein, 1994; Vogel, 2003]. This type of analysis is especially relevant for descriptive studies with the benefit of hindsight.

Secondly, those authors informed by *organization* theory presume that policy-makers will seek information and comply with persons who are able to provide credible advice [Lipshitz et al., 2001; Weick, 1995]. The

latter approach is taken here, as it gives the opportunity to develop tools for policy appraisal that might help in finding at least partial solutions, such as new ways of representing a problem and identifying potentially manageable issues.

The following sections of this paper will elaborate the critical choices and assumptions in the context of the main problems that each stage of an appraisal generates. These include framing problems, grounding problems, prediction problems and qualification problems. The paper starts with a short discussion on appraisal tools.

1.2. Appraisal tools

The tools that are available to support climate policy appraisals have been developed by experts from strongly divergent disciplines, covering both the natural and the social sciences. A meaningful way to organize the tools is to group them together and link them to the appraisal stages. As was shown in Figure 1, the description of these stages varies depending on how the appraisal is framed. This also explains why the stages are described in the literature under different headings. In general, an appraisal will go through four main stages, which involve:

- the preliminary understanding of the issues at hand (also known as "sense making" or "scoping"),
- the structuring of options for a change (also "definition" or "envisioning"),
- the prediction of differences between options (also "analysis" or "experimenting") and
- the evaluation of the combined outcomes (also "deciding" or "learning").

Table 1 provides an overview of the relevant tool groups and their links with appraisal as a learning problem. In the context of sustainability assessment a similar approach has been taken [de Ridder et al., 2007], although it should be mentioned that these researchers put much less emphasis on the distinction between prediction and evaluation. However, this distinction may be crucial for quality control and learning.

Table 1. Overview of tool groups and their links with appraisal as learning problem

Tool groups	**Stages of appraisal as learning problem**			
	Preliminary understanding of what is going on	Extracting and structuring policy options	Generating predictions or estimations	Integrating and evaluating
Cognitive aids and "soft modelling tools", e.g. concept mapping	x	x		
Participatory tools, e.g. stakeholder dialogues and focus groups[1])	x	x		x
Scenario analysis tools, e.g. expert panels and simulation gaming [1])		x	x	
Model tools, e.g. biophysical (climate), socio-economic, or integrated (land use) [1])			x	
Accounting tools, physical analysis tools (Lifecycle assessment) and indicator sets[1])		x		x
Multi-criteria analysis tools, e.g. multi-attribute value approach[1])		x		x

Cost–benefit analysis tools and cost-effectiveness analysis tools[1])	x	x
Argumentation support tools, e.g. scaffolds or formal frameworks for ethical argumentation	x	x

[1]) Tool groups covered by the *SustainabilityA*-test project [de Ridder et al., 2007].

The links between the tool groups and the appraisal stages depicted in Table 1 are intended as indicative information on the relevant activities. Therefore, it should be emphasized that differences between appraisals in terms of framing and depth may create serious misunderstandings about the nature of appraisal tools. For example, a rough approximation of a balance sheet that is used as a cognitive aid to gain a preliminary understanding of a climate policy problem may not be very different from a simplified or "quick scan" CBA, but the latter should be distinguished from a full CBA that is part of a learning process. Similarly, a simplified version of climate model tools may be a very relevant cognitive aid at the beginning of an appraisal, but should not be confused with a formal model.

The conventional tools presented in Table 1, such as scenario analysis, model tools, accounting tools, MCA and CBA, are not linked to the initial stage of an appraisal that is framed as a learning problem. In fact, the very notion that appraisals can be framed as a learning problem may be more in line with the tools that are relatively novel. The latter include cognitive aids and soft modelling tools – originating in the field of Operations Research – participatory tools and argumentation support tools – developed in the social sciences and in philosophy. As Table 1 shows, none of the tool groups can be expected to cover all the four appraisal stages and this means that in any case some combination of tools will be necessary. What the novel tools can contribute here is that they may enable decision-makers to become more open-minded and cooperative in their problem-solving approach.

Whether decision-makers really want a more open-minded and cooperative approach depends basically on three psychological [Schein, 1996] and political [Lindblom, 1990] conditions. Firstly, all forms of learning and change start with some degree of dissatisfaction generated by perceptions that disconfirm a person's expectations or hopes. This point characterizes any policy issue. Secondly, the dissatisfaction must create a sense of urgency that helps to get things done. The issue involves an ill to escape or an opportunity not to be missed. And thirdly, there should be sufficient psychological and political safety that allows the decision-maker to enter a learning or change process. Allowing some trial and error may require that all kinds of restraining forces (e.g. "limits" or "barriers") be removed.

Accordingly, even if climate policy issues create a sense of urgency to avoid ills or approach opportunities, the impact of a decision-maker's psychological and political safety should not be underestimated. Unless sufficient safety is created, decision-makers will tend to avoid an open-minded and cooperative approach. This point underlines the view that the strengths and weaknesses of appraisal tools cannot be seen in isolation. As reported by many authors in this field [e.g. Schein, 1996], the famous notion of "planned change" might be better conceptualized as "managed learning". The next sections will take a closer look at the pattern of critical choices and assumptions that have to be made for appraisal and learning.

1.3. Framing problems

Frames are crucial for any appraisal as they shape the selectivity and organization of perceptions that classify changes in the environment. Although there may be slight differences between various definitions [Chong and Druckman, 2007; Graf, 2006], frames are generally conceived as organizing principles that enable a person to predict and qualify the continuous changes in his or her environment as a basis for action. Notably, frames are not just personal mindsets but also cultural structures. In the literature on policy controversies [Schön and Rein, 1994], frames are depicted in terms of "underlying mental structures" of belief, perception and appreciation, which enable people to take shared or opposing political positions.

To illustrate the role of frames, Figure 2 shows the processing of information by a person who is exposed to environmental sounds. In processing the sound signals the person will automatically apply speech-frames that classify the sounds, for example, as the voice of a woman (Frame 1) and as English speech (Frame N). Next, it is the combination

of these frames that generates the perception of an English-speaking woman. In the same way, the perception of climate change is also based on the combination of frames (Figure 2). The very notion of climate change requires frames to classify global features (e.g. melting ice caps), frames to classify local features (e.g. sea level observation), and ways to combine the frames (linking changes in sea level to melting ice). Unlike speech-perception, however, the perception of climate change is new.

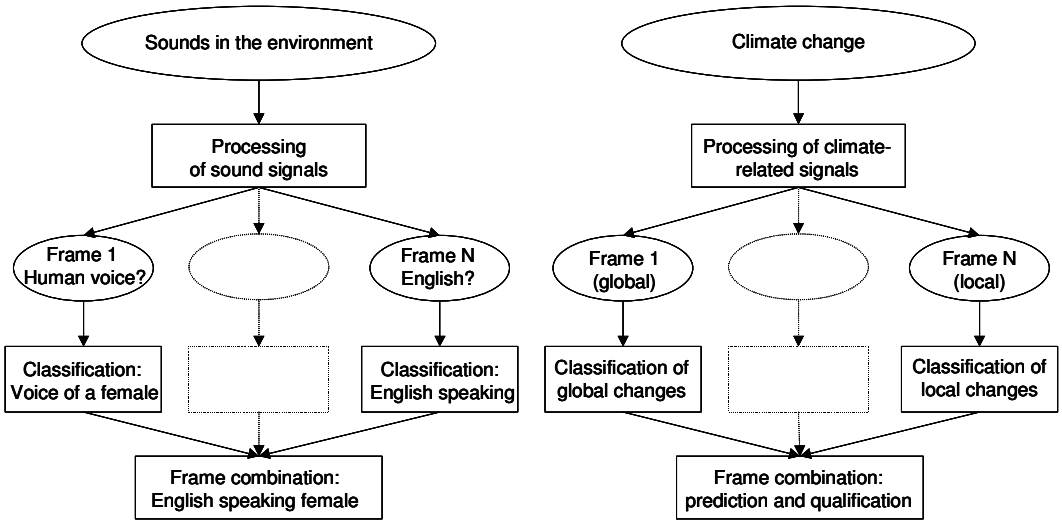

Figure 2. A person's processing of sound signals (left) compared with the processing of climate-related signals (right) to illustrate the notion of frame combination.

All the tool groups presented in Table 1 have their own built-in frames that shape the selectivity and organization of information. This may be extremely helpful for decision-makers provided that they understand the underlying principles. With regard to climate change, a multitude of frames and frame combinations has been developed by experts who, in turn, have combined their classifications to inform decision-makers and the wider public. Among other things, this has resulted in the series of reports produced by the Intergovernmental Panel on Climate Change (IPCC). However, it is a major challenge for decision-makers that climate change is still very much a scientific problem [Robinson et al., 2006].

Accordingly, framing problems often relate to scientific uncertainty. Because even skilled decision-makers lack the frames to classify uncertainties, they may not recognize that their understanding of complex issues is limited. Yet, they have to deal with the discipline-based cultures of uncertainty management that have been put forward by natural scientists [Carter et al., 2007] and economists [Halsnæs et al.,

2007]. For instance, an urgent question for experts in this field is how they should best characterize scientific uncertainties for decision-makers [Lempert et al., 2004]. For the latter, however, this question may not be just as urgent [Dessai and Hulme, 2004].

Another framing problem relates to the relevance of causal thinking for frames and frame combinations. People assume and prefer a common-cause structure regarding "natural" categories [Ahn et al., 2001]. An example is the idea that living things, such as dogs, have an essence that works as a common-cause of all the different dog-like phenomena. In contrast, common-effect models often relate to ideas about artefacts that have been assembled, such as a table; its different constituting elements produce the table-like function as their common effect. Common-cause models are relatively easy to understand and can flexibly be extended or reduced [Kinchin et al., 2000]. In contrast, common-effect models require more knowledge about the constituting elements and their mutual relationships.

The common-cause model may help people to become aware of the many ways in which climate change can become manifest, such as by changes at the North pole, in the Alps, in sea level and in patterns of rainfall. This may happen even if their understanding of these issues is not completely in line with established scientific knowledge. In contrast, making a country climate proof by adaptation and mitigation measures requires a completely different mental model. Climate proofing should be driven by opportunities for technological, institutional and societal innovations, rather than purely by fear of the negative effects of climate change [Kabat et al., 2005]. Therefore, climate proofing is a common effect of different constituting elements that have to be balanced carefully. The contrast between the two mental models is illustrated in Figure 3.

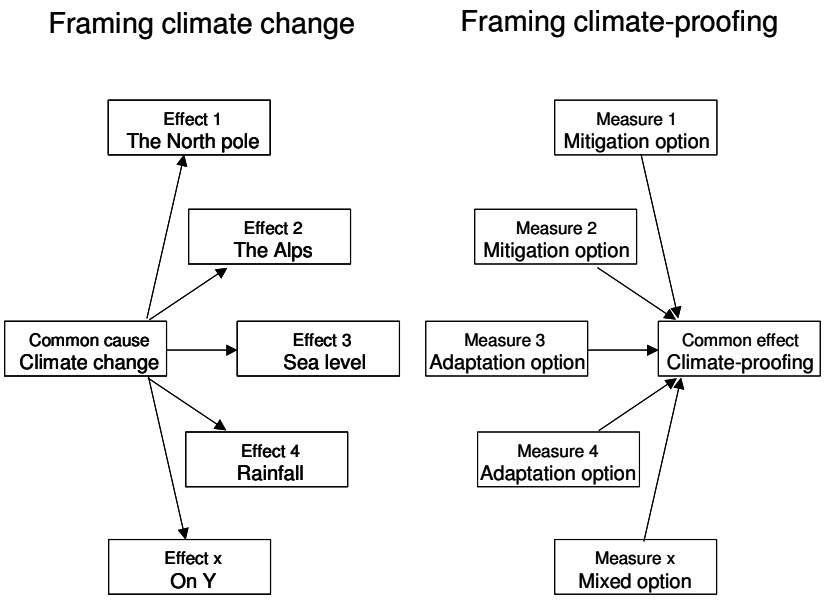

Figure 3. Climate change is a common cause; climate proofing is a common effect.

A better understanding of causal relationships may put a policy issue in a different frame, for example, in relation to common causes or common effects. What is needed for such a conceptual change is, basically, a different interpretation of observations. This is a crucial point because the impacts of policy options on climate change adaptation and mitigation appear to be very context specific [Halsnæs et al., 2007]. In particular, the role of other human-caused environmental changes, such as changes in regional land use patterns, should be taken into account. It is the specific combination of climate change and other environmental changes that may create the most significant impacts for society (i.e. a common-effect model). Consequently, it is extremely difficult, also for skilled decision-makers, to determine the main priorities and avoid short-sighted solutions.

In the case of policy controversies, conflicts of interests have been triggered that may partly be rooted in the frames of the parties involved [Schön and Rein, 1994]. As far as the conflicting policy-positions have been shaped by divergent frames, it makes sense to reflect on the frames and the ways in which they are combined. Moreover, frames are not only relevant for an understanding of the conflict itself, but also for insight into the type of negotiation that might end it. For example, Eastern and Western approaches to negotiation are very different [Nisbett, 2003]. The analysis of frames in this context is quite new, however.

1.4. Grounding problems

Frames have an important impact on the basic understanding of what is going on and, consequently, on the next steps of the appraisal. They also shape the notion whether and how it is possible to structure one or more policy options with the aim to make a difference for society. Finding a proper ground for extracting and structuring policy options requires several critical choices, however. These include choices regarding the use of multiple perspectives, having narrow or broad aims, and taking a short- or a long-term view (Figure 4).

Given the complexity of the issues at hand, an important choice is whether more than one perspective should be used. This choice is not mentioned by the conventional tools, which typically provide only a single view. However, one of the main characteristics of a single view is that it tends to induce passive acceptance of the information given [Kahneman, 2003]. A relatively novel approach is to involve experts from disciplines that are closely linked to different perspectives, such as economists, ecologists and political scientists [von Winterfeldt and Edwards, 1986]. A similar approach is to bring in stakeholders from the appropriate sectors of society, such as industry, NGOs and citizen groups. This may require new strategies to improve the quality of stakeholder input, such as a structured decision approach [Failing et al., 2007].

Another tool to create different perspectives looks for conceptual contrasts that describe alternative futures, such as futures with high or low degrees of international cooperation. This approach, developed by the group who created the Shell-scenarios [Shell, 2003;2005], was also taken up by IPCC [2000]. Its four scenario families are alternative images of how the future might unfold and assist in climate change analysis, including climate modelling and the assessment of impacts, adaptation, and mitigation. It should be noted, however, that scenarios can only provide meaningful perspectives if potential users can relate personally to the factors that are included [Shell, 2003].

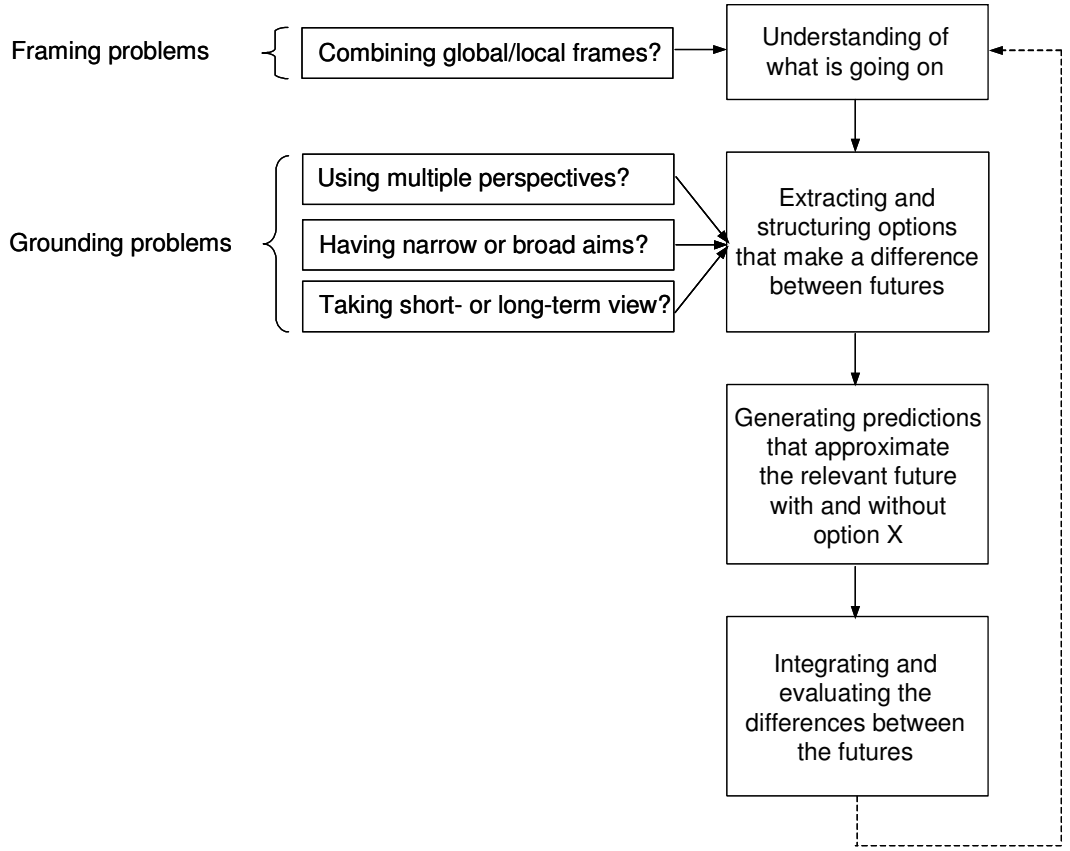

Figure 4. Critical choices for extracting and structuring policy options.

Another choice relates to the scope of the policy objectives. Having narrow aims, such as the protection of an area against some specific level of flooding, may contribute to a decision-making process that is adequate and efficient. However, if the broader context of climate change is taken into account, it may appear that having a narrow aim also contributes to a tunnel vision or "group think" [Janis and Mann, 1977], which misses solutions that are really more sustainable. Recent work on decision-making has demonstrated how broad aims can be specified in a hierarchical structure, such as a goal hierarchy or a value tree [Gregory, 2000; Keeney, 1992], which provides a meaningful starting point for thinking about alternative futures.

Considering a higher level in the hierarchy of goals is a crucial way to open-up and reframe a situation. Goal-directed behaviour is only possible on the basis of a number of functional levels of behavioural control [Carver and Scheier, 1998]. Table 2 presents the three top levels of control; they are called system concepts, guiding principles and programmes, and they explain "why" and "how" a course of action is taken. For example, being actively involved in climate change adaptation and mitigation is in fact a guiding principle only; adaptation and

mitigation are content-free, applicable to many kinds of policy programmes, and not an end in itself. In contrast, it may be helpful for decision-makers to put adaptation and mitigation in the context of a higher-level objective, such as sustainable development [Robinson et al., 2006; Yohe et al., 2007]. Emphasizing the functional relationship with sustainable development makes it easier to combine the aims of adaptation and mitigation with those of other environmental or socio-economic issues.

Table 2. Levels in the hierarchy of goals [adapted from Carver and Scheier, 1998].

Functional level of control	Key question	Examples
System concepts	Why?	Big ideas such as security, equity, and sustainable development
Guiding principles	How?	Be actively involved in climate change adaptation and mitigation
Programmes	Another how?	Prepare regional flood protection programmes and energy conservation schemes

Closely related with the choice of aims is the choice of a time frame. In cases related to climate change, both short-term and long-term views are relevant. A really long-term view is necessary to capture the possibilities of extreme changes in climate and land use. However, a long-term perspective that goes far beyond the conventional planning horizon exceeds the capabilities of the available decision-support tools, including notions of discount rates that are crucial for CBA [Turner, 2007].

Changing the time frame is a way to open-up processes of reasoning and policy-making. However, just focussing on long-term goals may frustrate the decision-making process. A recent evaluation study on the quality of information tools for community adaptation to changes in climate or land use showed that many local and regional decision-makers want detailed local projections for periods short enough to account for extreme events; this in contrast to the broader spatial and

temporal observations and projections that are available at a regional level [Dempsey and Fisher, 2005]. This result suggests that skilled decision-makers should be enabled to flexibly move up and down the "time ladder", for example, to explore whether or not it is allowed to attend a set of problems in a sequential fashion.

1.5. Prediction problems

The next step in an appraisal is generating predictions that approximate the relevant future with and without certain policy options (Figure 5). Given the information limitations inherent to an appraisal, this step has to be based on one or more of the following general types of tools, namely logical reasoning (including scenario planning [van der Heijden, 2004]), mental models or influence diagrams (including Bayesian Belief Networks [Castelletti and Soncini-Sessa, 2007]), and dynamic models (including computable general equilibrium models [Böhringer and Löschel, 2006]).

From the perspective of information processing, it should be noticed that the prediction tools are based on three common processes for reasoning about novel situations [Rumelhart, 1989]. They are:

- Reasoning by similarity; a problem is solved by seeing the current situation as similar to a previous one in which the solution is known. In this category fall intuition, reasoning by example, generalization and analogical reasoning.
- Reasoning by mental simulation; a problem is solved by imagining the consequence of an action and making the knowledge that is implicit in our ability to imagine an event explicit. This category includes story-building to mentally simulate the events leading up to a certain ending.
- Formal reasoning; a formal symbolic system, such as logic or mathematics, is employed in the solution of a problem.

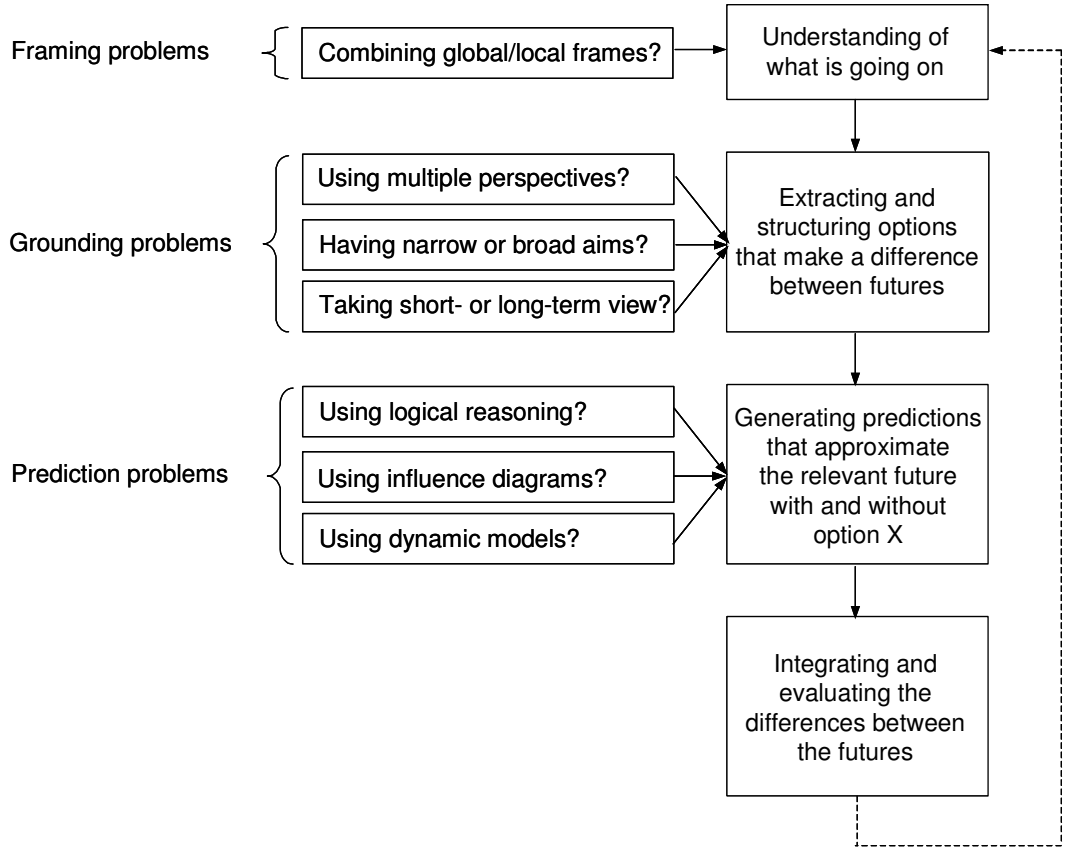

Figure 5. Critical choices for generating predictions of alternative futures.

Reasoning by similarity and mental simulation are important ways in which skilled decision-makers can build on their experience to make decisions. The various formal approaches that they may have at their disposal are extensions of the other two ways of reasoning. For example, logically constructed checklists may provide a systematic test of the similarity between a novel situation and a situation in which the solution is known. Similarly, influence diagrams and computer simulation build upon mental simulation of processes in the real world by using mathematics and formal analysis.

The relevance of scientific uncertainty is one of the topics that can lead to difficult discussions between decision-makers and experts on the deployment of formal methods. The ability to learn from experience enables decision-makers to combine several approaches in a pragmatic way. For example, research in the field of "naturalistic decision-making" [Lipshitz et al., 2001] shows that skilled decision-makers may not be interested in all the scientific uncertainties with regard to an issue. Instead, they tend to mentally simulate a course of action – like chess masters who are considering their next move – to see if it will work, and

to look for unintended consequences that might be unacceptable. In this line of reasoning, not all the scientific uncertainties are interesting, but only those that are most relevant to choosing among alternative policies. The latter approach has also been suggested for climate change issues [Lempert et al., 2004].

Although computational models will often be too complex for decision-makers to understand, a simplified causal model may be a helpful tool to reduce serious misconceptions. For example, Sterman and Booth Sweeney [2007] showed that a group of highly educated adults tended to assess climate system dynamics using a pattern matching approach, in which past correlations between emissions, CO_2 concentrations and temperature were used to project future correlations. As a result, they incorrectly predicted that stabilizing emissions would rapidly stabilize climate, and emissions cuts would quickly reverse warming and limit damage from climate change. Conversely, a simplified model with pictures of stock-flow structures as bathtubs with tap and drain may be of help to explain that a bathtub will overflow as long as it is filled faster than it drains. This analogical reasoning may also change the time horizon that is considered relevant.

New assessment methods combine model-derived estimates of future climate conditions in a region with other reasoning methods. This work includes artificial experiments and analogues based on recorded climate conditions in the past or in an other region that are considered to adequately represent key weather variables affecting vulnerability in the study region [Carter et al., 2007].

1.6. Qualification problems

Integrating and evaluating the differences between the futures is, in principle, the final step of an appraisal (Figure 6). Integration is required to summarize the differences and evaluation is needed to produce value-based qualifications of the outcomes. This step can be framed in two different ways, each with its own focus and decision rule [Beach, 1990; Lindblom, 1990; Lipshitz et al., 2001; Simon, 1964]. The first frame sees the decision situation as a problem whose solution should satisfy a wide set of constraints. The intended course of action, for example, should not only be technically suitable but also acceptable to all kinds of stakeholders. In fact, this frame is mainly focussed on strategies to prevent the unintended and unacceptable consequences of a wrong decision.

The second frame sees the decision situation as a problem for which an optimal solution might exists. Simply put, the ideal is an option that would be preferred to all other options in an imaginary decision space. In this case, the focus is largely on achieving positive outcomes, although trade-offs may have to be accepted. The notion of trade-offs can be an argument to opt for a transparent, quantitative evaluation of the differences between the solutions.

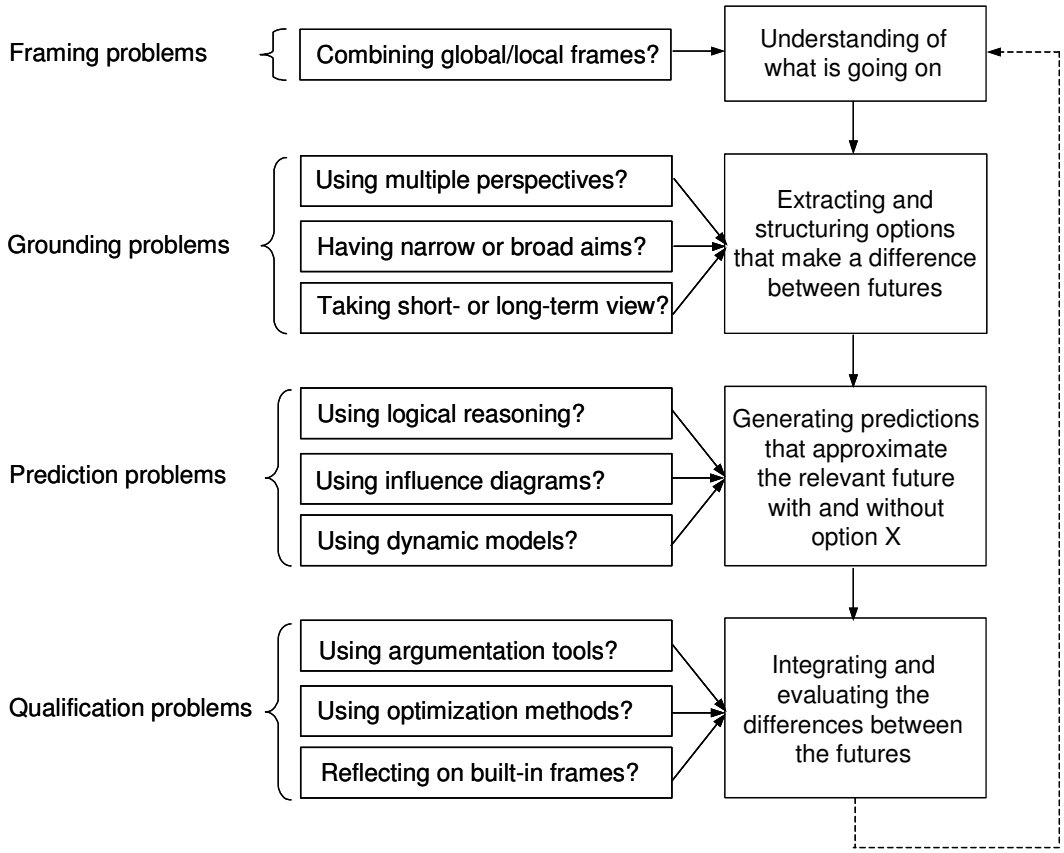

Figure 6. Critical choices in an appraisal of climate policy options.

Each of the two frames is to a certain extent incorporated in people's experience and in the formal methods they may use for decision-making (see Table 3). If a solution should satisfy a wide set of constraints, problem-solving may involve a strategy of matching the characteristics of the current problem with those of problems that have already been solved. For example, the argument that nature has already solved certain problems can be used in evaluations of policy options that take inspiration from nature, such as coastal defence solutions preserving natural habitats and providing coastal defence. The uses of argument can be supported by argumentation schemes that scrutinize the quality of a reasoning process.

Table 3. Combinations of frames and processes for reasoning about a novel situation.

Framing of the situation	Basis of decision-making	
	Experience	**Formal methods**
As a problem whose solution should satisfy a wide set of constraints	Analogical reasoning and pattern matching	Argumentation schemes and lexicographic methods, such as checklists
As a problem for which an optimal solution exists	Mental simulation, estimation of expected values	Computational models and cost benefit analysis

If there is a problem for which an optimal solution might exists, conventional decision tools such as CBA can be indispensable. CBA can identify the most advantageous solution or at least those options for which benefits are greater than the costs. There may be a particular "fit" between, on the one hand CBA or MCA, and, on the other hand, model tools that allow for optimization of policy options. In addition, new evaluation methods, such as a participatory, multi-criteria, option appraisal process [Burgess et al., 2007], seek to combine the conventional tools with different value-laden perspectives to assess what the optimal solution will be under various assumptions about stakeholder positions.

Reflecting on the outcomes of an appraisal is a usual part of many conventional tools, for example, by testing the impacts of uncertainty on predictions and evaluations. However, a characteristic of the novel tools, such as argumentation frameworks, is that they may also stimulate reflection on the built-in frames of the various tools. This applies in particular to reflection on CBA, which can be framed as a process of aggregating independent individual choices in a market context. The notion of attaching a monetary value to every aspect considered relevant to society may raise serious questions about how to value and discount environmental gains and losses over time. The main contested elements of CBA are equity-related and time-related aspects; CBA is not adapted to long time horizons (> 25 years) and future surprises [Turner, 2007].

Until now reflective thinking on the built-in frames of participatory tools has been far less common than that on the nature of CBA. Participatory tools can be framed as building on deliberative democratic forums. This notion may involve some form of open, goal-directed conversation or

"dialogue" between decision-makers, experts and other stakeholders, which should create favourable conditions for the exchange of diverging arguments. In the context of climate change adaptation, however, stakeholder participation is often restricted by strategic planning processes that are coordinated by governmental institutions and other agencies [Few et al., 2007]. The tensions that may arise between the planning agency and the local stakeholders can seriously hamper any open-minded conversation. According to Few et al. [2007], these tensions might be less if a planning agency is explicit from the outset about the true scope of the purpose, limits and expected outcomes of stakeholder participation.

1.7. Conclusions

Based on the previous sections, the position of novel analytical tools for climate policy appraisal can be better understood. It was shown that debates on policy-relevant information are closely related to the ways in which appraisals are framed. Appraisals may be framed as a control problem or as a learning process. Framing climate policy as a control problem may be indispensable to produce at least some rough calculations of the impacts of policy options. In addition, emphasizing the relevance of sequential decision-making under uncertainty and learning explicitly acknowledges that process variables, target levels, manipulative variables and decision rules are not well understood. This means that there is no single tool or combination of tools that will always lead to the right conclusion. The majority of voters may be wrong, skilled decision-makers and experts may be wrong, and all other fixed decision rules may be wrong.

Novel tools seem to have gained ground due to dissatisfaction with conventional tools. However, further polarisation between these tool groups is unnecessary and unwanted. As any climate policy appraisal will require a combination of analytical tools, combinations of conventional and novel tools may increasingly be called for. Some examples of new assessment methods demonstrated the relevance of this approach. Additionally, it should be noted that most tools are developed from the perspective of a single decision-maker. With regard to climate issues, however, it may be crucial to add more perspectives, for example to avoid a passive processing of information and to elicit counter-arguments.

What the novel tools have in common is that they aim to stimulate a more open-minded and cooperative approach to appraisals. It has to be emphasized, however, that such an approach is not just a matter of

tools. Even if climate policy issues create a sense of urgency to avoid ills or approach opportunities, decision-makers will tend to avoid an open-minded and cooperative approach unless sufficient psychological and political safety is created. In the context of climate change adaptation at the regional level, for example, tensions have risen between governmental institutions and local stakeholders, which created severe barriers for an open-minded exchange of arguments. Accordingly, it should be taken into account that institutional and procedural arrangements may not enable decision-makers, experts and stakeholders to adopt a more open and cooperative approach.

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