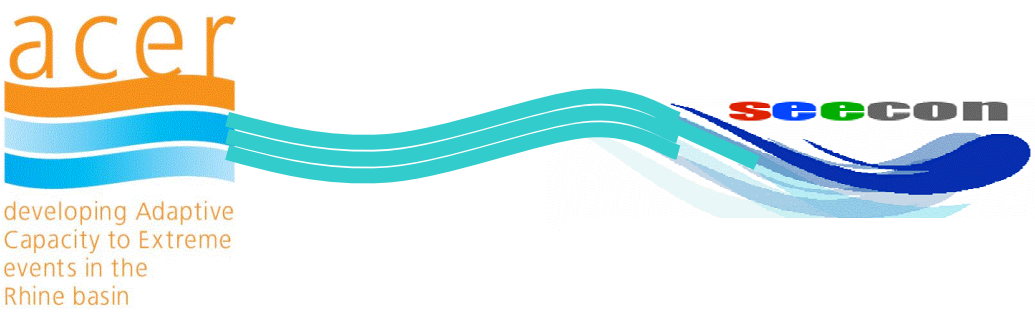

How can models being used in participatory processes?

Experiences from the Case Studies „Wupper“ and „Niederrhein“

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Karina Speil

Seecon Deutschland GmbH

Content

Abstract

Managers need to take decisions on complex systems. Models can help to assess and communicate current system dynamics and the effects of potential measures.

In some fields, such as flood management, there is a high relevance of technical models in decision-making. At the same time, participation of stakeholders in decision making increases - creating a need for stakeholders to interact with technical models.

Additionally, conceptual models can be used in participatory processes in order to support effective communication and transparency.

In this study, we will examine these two types of models (technical and conceptual models) and the roles they can play in specific phases of participatory processes. A focus is here on participatory processes embedded into research. The analysis is built on two examples of participatory processes in which models were applied for different purposes and with different experiences. Both processes were carried out as part of the research projects ACER and NeWater.

The conclusions of this analysis are:

- Group model building (GMB) can facilitate the elicitation and exchange of perspectives as well as the co-development of a technical model with practical relevance.
- The methodology of GMB can and should be adapted to the specific purpose.
- It is important to clarify the limitations of the methodology beforehand.
- In order to make the results relevant for further stages of the process, they need to be compiled and re-introduced to the stakeholder group.
- At the same time, there needs to be openness for the implementation of additional elements in the model that are of interest to the stakeholders – though this may require additional resources.
- The participatory process needs to be closely interlinked with the modelling process, as well as the management / decision-making process.

1 Introduction

1.1 Background and goal of this document

1.1.1 Background

The relevance of technical or mathematical models in decision-making
Systems to be managed are often complex. They contain plenty of interacting elements, non-linear relationships and feedbacks, inherent uncertainties and multiple stakeholder-perceptions[1]. Thus, effects of internal or external changes are difficult or impossible to predict (Brugnach and Pahl-Wostl 2006). The adaptive capacity of the human brain cannot cope with the system complexity. This prevents decision-makers to take founded decisions about how to influence the system in order to drive it to a specific target state.

Models can contain and process a high amount of structural information about a system and its dynamics and can thus help to understand the system and to take decisions on its management. Furthermore, models can help to structure, simplify and visualise information.

There are different types of models, which can contribute in different ways to decision-making and communication. The choice of appropriate models and processes of model application in a participatory setting is subject of this paper.

In some fields, such as flood management, there is a high relevance of technical or mathematical models in decision-making. They produce statements on the probability of flooding events and their effects in terms of discharge and expected damage. They allow creating inundation maps that have a practical relevance for policy. Furthermore, they are able to support planners in assessing the effectiveness of potential flood management measures.
In water quality issues, mathematical models can describe the diffusion and transportation processes of chemicals in water bodies. They allow detecting the sources of pollution or defining appropriate legal pollution thresholds, avoiding damage to human beings and nature.

The role of stakeholders in decision-making
At the same time, we observe another development: there is a growing understanding that stakeholders need to be involved in decision making in order to include their knowledge and gain their support for the implementation of the decision. A non-exhaustive list of reasons to involve stakeholders[2] in planning and decision making are given in table 1.

Generate a larger knowledge base for decision making
Gain acceptance for decisions in order to support efficient implementation
Generate trust / image of a responsive organisation
Support social learning, awareness of other's needs, of ecological values and social responsibility, acknowledge engagement of individuals in society

[1] Vennix calls the problem of managing such system 'messy'.

[2] Definition of stakeholder: "Any person, group or organisation with an interest or "stake" in an issue, either because they will be affected or because they may have some influence on its outcome. Stakeholders may include other government bodies. Sometimes, the term is reserved for well-organised and active groups and organisations, thus excluding the general public. (Ridder et al 2005)

Support sustainable use of infrastructure by stakeholders

Table 1: Examples of reasons for stakeholder participation

How to bring stakeholders and models together?

The consequence of the high (and growing) importance of models for decision-making and the growing stakeholder involvement is that model results, where they come from and what they mean need to be communicated to stakeholders[3]. Those, however, do not necessarily have the technical expertise the decision makers have. The challenge here is to communicate information that is complex, technical and still contains assumptions and uncertainties to stakeholders that are influenced by decisions taken based on these model results.

Other, more simple models, may also be set up especially in order to support the interaction/communication between the involved parties and thus support transparency and efficiency of participatory processes and decision making (see e.g. Eden 1988, where a model is described as a 'negotiative device'). These may not necessarily be mathematical /computer-models but can also only be conceptual / graphical representations of the system at stake, representing its elements and relationships, e.g. as interconnected boxes and arrows.

In this paper, we will present the case study Wupper as an example in which conceptual models are build up among key actors and used as a basis for further planning the participatory process as well as in order to support communication among stakeholders (section 4).

Stakeholder involvement is not only relevant in practical decision-making but also in research. Stakeholders in this case can be actors that operate in the system with its subject to research. They may possess relevant information/data or they may be interested in the research results as a basis for future decision making. In order to tailor the model to their practical needs, stakeholders need to be able to influence the model design[4].

Additionally to the Wupper case, we will consider the Niederrhein case study (section 5) as an example of a research project in which the model development process is accompanied by a process of stakeholder involvement in order to elicit relevant scenarios and indicators and use the stakeholders' expertise for the interpretation of model results.

The two case studies that will be described here are part of the research project ACER, in close collaboration with the project NeWater. Both research projects try to identify ways towards more adaptive water management (AM). The main idea of AM is to improve the robustness/resilience of a system by acknowledging existing uncertainties and implementing a more flexible management. Models that reflect the system complexity, scenarios that show possible (uncertain) futures and the involvement of stakeholders are considered as elements to adaptive and thus also effective/sustainable water management.

Further model applications in other NeWater case studies are described in the upcoming papers of Zorilla et al. (2008)[5] and Haase (2008)[6].

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[3] Brugnach and Pahl-Wostl 2006 explain model-building as a process of learning where stakeholders with their beliefs and perceptions are part of the systems to be studied.

[4] Rotter and Rasche 2007 have examined experiences from the involvement of end users in 12 research projects focusing on the development of technical models.

[5] application of Bayesian Belief Networks (BBNs) as a participatory method in the Guadiana basin in order to support the interaction between stakeholder groups and integrate the BBN into existing simulations/assessment of water management measures

1.1.2 Goal

The goal of this document is to synthesize the experiences from the Wupper and Niederrhein case studies. The conclusions allow managers of future projects to recognise the diversity of models, the ways of how to apply them and what they can contribute to their participatory process. Researcher but also practitioners should be encouraged to make use of this potential and the results shown herein should help them to avoid mistakes.

[6] application of conceptual models in the Tisza basin for assessing local flood vulnerability and creating awareness of risk and personal responsibility

2 Framework

2.1 Types and roles of models

A model is a simplified representation of a specific part of reality. It is designed to fulfil a specific purpose.

Models are used in participatory processes to (a) generate new knowledge (through prediction / simulation) or to (b) support communication[7].

In practice, often models are also used to achieve both objectives.

Still, depending on the main purpose of the model (a or b), models have different characteristics. Models that are used to generate new knowledge about a complex system (a) are often mathematical models in which a computer calculates the outcomes of a specific parameter set, taking into account the diverse relationships and feedbacks among the system elements[8].

Models that are supposed to support communication (b) usually represent the views of the respective stakeholders on a system in a conceptual / graphical way[9].

Through their different characteristics and purposes, these models also offer different opportunities for stakeholder involvement into the model building process or stakeholder interaction with the model.

For (a), stakeholders can be involved to define the system that is to be modelled and the output parameters, deliver information about system elements, relationships and parameters, validate the model, discuss the model outputs and use them as a basis for decision-making.

For (b), the model can be build by the stakeholders themselves or with slight support through facilitators. The question at stake / the system boundaries may be predefined. Stakeholders then collect the main system elements that they consider as important and create the system structure by defining the internal relationships. Different individual views on the system structure will be made explicit and can be discussed. The output can be a commonly accepted model of all important system elements. This can serve as a basis for further discussion and decision-making. In this group model, all stakeholders can see their input/view represented and at the same time gain an understanding/awareness of other stakeholders' views.

The models that are built by stakeholders can be manifold. In this paper, we will focus on conceptual models in which system elements are represented on cards (with the name of the

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[7] Brugnach and Pahl-Wostl 2006 identify four modelling purposes (prediction, exploratory analysis, communication, learning) which are broken down to two major purposes (generating new knowledge, communication) here.

[8] These models can be designed in different ways. They may be deterministic or indeterministic, environmental state-based or agent-based, with or without spatial reference, etc. Furthermore, they contain a different degree of uncertainty and internal assumptions as well as provide a different degree of accessibility/transparency for stakeholders.

[9] Lynam et al (2002) have shown multiple ways about how to represent systems and the stakeholders` views of them. From this range of representations the appropriate one is to be selected depending on the purpose and stakeholder group.

system element, sometimes colour-coded) and that are connected either through their spatial arrangement or through connecting arrows (which may contain symbols for their amplifying or counteracting influence (+/-), their strength[10] or type[11]).
Other types of models that may support stakeholder communication about a specific system are for example commonly created 3D-models, pictures or maps.

Different kinds of models can be applied at different stages of a participatory process and with different participants.
Thus, in order to describe how models are used in participation, we need to answer the following questions:

a) What kind of model is applied and how?
b) At which stage of the process and with what purpose?
c) With whom?
d) What are the outcome / learning effect?

2.2 Embedding the model in the participatory process

The role of a model in a participatory process depends on the process objectives, the question at stake (e.g. complexity, degree of consensus/disagreement etc.), the availability and relevance of existing models, the kind of stakeholders involved (e.g. their cognitive capacity, their experience in working with models), the number of stakeholders involved, the level of involvement (active involvement, consultation, information), the time frame, etc.

Activities of participatory model development or application need to be integrated into a coherent participatory process. Several model development activities can build on each other. For example, a conceptual model can be created by stakeholders as a basis for a computer model. The results of the model runs, on the other hand, can later be validated and discussed by stakeholders. Vennix' (1996) approach of applying quantitative system dynamic models with stakeholders can be considered an intermediary step. Lynam et al (2002) used the behaviour stakeholders showed in a role playing game (physical board game) as a basis for an agent based model which then allowed stakeholders to ('fast-track') "play" specific scenarios and see how they work out.

Different phases of the model development and application process can be carried out either by stakeholders or by the modellers. E.g. the stakeholder role may be restricted to input/data/knowledge, letting the modellers build the model, and then discuss and interpret the results. For each phase of the model building and model application process, the role of stakeholders and modellers is to be defined and communicated. Thus, many different process designs are possible.

2.3 Difficulties with model application in participatory processes

There are several difficulties that may arise when applying models in participatory processes. They should be taken into account when designing the participatory process. Some of them

[10] strength can e.g. be represented by the thickness of the arrow, colour or other symbols such as ++ for strong positive relationships and + for weaker positive relationships

[11] e.g. the unified modelling language allows different types of connections that are represented by arrows with dotted lines, filled or empty heads, explaining text etc.

can be solved through clear and sufficient communication with the stakeholders[12]. Others may ask for changes in the process design:

- Problem of institutional hogging. A model is chosen due to its availability and personal/institutional interest, not because it fits the purpose.
- Model results are interpreted as predictions, not taking into account inherent uncertainties.
- Limitations of the model are not communicated properly to stakeholders. They raise expectations that cannot be met.
- Lack of technical feasibility to answer the questions that stakeholders are most interested in (e.g. not possible to do modelling on spatial scale that they operate on).
- Incongruity of stakeholder interests and research interests.
- Temporal incongruity of modelling vs. decision-making processes, e.g. long time gaps between defining scenarios and receiving simulation results.

3 Phases of a participatory process and what models can contribute

Models can contribute to many phases of participatory process (table 2).

Phase of a participatory process	**Role of models**
Stakeholder and issue analysis	Conceptual models can show the individual stakeholder's perspectives on the system, all relevant drivers and effects related to the question at stake[13]. This helps to identify further stakeholders that can influence or are influenced by it.
Exchange of information, getting to know each other and the system at stake	Conceptual models can help to represent the views of individual stakeholders and help to generate a common view on the system
Identifying management options	Conceptual models can help to identify system elements that may be influenced by management options.
Assessing and choosing management options	Conceptual models can help to see which elements are influence positively or negatively (strongly or weakly) by management options. Computer models can deliver quantified states of target values under specific scenario runs, taking into account complex interactions and feedbacks within the system.

Table 2: Role of models in specific phases of a participatory process

The NeWater project uses the following graphic to represent the role of models / tools in different policy stages the other way round: Models support the 'problem structuring' which implies the identification of issues, environmental factors, stakeholders etc. During 'model

[12] Vennix 1996 also gives a useful guideline on how to be a good facilitator in group model building session (Vennix 1996, chapter 5)

[13] Eden 1988 describes this role of the model or cognitive map as 'reflective style' (…) used to establish the views held by each individual team member' as a first stage in a stakeholder process before exchanging the maps among group members or building a common so-called 'team map'.

building' values, criteria and alternatives are defined. The model application can be used to inform and challenge thinking in the process of synthesising information or carrying out sensitivity analysis. This can then be the basis for the planning of actions.

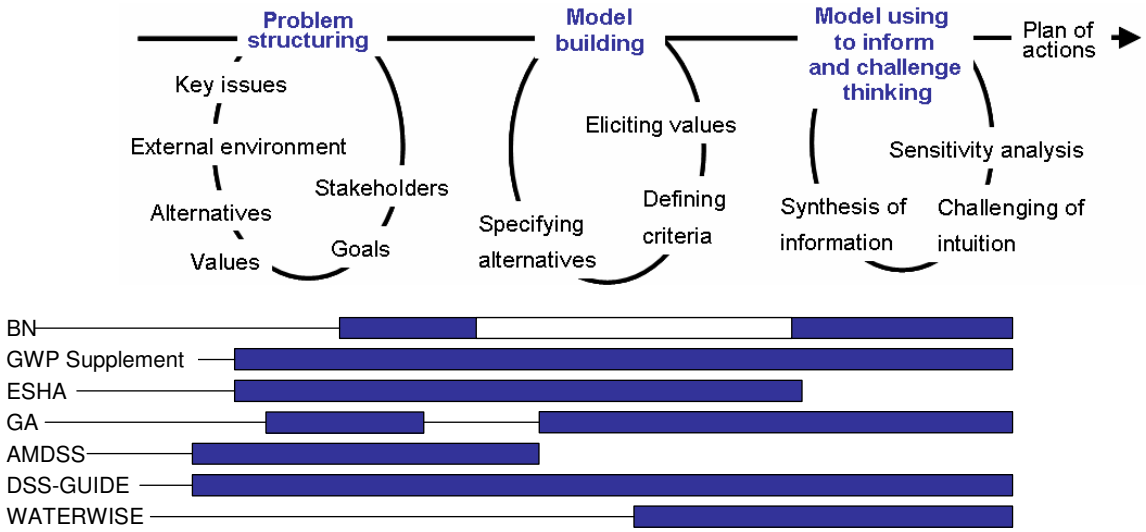

Figure 1 Tools for water management and their distribution of competencies and applicability across idealized policy stages (NeWater 2007)

It shall, however, not be forgotten, that beyond planning, participatory approaches and model-based discussion and decision-making can be part of the implementation and monitoring / evaluation phases of the policy and implementation cycle. These, however, are not part of this paper as they are not covered by the two case studies that are described here.

4 Case study 'Wupper'

4.1 Background of the case study

The case study 'Wupper' builds on a cooperation between the Wupperverband, the water management organisation for the river 'Wupper', and the research projects ACER and NeWater. The cooperation covers research on the management style of the Wupperverband as well as the implementation of a participatory water management process. This process is supposed to provide learning effects on how participation can support a more adaptive water management.

The issue at stake concerns the small river Dhünn, including its two main tributaries Eifgenbach and Scherfbach. As the river Dhünn is separated by a large drinking water reservoir, only the lower part of the river (downstream of the reservoir) is considered.

Like all rivers in Europe, it faces the implementation of the European Water Framework Directive, which calls for a good ecological status by 2015.

While water quality in the river Dhünn is good, is displays deficits in the fish fauna[14] due to

1. the water temperature, which is too low, especially in summer, as the water feeding the lower Dhünn comes from deep and cold layers of the large reservoir;
2. the structural quality of the river, which does not present enough gravel etc. for fish to breed in, due to remains of the river construction activities especially in the early 60's;
3. few smaller weirs, inhibiting migrating fish (such as salmon) to pass the whole length of the river up to the reservoir dam.

Furthermore, river management has to be integrated with the planning and management of building, leisure and farming activities and with the protection of floodplain habitats and archaeological goods.

A participatory process has been set up, involving a number of more than 50 stakeholders from all relevant sectors in the development and discussion of management options.

The process consists of an extensive stakeholder analysis (document analysis, interviews and questionnaires) as well as 3 workshops. The main output of the process is a document of recommendations on which all involved stakeholders have agreed. It is handed over to the Wupperverband and regional authorities and will be used as a basis for further planning of measures.

Beyond that, knowledge gained on all sides and newly established networks support future dialogue and cooperation (Speil et al. 2008 in press).

4.2 Description of models and the process of application

As part of the participatory process, conceptual models are applied in two different phases:

1. As an interview technique (individual elicitation of mental models/cognitive maps and 'off-line' group model building) in the phase of the stakeholder and issue-analysis, and
2. As a moderation technique ('on-line' group model building) during the first workshop.

For each of those applications we will answer the following questions:

a) What kind of model is applied and how?
b) At which stage of the process and with what purpose?
c) With whom?
d) What are the outcome / learning effect?

There has been no application of computer models in the participatory process. The participatory process aims at the identification and preliminary discussion of possible water management measures. Computer models are only used in later stages (detailed planning). As a result of the participatory process, however, there has been a request by the stakeholders for modelling the effects of specific measures e.g. on the water temperatures. Thus, the communication of such modelling results to stakeholders will be an issue for the Wupperverband in the future.

[14] and potentially deficits in the populations of macro-zoobenthos (small animals living at the bottom of the river), this, however, has not yet been verified due to a lack of measuring methods.

4.2.1 'Off-line' group model building as part of the stakeholder and issue analysis

a) What kind of model is applied and how?

A specific approach of eliciting individual 'mental models' (also called 'cognitive maps') has been applied as an interview technique. It involves the identification of current problems and corresponding solutions, which are written on green and red cards and arranged in a tree structure[15].

The emerging 'problem-and-solution trees' of several interviewees (staff members of the Wupperverband) have been typed up and combined[16] to a 'problem-and-solution tree' representing the Wupperverband's view on the system at stake and the issues to be discussed as part of the participatory process.

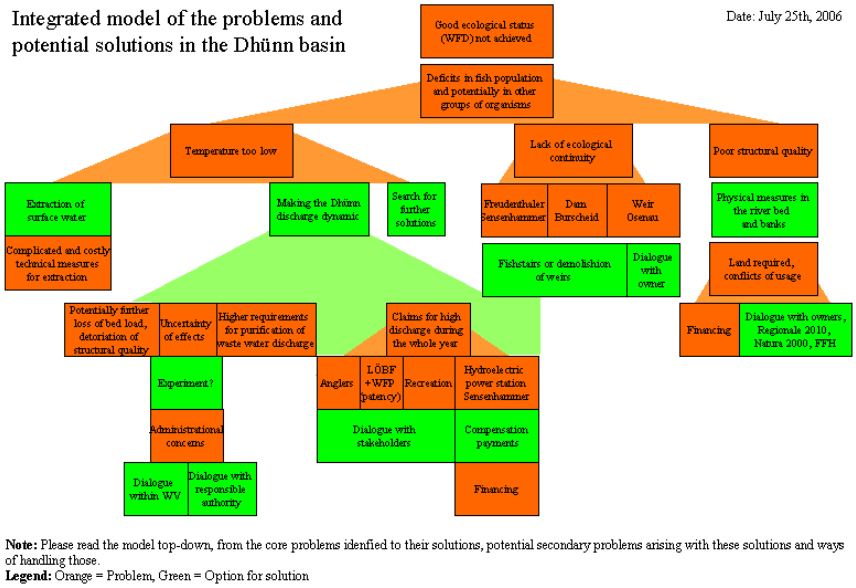

Figure 3: Agreed problem-and-solution tree of the Wupperverband

b) At which stage of the process and with what purpose?

The individual approach for the elicitation of so-called 'mental models' or 'cognitive maps' was applied in the stage of the stakeholder and issue analysis. It was part of interviews carried out with the Wupperverband staff in order to collect the individually perceived problems and solutions and thus get an overview on the scope of issues to be discussed within the participatory process to further identify possible conflicts and relevant stakeholders. This was supposed to deepen the insight of researchers and consultants in the system at stake as well as generating a common understanding among the Wupperverband staff on the purpose and frame of the participatory process. The resulting problem-and-solution tree further served as a basis for identifying relevant stakeholders.

c) With whom?

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[15] The approach is based on the methodology of causal modelling which has been coined by Vennix (1996). The application here is also strongly related to a traditional cause-and effect-matrix.

[16] This combining has been done by the consultants (thus 'off-line'). The resulting 'group model' was presented back to the group of interviewees and their feedback was integrated into the model.

The interviews were carried out with 7 heads/staff members of different departments of the Wupperverband. Later in the stakeholder analysis, it was also applied with a range of further stakeholders.

d) What are the outcome / learning effect?

The interviewees stated that the methodology helped them to structure their thoughts and that it was useful to make their view on the system accessible to others. They did not have any difficulties understanding the methodology[17]. The resulting problem-and-solution trees were in general accurately representing their view on the system. However, some of them mentioned the constraints of the methodology. For example, it was not allowed to arrange the problems in a circle, as one of the interviewees would have liked to do.

An important learning effect here is that some flexibility in the methodology can be left open, such as allowing connections between sub-trees, if they are important. It is useful if the interviewer is in a position to know what kind of flexibility can be granted without restricting the analysis of the models. Any kind of additional information, that cannot be represented in the model, should be documented in accompanying text along with the model.

In general, it was well worth adapting the Vennix methodology to fit the specific purposes of the Dhünn stakeholder and issue analysis[18]. It allowed eliciting the relevant problems and solutions in an efficient way. Furthermore, it represents a person's view on a system in a quickly accessible way, allowing the reader to start from the top element and follow the branches as lines of thought (What is the problem? What is a possible solution? What are the problems with implementing this solution? What solutions exist to this secondary problem?).

The combination of several such individual mental models/cognitive maps can be done either on-line (by the group) or off-line (by researchers / consultants). In the Dhünn case study, it was done off-line by Seecon, clustering similar elements of the individual models together and representing them by only one element in the common tree. This, however, was only possible due to the limited number (7) of models to be combined and due to the fact that these were not contradicting each other in their general structure. This is mainly due to the fact that the interviewees came from the same organisation. It was, therefore, possible, to agree on an overarching main problem and structure of sub-problems and solutions with all interviewees. When trying to build a common group model of a more diverse group of stakeholders off-line, it will very likely be necessary to spend more thought on how to represent contradicting points of view.

4.2.2 Group model building as a moderation technique

a) What kind of model is applied and how?

[17] one relevant aspect here may be that – instead of a long introduction to the methodology - the interviewer just started writing and arranging the cards while they were telling the problems and solutions they perceive. Thus, they could see how the first branches of the tree were emerging and could then refer back to the model, complete and change it.

[18] Obviously, the adaptation of the methodology, on the other hand, limits the explanatory power of the model in the sense that not all causal relationships and none of the feedbacks are represented that characterise the dynamics of the system at stake. Thus, the emerging problem and solution tree is a useful tool for representing the problems and solutions in a graphical way, but not to actually explain 'how the system works'.

Workshop 1 of the Dhünn participatory process aimed at informing the stakeholders about the situation in the Dhünn, allowing them a first exchange of their different perspectives (goals) and collecting from them a first set of possible measures that they have in mind and the open questions that need to be clarified before being able to discuss the measures in detail (workshop 2).

Thus, after some introductory presentations, the stakeholders were split up in three working groups with a specific thematic focus. In the working groups, a moderator helped them to collect the items listed above (goals, measures, open questions). This was done in form of a group modelling session with a structured modelling approach. Such as described above, the approach was based on the methodology described by Vennix, but was adapted in the sense that not all relationships and feedbacks were elicited and that specific questions (goals, measures, open questions) of interest were tackled one after the other and the answers were represented by different coloured cards. These were arranged (more or less) as circles around the central question at stake.

All participants had a chance to bring in their views into the common model by

1. writing their most important goals, measures and open questions on a limited number of colour-coded cards
2. then, one by one, come to the front and present a card to the group, add it to the board and draw in relationships to the other cards. Here, cards on the board can be grouped together if they are similar[19]. The group may ask questions of understanding in order to make sure that everybody has understood what a card means
3. the whole group completes and discusses the model and agrees on it. If agreement cannot be found on specific elements/relationships, they are marked as controversial points (e.g. trough drawing a specific symbol that is then explained in a legend along with the model).

After the workshop: Models were typed up and included in the workshop minutes.

b) At which stage of the process and with what purpose?

The group model building methodology was applied in workshop 1 as a means to facilitate the exchange of information and views among the participants and collect answers from them with regards to specific questions (goals, measures, open questions). The emerging model allowed for a visual representation of these points and served as a basis for the documentation of the workshop.

c) With whom?

The participants were 50-60 representatives of all relevant sectors / organisations with regard to water management in the lower Dhünn. They were split up in working groups of max. 20 persons. Besides keeping the groups small enough, this allowed to work out three different thematic areas at the same time.

d) What are the outcome / learning effect?

The methodology of group model building has proven as useful for guiding the exchange and collection of viewpoints from many participants. It makes sure that everyone gets a say and that all can see their points represented in the final model.

[19] in order to increase the 'readability' of the model, it is sometimes useful to draw a line around such clusters and give them a name

Like other methods in cognitive mapping it structures a discussion in a goal-oriented manner.

However, there are limits to it. With a large group of many cards, the model easily reaches a complexity that makes it impossible for others to read and understand it. In the Dhünn workshop we hit the boundary of useful complexity[20]. This makes it especially important that the models are not only included in the minutes as photographs, but are – as done in the Dhünn workshop – typed up and delivered with accompanying text, that explains the main outcomes of the group discussion and guides the reader through the model.

Obviously, an important question is how to make the resulting models relevant for further steps of the process. In the Dhünn, the collected measures were listed in tables and discussed further in the coming workshops 2 and 3.
The collected open questions were also transferred to a table and distributed among the participants between workshop 1 and 2. All were asked to answer any questions that are in their competency. This allowed setting up a significant pool of relevant additional information that supported the discussion in workshop 2.

A lesson learnt from this is that in order to make the information from such group models usable for further steps, it is useful to type them up and also transfer them to tables or lists.
For typing the models up, a specially designed moderation software is useful. Appropriate software could help in order to represent complex models and transfer them to tables etc.

In Workshop 2 and 3 no models were applied, as it did not seem appropriate for the specific workshop goals, i.e. specifying where and how measures could be implemented and discussing and deciding on specific statements in the results document.

5 Case study "Niederrhein"

5.1 Background of the case study

The Niederrhein case study focuses on the development and assessment of strategies for flood management in the Rhine. Computer models are developed and applied in order to test the strategies under specific scenarios and thus assess their robustness.

Representatives of governmental bodies for water management and to a lesser degree, spatial planning, NGOs etc. from both German and Dutch regions within the Rhine basin, are involved as stakeholders in the project.

In three workshops, they had a chance to be informed about the modelling activities and specify which scenarios, strategies and evaluation criteria (indicators) are of interest for their water management activities. By picking those up in the research project, the practical

[20] some participants mentioned that it was difficult for them to get an overview on the complex models that the other break out groups had developed

relevance of the scientific results is increased. At the same time, stakeholders bring in their expert knowledge and contribute to the validity of the project outputs.

An individual mental modelling / cognitive mapping approach is used – such as in the Wupper case - in interviews before the first workshop and as part of the first workshop. These will be described here in combination.

The major process of interaction between stakeholders and models, however, covers the whole process of 3 workshops: Information was fed from the stakeholder process into the computer models and preliminary model results were presented and discussed in the workshops.

5.2 Description of models and the process of application

5.2.1 Individual mental modelling / cognitive mapping in interviews and workshop

a) What kind of model is applied and how?
Such as described in the Dhünn case study, individual views of involved stakeholders were elicited by asking them specific questions which were then written on colour-coded cards and arranged in a structured model / map. Here, the questions covered relevant external developments (such as climate change and socio-economical developments), the target state of water management in 2050, and the way to get there[21].

b) At which stage of the process and with what purpose?
The individual models were set up as part of the individual interviews with the purpose of getting to know the stakeholder perspectives / 'visions of water management in 2050'. Further, they were used as a means for facilitating the exchange within small working groups (max. 5-6 participants) in the first workshop ('visioning workshop').

c) With whom?
Per workshop approximately 15 to 20 representatives from water management and spatial planning in the Rhine came together.

d) What are the outcome / learning effect?
The methodology in general worked out fine. People understood how to apply it and generated visual representations of their 'vision' of water management by 2050.
The generated information was typed up and served as a basis for scientific analysis.

However, it was difficult to take the generated results up and bring them into the next workshop as an important knowledge base. This had to do with the fact that information on developments, measures/strategies and indicators was also available from other sources.

Thus, the methodology was more used as a communication tool and for the elicitation and comparison of viewpoints than for bringing in new information into the process.

[21] The methodology is explained further in NeWater 2005

5.2.2 Integrating stakeholder expertise and model-based information

a) What kind of model is applied and how?

The major output of the ACER project is a hydrological/hydraulic model for the Rhine basin which is able to calculate water levels and thus probabilities of flooding under a specific climate change and land use scenario. It is coupled with a damage model calculating the losses that can be expected in specific flooding events.

In order to make these models relevant for decision making, the researchers offered stakeholders the chance to define the scenarios (as a combination of autonomous developments, tailored to the Rhine basin) as well as relevant strategies (as a combination of measures) that were to be simulated. Furthermore, the appropriateness/effectiveness of the individual strategies was to be tested according to criteria (indicators) specified by the stakeholders. Thus, their involvement in the modelling process gave them a say on the scope of research and thus gave them a chance to get their specific questions answered. Furthermore, through their participation in the workshops, they learnt about the state of research and had the opportunity for some exchange and network building with colleagues from other German and Dutch regions.

b) At which stage of the process and with what purpose?

Stakeholder interaction with the models happened during all workshops. In each workshop, the goal and state of the modelling activities were explained. Beyond that, stakeholders discussed in each workshop crucial elements of the modelling process such as the definition of scenarios, strategies and indicators for the simulation setup.

In workshop 1, participants defined their 'vision' of flood management in 2050. This involved the collection of 'autonomous developments', first ideas for strategies and indicators for 'good/successful' flood management (see above).
In workshop 2, participants tailored a set of four scenarios (pre-defined by researchers) to the Rhine by defining how they would influence water management as well as land use patterns and socio-economical developments in this area.
In the third workshop, stakeholders were presented with first modelling results. Furthermore, they prioritised and refined the strategies (sets of measures) for the individual scenarios. This involved spatially explicit land use changes and information about changing dike heights or retention measures in specific areas.
Finally, participants chose a set of indicators as a basis for the assessment of the strategies under the different scenarios.

A final conference is planned in which project results – strategies under different scenarios – are presented and feedback from experts is collected.

c) With whom?

All workshop participants (representatives from water management, spatial planning etc. from German and Dutch parts of the Rhine basin) took part in defining the scenarios, strategies and indicators for the modelling activities and discussed first modelling results.

d) What are the outcome / learning effect?

While modelling activities in many research projects are not accompanied with an extensive stakeholder process or only at a very late stage, the ACER project here takes an important step towards interlinking science and practice to the benefits of both sides.

Workshop participants gave positive feedback in the evaluation questionnaires at the end of each workshop, showing that they had gained new insights in the modelling activities as well as in the viewpoints of their colleagues from different regions and sectors. Whether or not the modelling results can answer the questions that are of relevance for their management practice cannot be judged at the current state in time, but should be in the focus of the feedback collected at the final conference.

An important and challenging element of the Niederrhein case study was the deliberate integration of modelling results with expert knowledge and thus the integration of (physical) developments, measures and indicators that could be implemented within the models (such as: developments: climate change/land use changes, measures: dike heights, retention, indicators: flooding probability) with ('soft') developments, measures and indicators that were beyond the scope of modelling (such as "strong EU", increasing awareness of environmental issues, etc.). Here, it was sometimes difficult to make sure that all information that was generated in a workshop could actually be fed back into the modelling and participation process. It should have been made clearer from the beginning, what kind of measures, indicators etc. could be modelled and what could not be modelled. Possibly, the workshops would have been set up a little differently in order to avoid the collection of any information that cannot later be processed.

Another challenge that is characteristic to carrying out interlinked participatory and modelling processes is the right pace to go. While the modelling all in all takes months and years, stakeholders tend to loose interest and commitment to a participatory process which lacks continuous interaction. The long time gaps of up to a year between two workshops will have contributed to the small number and changing composition of workshop participants. In future projects, specific methods should be applied to bridge these large gaps, e.g. through additional smaller round table talks, continuous information via an email newsletter, presentations of first modelling results at practitioner's events etc.

6 Conclusions

The following conclusions can be drawn from the experiences in the two case studies:

- Individual or group model building can facilitate the elicitation and exchange of perspectives, especially when dealing with complex systems. However, there are limitations to these techniques in terms of the number and type of elements and relationships that can be covered in the models.
- The methodology can be adapted to the specific purpose allowing lots of flexibility. However, the methodology should only be adapted to the purpose if the interviewer/facilitator feels confident to still apply it in a consistent way. Otherwise, it is useful to stick to established methods.
- In order to make the results relevant for further steps of the process, they need to be compiled to tables or lists and re-introduced to the group. Furthermore, it is important to communicate already beforehand what the purpose of model application is and what is going to happen with the participants input and the model results.
- Individual or group model building can lay a basis for the co-development of technical models / scenarios with practical relevance.
- When using computer models with stakeholders, it is important to clarify the technical limitations beforehand.
- The participatory process needs to be closely interlinked with the modelling process, both in its time steps and content. A difficulty here is to bridge long time gaps between individual workshops.
- Linking the modelling and participatory process to specific practical management processes and events may increase the practical relevance of scientific results and contribute to the motivation of stakeholders to attend workshops.

In general, it is useful to apply models in participation in the following cases:

- the system at stake is complex and models may help participants to understand the existing relationships;
- a technical model is relevant for decision-making and it should be explained to the stakeholders in order to increase transparency;
- participants ask for additional information which a model may produce;
- the model is able to represent relationships to increase the system understanding of participants and thus support the discussion.

It is not useful to apply models in participation,

- if the model cannot answer any questions relevant to stakeholders;
- if the model is too complex and there is no material available to explain it to the participants in an easy way;
- if participants are not open for it;
- if the purpose/ objective is not suitable for this methodology, e.g. if a workshop aims not at understanding the system and exchanging information, but on the agreement of predefined measures to be taken.

In any case it is worth thinking to make use of models or other tools to support a participatory process. It is enriching the process and as tools and models are available, ranging from very complex and harder to use to quite simple and easy to use, everybody may find something suitable or adapt it that it becomes suitable.

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