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Harmonised Principles for Public Participation in Quality Assurance of Integrated Water Resources Modelling

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Abstract The main purpose of public participation in integrated water resources modelling is to improve decision-making by ensuring that decisions are soundly based on shared knowledge, experience and scientific evidence. The present paper describes stakeholder involvement in the modelling process. The point of departure is the guidelines for quality assurance for 'scientific' water resources modelling developed under the EU research project HarmoniQuA, which has developed a computer based Modelling Support Tool (MoST) to provide a user-friendly guidance and a quality assurance framework that aim for enhancing the credibility of river basin modelling. MoST prescribes interaction, which is a form of participation above consultation but below engagement of stakeholders and the public in the early phases of the modelling cycle and under review tasks throughout the process. MoST is a flexible tool which supports different types of users and facilitates interaction between modeller, manager and stakeholders. The perspective of using MoST for engagement of stakeholders e.g. higher level participation throughout the modelling process as part of integrated water resource management is evaluated.

Keywords Public participation · Water resource modelling · Quality assurance · Interaction · Engagement · MoST · HarmoniQuA

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1 Introduction

The WFD guidelines for planning do not provide details for water resource modelling or use of decision support tools. This means that how modelling tools are related to the overall planning and decision making process, and to which extent participation should be included in the modelling process and the associated decision-making process is not clear at the moment. Traditionally, a distinction is made between different levels of public participation ranging from non-participation, informing, consultation, placation, partnership, delegated power to citizens control, see Table 1 for definitions of terms (Arnstein 1969; Mostert 2003). Consultation happens when the modelling team asks stakeholders for oral or written feedback and advice. Placation is a term coined by Arnstein which means that stakeholders have some degree of influence but without authority to make decisions. In the following we will use the term *interaction* instead of placation. This is the level which best corresponds to stakeholders which become part of the modelling team and participate at certain steps, which is the case in MoST, but where the authority to take decisions still is in the hand of the manager and/or modeller depending on which task we look at. By partnership a real interaction takes place which corresponds to active involvement or engagement. In the following we will use the term *engagement* for this higher level

Table 1 Terminology for participation in the modelling process

Terminology in this paper	Participation levels (Arnstein 1969)	Similar to Mostert (2003)	Definition of participation level (Mostert 2003; Arnstein 1969)
	Citizens control	Active involvement: public decision making	The public performs public tasks independently. Stakeholders obtain full managerial power
	Delegated power	Active involvement: shared/co-decision making	The public share decision making powers with government. Stakeholders obtain the majority of decision-making
Engagement	Partnership	Active involvement: discussion	Engagement. Real interaction takes place between the public and government. Enables stakeholders to negotiate and engage in trade-offs with traditional power holders
Interaction	Placation		Some degree of influence. Stakeholders are allowed to advice but retain for power-holders the continued right to decide
Consultation	Consultation	Consultation	The views of the public are sought. Reply forms, opportunity to comment
	Informing	Public information	The public is provided with or has access to information
	Non-participation		Substitution for real participation. Real objective is not to enable people to participate in planning or conducting programs, but to enable power holders "to educate" or "cure" the participants

Inspired after Arnsteins ladder of citizens participation (Arnstein 1969) and Mostert (2003)

which signifies a deeper capturing of people's attention (Aslin and Brown 2004) and an active collaboration in the modelling process, also with commitment in terms of taking decisions and getting a higher degree of ownership to the constructed models and the developed simulation scenarios. Participatory decision-making processes like engagement usually take much more time than unilateral decision making based on information and consultation. However, this is usually more than offset by time gains in the implementation phase (Ridder et al. 2005).

The quality assurance tool was developed in the EU research project HarmoniQuA (Refsgaard and Henriksen 2004; Refsgaard et al. 2005; Scholten et al. 2007). MoST facilitates participation of stakeholders that can take place at selected (fixed) tasks in the modelling process following a flowchart with a total of five steps and 48 tasks harmonised for seven domains: groundwater, precipitation-runoff, river hydrodynamics, flood forecasting, water quality, ecology, and socio-economics. The level of participation corresponds to interaction because the stakeholders are allowed to advice, but it retain for water manager and modeller the continued right to make the final decisions about how to construct the model and carry out the predictive simulations.

However, higher levels of public participation like engagement or co-decision making (Pahl-Wostl and Hare 2004; Maurel et al. 2007; Ridder et al. 2005; Tippett et al. 2005) could be of relevance since the Water Framework Directive (WFD) encourages Member States to such processes e.g. engagement of all interested parties as part of the implementation of the Directive, engaging stakeholders and the public in planning or co-decision making that impact their livelihoods or environment (Maurel et al. 2007). When successful, such higher order participation like engagement can create trust, social learning, novel working relationships across society, contribute to new learning etc., which also support the need of integrating research, policy and local experience and practice (Brugnach et al. 2007; Innes and Booher 1999a, b).

Exploration of a broad spectrum of uncertainties (van der Keur et al. 2008) also requires high level participation of stakeholders in the environmental modelling process, because this can provide learning about assessment and management of complex problems in a better way (Refsgaard et al. 2007), by enabling stakeholders to articulate issues of concern, by improving framing (terms of references of the modelling study), by utilising stakeholders knowledge and observations, and by involving stakeholders in quality control of the produced operational knowledge.

This means that there is an opportunity for enhancement of MoST for the purpose of higher order public participation, such as active involvement and engagement of stakeholders, in the modelling process, in order to allow interaction between stakeholders through two-way communication and for supporting not only the complex technical task of constructing the model, but also as a tool supporting social-relational activities (Maurel et al. 2007). Traditionally, typical tools for engagement and social-relational activities are based on brainstorming, citizens' jury, group model building, role playing games, reframing workshop and Bayesian networks (Ridder et al. 2005). By actively involving and engaging stakeholders the level of public accountability may be increased, which again may increase the public support for implementation of subsequent management decisions (Refsgaard et al. 2007).

The purpose of the present paper is to describe how water resource modelling and PP processes should be linked within the context of the overall planning process. First, the paper describes the management process with the background

for public participation and how the WFD prescribes information and consultation and encourages active involvement of stakeholders. Next, the paper describes MoST with a focus on the strengths and weaknesses of its use to facilitate participation of stakeholders and general public (corresponding to the level of interaction). Finally, the paper evaluates on opportunities and threats of using MoST for higher level participation (corresponding to the level of engagement) of stakeholders and general public. Thus the objectives are threefold:

1. To describe how participation of stakeholders and general public are introduced in the modelling process by MoST
2. To reflect on strengths and weaknesses of the way participation has been incorporated in MoST at the level of interaction (stakeholders having some degree of influence)
3. To evaluate on opportunities and threats of introducing higher order participation in MoST e.g. by supporting levels of participating corresponding to engagement of stakeholders

2 Participation

2.1 Overall Background

With regard to decision making, humans are limited in the amount of information they can access and process, the number of possible alternatives they are able to consider and their ability to predict the consequences of their actions. These human limitations create bounds on the capacity for rational decision making. Thus, March and Simon (1958) suggested that the rational economic man who made optimal decisions should be replaced by the administrative human who made satisfactory decisions (hereby introducing the concept of *bounded rationality* and the term *satisfacing*, i.e. good enough). This concept points toward participatory approaches.

Participatory approaches to research and development date back to members of the first generation of the Frankfurt School of sociology in the 1960s which suggested to break down the presumptions of rationality behind science. These initial steps aimed to enhance local problem solving abilities through widening discourse, dialogue and respect for different kinds of knowledge (Horkheimer and Adorno 1976; Marcuse 1964). In *Dialectic of Enlightenment* by Horkheimer and Adorno a critique of *Enlightenment rationality* was developed. As Enlightenment rationality leads to domination of nature, it also inevitably leads to domination over human beings. This means that the control of nature through science and technology extends to the domination of humans through bureaucratic forms of social organization. Technical rationality becomes a tool of organizational and ideological social control.

Jürgen Habermas further developed thoughts of rationality and a need for dialogue. Habermas was a member of the second generation of the Frankfurt School, and he claimed that there is no possible escape from the problems raised by subjectivity and Enlightenment. However, intersubjectivity may be positioned as a way to avoid the dilemmas. Hereby, instrumental rationality can be replaced

by '*communicative rationality*' in an endeavour to rethink the critical theory along intersubjective lines. The work of Habermas, particularly his *Theory of Communicative Action*, has often been invoked to help understand consensus building dialogue (Habermas 1981). However, Habermas has also been criticized for overestimating the possibilities of reaching consensus based on rational dialogue, due to the incompatibility of different perspectives and interests (Foucault 1961, 1971).

The characteristics of the post-modern society includes parameters like the revolution of information technologies, globalisation, and '*manifactured risk*' i.e. risk created by the very impact of our developing knowledge upon the world (Giddens 1999). Furthermore nowadays, systems and organisations have more permeable boundaries in terms of openness to information flow, but at the same time with increased risk awareness (Huffington et al. 2004).

Reflexivity is one of the distinguishing features of post-modern society (Giddens 1990; Beck 1992). Reflexivity in relation to decision making stands for a policy making where knowledge production continuously has to reconstruct the boundaries between science and society, with new and different demands, e.g. stakeholders that question the value of science and knowledge behind decision-making plans, or show lack of trust in knowledge-producing institutions and teams (Healey 1997). Scientific and societal criteria are operational simultaneously (Forrester 1989; Almendinger 2001) and goals no longer just valid, reliable knowledge.

The evaluators or reviewers are broader groups than before, and local feedback and participation are needed as part of a more deliberative, strategically integrated water resource planning (Healey 2004; Hillier 2007). Where in the past, the evaluation took place after the production of the final model, it now takes place throughout the modelling and integrated water resource management planning process.

2.2 Participation in the Management Process

In recent years, human dimension and governance issues have become increasingly important in the management of natural and water resources. Understanding the proper ways to inform, consult and engage stakeholders and the general public and thereby assure space and time for the subsequent processes of social learning that precede any collective decision making (Pahl-Wostl and Hare 2004) is a key issue for the WFD and Integrated Water Resource Management (IWRM).

Professionals who facilitate collaborative dialogues know that any process without a key stakeholder is likely to lack the necessary information to develop a feasible strategy and the legitimacy that is essential to implementing it (Innes 2004). Beck (2005) argues that the entire style of the relationship amongst the public, science, technology and the environment has shifted. Achieving sustainability in the water sector has become *the* issue. Ordinary, technological and scientific lay people matter with respect to managing the environment, especially those holding a stake in the outcomes of the technocratic process.

Even though the quality of participatory planning and decision making processes is inevitably subjective, there are two types of processes and outcomes by which the quality can be judged. The first criterion is the quality of the analytical content, which can be high or low. The second criterion focuses on the impact on the decisions made, since these participatory processes are often embedded in a broader societal decision-making setting (Enserink and Monnikhof 2003).

Three main motives for enhancing public participation in preparation of management plans and subsequent decision making have been brought forward by Enserink and Monnikhof (2003):

- Public participation may improve the quality and effectiveness of policy proposals (Pelletier et al. 1999).
- Public participation may increase support for possibly controversial policy proposals.
- Public participation may enhance the involvement of specific social groups in democracy.

The first motive is here regarded as the most critical one, because research into actual participatory processes indicates that on average people participate in these processes mainly because of their interest in the outcomes of the processes. Their support for these outcomes is therefore highly dependent on how they perceive quality in terms of their own preferences (Firth 1998). Also, since outcomes are considered crucial, good-quality outcomes seem essential for achieving the participation of people at all (Enserink and Monnikhof 2003).

2.3 Prescribed Public Participation According to the Water Frameworks Directive

According to the guidance document on public participation (EC 2003b), participation can be categorised into four levels, which are of importance to the WFD:

- Information provision (about management timetables, issues and the participants. It is considered the foundation of all further participation activities).
- Consultation (encouraging written and oral responses).
- Engagement (actively involving people in "developing and implementing plans" that could form the final plan decided upon).
- Co-decision making (helping to make the final decision about which plan to implement and taking responsibility for the decision).

WFD only prescribes information and consultation as obligatory levels of participation, but encourage engagement of stakeholders. However, there is no specific intermediate level similar to interaction (Table 1).

There is also a meta-level of participation termed 'awareness raising & developing a learning approach', supporting all the other levels of participation and management. Participation in river basin management concerns three separate groups: Competent authority; Stakeholders (interested parties) and Public (general public). *Competent authorities* are the authorities given final responsibility for deciding on and implementing the management plan. *Stakeholders* are persons, groups or organisations affected by a management plan, e.g. professional bodies, government authorities, resident organisations, farmers' groups, individual landowners or residents. Usually, stakeholders invited to participate are representatives of such groups. Unorganised groups of individuals in the community who nevertheless have a stake in the management of the river basin are termed *general public*.

Legally, the WFD requires three rounds of written consultation in the river basin management planning process (article 14 of EC 2003a, b). Background information must be made available on request. The reactions of the public must to be collected and considered seriously.

Even though the higher level forms of public participation like engagement and co-decision making are not legally required, they may be required for reaching the ambitious environment goals of the WFD and for "ensuring the success of the directive" (preamble 14).

3 Quality Assurance with MoST

3.1 Planning and Modelling in Relation to IWRM and WFD

The guidance document for the planning process of the European WFD describes the overall process in general terms. However, as stated (EC 2003a): "The guidance does not focus on specific methodologies for the planning process: hydrological modelling, decision support system, etc."

Adopting an IWRM approach requires that (GWP 2000):

- Policies and priorities take water resource implications into account, including the two-way relationship between macro-economic policies and water development, management, and use;
- There is cross-sectoral integration in policy development;
- Stakeholders are given a voice in water planning and management, with particular attention to securing the participation of women and the poor;
- Water related decisions made at local and river basin scale are in-line with, or at least do not conflict with, the achievement of broader national objectives; and
- Water planning and strategies are integrated into broader social, economic, and environmental goals.

Viewing modelling in the course of the past decade, numerous problems of low-quality modelling projects, over-expectations and a lack of credibility of modelling results among end-users have emerged. Some of the reasons for this lack of quality can be contributed to (Refsgaard et al. 2005):

- Ambiguous terminology and a lack of understanding between key players (modellers, clients, auditors, stakeholders and concerned members of the public);
- Malpractice (careless handling of input data, inadequate model set-up, insufficient calibration/validation and model use outside of its scope);
- Lack of data or poor quality of available data;
- Insufficient knowledge on the processes hindering ecological (biota) modelling;
- Miscommunication by the modeller to the end-user about the possibilities and limitations of the modelling project and overselling of model capabilities;
- Confusion on how to use model results in decision making;
- Lack of documentation and transparency of the modelling process, leading to projects, which can hardly be audited or reconstructed; and
- Insufficient consideration of economic, institutional and political issues and a lack of integrated modelling.

In order to overcome some of these problems guidance from US EPA on regulatory environmental models (Fig. 1— Refsgaard et al. 2007; Pascual et al. 2003) suggest that planning and modelling is better integrated, by introducing more

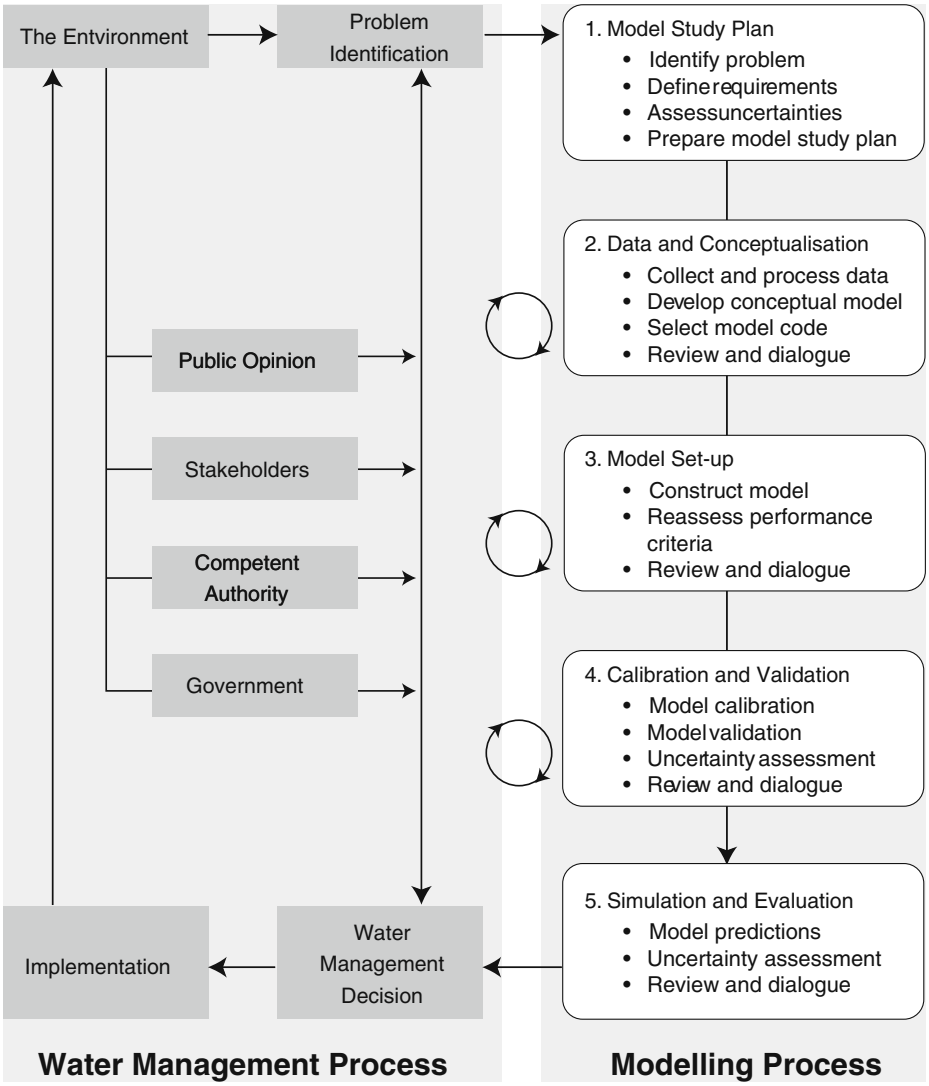

Fig. 1 Interaction between water management and modelling process. Water management process is strongly interlinked with modelling process (Refsgaard et al. 2007). Illustration is modified from 'Draft guidance on the development, evaluation and application of regulatory environmental models' from US EPA (Pascual et al. 2003)

focus on the need for linkages between modelling and PP. Problem identification, legislation and stakeholders, economy, politics and the general public provide input for the modelling process. Throughout the modelling process there are interactions with authorities, stakeholders and the public where required. Finally, the output of the modelling process feeds back to the decision makers. This leads us to the way these linkages and stakeholder and public participation in MoST has been considered in order to improve quality assurance in modelling processes.

3.2 Quality Assurance (QA) of Model-based Water Management

The increasing demand for QA—as demonstrated by the bullet points in the previous section—has lead to the development of the MoST tool, to support quality assurance in the modelling process through guiding, monitoring and reporting. In the MoST quality assurance is defined as: "... the procedural and operational framework used by an organisation managing the modelling study to build consensus among the organisations concerned in its implementation, to assure technically and scientifically adequate execution of all tasks included in the study, and to assure that all modelling-based analysis is reproducible and justifiable".

MoST supports multi-domain studies, accommodates working in teams of which the members have different professional backgrounds and represent several user types (water managers, modellers, auditors, stakeholders and members of the public), and contains an interactive glossary that is accessible via hyperlinked text. The key functionality of MoST is to

- Guide, to ensure a model has been properly applied.
- Monitor, to record decisions, methods and data used in all task and log doings and results.
- Report, to provide suitable reports of what has been done for managers/clients, modellers, auditors, stakeholders and the general public.

The modelling process has been broken down into five 'steps'. The five-step system is shown in the flowchart in Fig. 2. Each step includes several tasks, activities and methods. The six tasks where stakeholders and general public are participating in the water resource modelling process are marked. The later steps end with a reporting task and a client review of past progress and future plans. The 'Knowledge Base' containing knowledge specific to seven domains (groundwater, precipitation-runoff, river hydrodynamics, flood forecasting, water quality, ecology, and socio-economics) forms the heart of the tool.

A computer based journal is produced within MoST where the water manager and modelling team record the progress and decisions made during a model study according to the tasks in the flowchart. This journal can be used when auditing the model study to judge its quality.

The most important principles for QA of modelling processes handled by MoST are:

- Public interactive guidelines, which means focus on facilitation of dialogue between modeller and water manager recorded by MoST, and provides means to include feedback from auditor, stakeholders and public in MoST.
- External reviews are prescribed as the key mechanism of ensuring that the knowledge and experience of other independent modellers are used and remembered.
- The five modelling steps are designed so that they are concluded by a formal dialogue between the modeller and manager, where activities and results from the present step are reported and reviewed, and details of plans for next step (new revised work plan) are discussed.
- MoST have many redo-loops, some 'purely' technical that only involve the modeller, others that may have implications on performance and/or economy, which may require decision making before costly additional work is initiated.

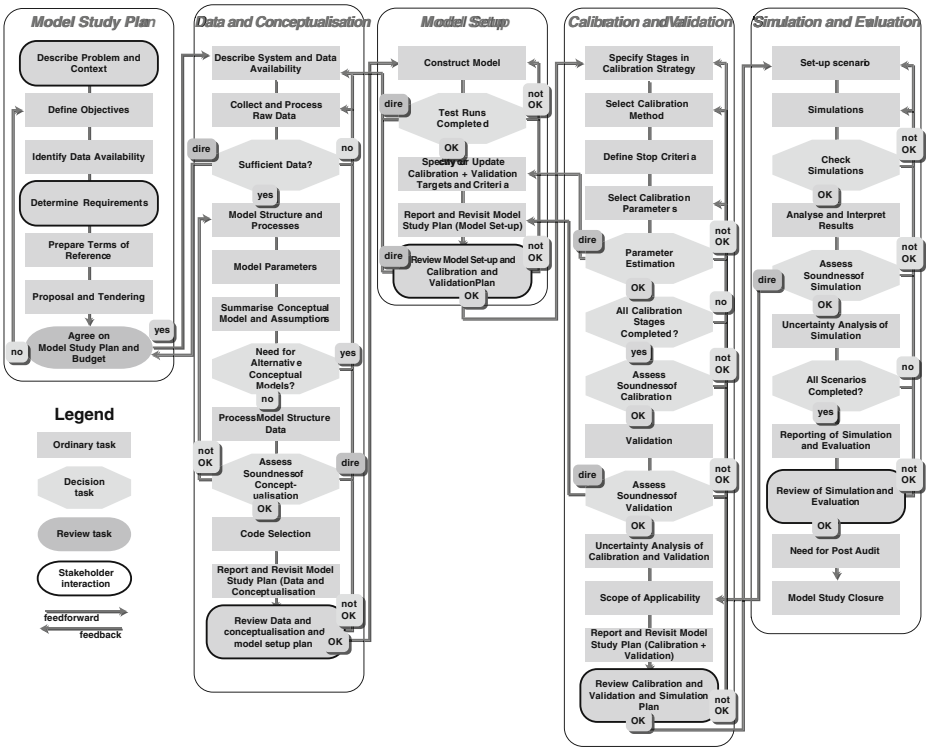

Fig. 2 Flowchart of five MoST modelling steps and 48 tasks. Ordinary tasks and review tasks including tasks where stakeholders are interacting are marked

- MoST put focus on validation schemes.
- Uncertainties must be explicitly recognised and assessed throughout the modelling process.

MoST will typically be used to support actual work in modelling projects. MoST corresponds to workflow management software in many aspects, but it differs in other aspects. Contrary to many business processes, consisting of relatively simple tasks which have to be executed frequently, modelling is a process consisting of many complex tasks, requiring various expertise and undergoing improvements based on scientific progress and increased computer power. To some extent MoST can be considered as groupware. MoST is a tool supporting water management modelling teams on a daily basis. MoST does not only give guidance, but it also monitors what all team members in a modelling project actually do, stores what is monitored in a model journal and helps generate reports for various audiences. In this way, MoST makes modelling more transparent and open for audits and for communication with stakeholders and concerned members of the public (Scholten et al. 2007). MoST and its associated software is very flexible. It can easily be used for extended or modified building on the Protégé knowledge base implementator (Scholten et al. 2007).

3.3 Public Participation with MoST

The modelling process as described in MoST (Fig. 2) proposes that stakeholder involvement and public participation take place at the beginning of the process, when the model study plan is developed, and also in review steps at the end of the last four steps. In the present version of MoST, public participation comes in at the following six tasks of the flowchart:

3.3.1 Model Study Plan

- 'Describe Problem and Context' which requires decision about to what extent stakeholders and the general public are involved. A decision is reached and a 'stakeholder involvement plan' is prepared identifying approaches for public participation to be carried out parallel to the scientific modelling process
- 'Determine Requirements' (stakeholder opinions on requirements)

3.3.2 Review Tasks Towards the End of the Four Last Steps

- 'Review Data & conceptualisation and Model Set-up Plan'
- 'Review Model Set-up and Calibration Validation Plan'
- 'Review Calibration and Validation and Simulation Plan'
- 'Review of Simulation and Evaluation'

For all activities there may be one or more methods (tools) which the users can look into and which can guide the work which is part of the activity.

The review tasks refer to the present (almost completed) step including evaluation of results of consultations with stakeholders. They also provide the opportunity to redefine the next step, based on the results and findings of the present step. Hence, co-design—at least to some extent—is possible. One example could be stakeholders and the public offering input to subsequent scenario analysis or the evaluation of possible data and sources for a subsequent set-up and calibration step. But it could also be evaluations by stakeholders about what to do with uncertainty, what is acceptable by the ones affected by the outcomes of the design?

MoST not only guide the users but also explain about possible sensitivities and pitfalls. At the task Describe Problem and Context the sensitivities and pitfalls are described in the following way (as an example): "Many examples of insufficient quality of modelling projects during the last decade are related to inappropriate stakeholder and general public participation e.g. by use of ambiguous terminology and a lack of understanding between key players, is communication, confusion on how to use model results in decision making and insufficient consideration of economic, institutional and political issues..."

In the stakeholder involvement plan the water manager describes the plans for involvement of stakeholders and the general public in the modelling process. The plan addresses the following questions:

- Which level of public participation (information provision, consultation, active involvement etc.) is required?
- Why public participation?
- Who should be involved?

- When should we involve them?
- How do we involve them?

A stakeholder analysis is necessary for the evaluation of the degree of common understanding of problems as well as for the identification of relevant stakeholder interests and responsibilities. Forming working groups, selecting a facilitator, preparing mission statements and initiatives regarding information to the general public and stakeholders require proper interaction and communication tools. The draft stakeholder involvement plan should be included in the terms of reference, discussed with the modeller and subsequently included in the model study plan as a separate chapter.

When requirements are identified, stakeholders and the general public shall be allowed to submit comments and opinions to the model study plan including the stakeholder involvement plan developed by the manager and discussed with the modelling team. Based on the stakeholder opinions on requirements, the water manager evaluates the comments and prepares answers to the stakeholder opinions. The final stakeholder involvement plan should be included in the terms of reference, discussed with the modeller and subsequently included in the model study plan.

During the review, stakeholders comment on tasks completed in the present step and suggest adjustments in planning of the next step. This could include actions to further support common understanding, clarification of team roles and responsibilities, changes in participating stakeholders in working groups, and additional needs for information to the general public and stakeholders.

The water manager addresses the comments from stakeholders and decides which adjustments are needed. The water manager reports the comments and answers to both reviewers and modeller. Adjustments are, after discussion with the modeller, subsequently included in the model study plan.

Under the WFD, it is the responsibility of the competent authority (equivalent to the water manager in MoST) to inform and consult the public as well as stakeholders. MoST is already designed with such functionality, by allowing stakeholders and the general public to provide input in the initial phase (model study plan), to comment on work as it progresses, and during review of the project. This means that MoST addresses the minimum requrequirement for information and consultation of stakeholders and the general public about the building of models in relation to WFD.

4 SWOT Analysis of using MoST for Interaction and Engagement of Stakeholders

4.1 Strengths and Weaknesses of using MoST for Participation of Stakeholders in the Modelling Process at the Level of Interaction

Credibility of water resource models are often questioned and with good reason. Therefore, rigorous procedures for quality assurance, including public participation, as prescribed by MoST are needed. The key strength of MoST is that it provides a common and transparent platform for what has to be done in each step, each task is clearly described, and there are a number of activities and methods suggested including possible pitfalls. Another strength is that the responsibilities are clearly stated, where water manager is responsible for some tasks, the modeller for other

tasks and so on. The stakeholders and general public can give input to the framing of the modelling study plan (the terms of references), and also later on give input at each review step. A third strength of MoST is the broader procedures for model validation and uncertainty assessment where stakeholders now are invited to interact with a possibility for sharing knowledge, understanding and expectations to various types of uncertainties. Yet another strength is the integration of the seven modelling domains, which the MoST software handles by generic and specific guidances, recording and reporting throughout a model process. That MoST can support multi-domain studies again makes the tool of generic value and important for providing a uniform language for communication between the users as part of quality assurance of the modelling process. The interactive glossary that is accessible via hyperlinked texts in the MoST software tool contributes to establishing a common language of interaction with minimum ambiquity due to differences in terminology among the various actors.

Among the weaknesses of MoST when used for participation of stakeholders is the lack of in-depth descriptions of various methods for carrying out the participation. MoST here tends to refer to only a limited set of methods from a few EU research projects, but do not provide a wider instruction for selection of appropriate tools and methods for such activities. Furthermore, there is no translation to local languages of material or training of stakeholders and general public with introduction to the modelling terminology. Therefore, it may be difficult for stakeholders and general public to understand the information that is part of the MoST guidance and the monitoring and reporting will require stakeholders experienced with modelling. Even though MoST provides interaction with some degree of stakeholder influence on the decisions made by manager and modeller in the modelling process, the limited number of tasks where stakeholders are participating, will still limit the room for open discussions and feedbacks, and hinder a real engagement of stakeholders. Therefore, a possible questioning of more basic assumptions, reflections and learning are only given a limited space in the current version of MoST.

With the option to introduce stakeholders and the public as users and with the built-in knowledge base MoST is a suitable tool for improving the quality of the modelling process including the information and consultation stages of public participation and introducing interaction as the level of public participation, where stakeholders has some influence, but without having the power to take the final decisions. However, when more extended forms of public participation such as engagement are required, MoST, as well as other existing modelling guidelines, becomes inadequate.

4.2 Opportunities and Threats of using MoST for Engagement of Stakeholders

Active involvement and engagement of stakeholders are important for a better understanding of stakeholders' perception of model credibility, stakeholder vulnerability in relation to scenarios, and for facilitating joint ownership of the model use among the stakeholders. If, through active involvement, the water resource model becomes a shared tool for decision making, then there is an opportunity for a broader identification of sources of uncertainty as part of integrated water resource management (van der Keur et al. 2008), with a better identification and design of possible management actions and a more concerned institutional capacity

building, more equitable and realistic scenario development, and better evaluation of implemented management plans, leading to more adaptive and integrated water resource management.

An example of how integrated water resource modelling is needed has recently been demonstrated in the Guadiana basin in Spain (Martínez-Santos et al. 2008), where a groundwater flow model was used in a participatory process with active involvement of stakeholders for integrated assessment providing insights for discussion and social learning. The numerical model allowed for the description of spatial and temporal variation and for the ability to validate the model by comparing the predicted groundwater levels with observed data from the farmers' irrigation wells. This was important for negotiating and building trust in model predictions. Allowing the stakeholders to take part in the modelling process facilitated a process where stakeholders could address their own vulnerability under different scenarios. The opportunity of supporting steps and tasks for guiding, monitoring and reporting participatory modelling as carried out in Guadiana exist in MoST, but the flowchart does not fully account for the comprehensive dialogue and social learning circles that typically occurs when stakeholders actively participate in scenario development and evaluations (Pahl-Wostl et al. 2007; Henriksen and Højby 2008).

When examining the threats of enhancing MoST for supporting engagement, there is a threat that engagement will be difficult to establish due to the need for at least some experience with modelling (in order to be engaged). A threat therefore is the time and resources which will be needed for training and introduction of stakeholders and lay people to the modelling process. In the social world the various forms and styles of interaction are brought into existence by people, where humans possess creative consciousness and the basis of social life is conscious individuals and groups of individuals who interact with one another on the basis of a variety of motives, purposes and interests. In order to acknowledge the full contribution of individuals, the modelling process has to be flexible and provide room for learning and dialogue. Our evaluation here is sceptical, because the idea of bringing a complex model into a room for learning and dialogue seems not very convincing. But in the later simulation stage, a loop could be established for scenario development, supported by MoST.

5 Conclusion

WFD prescribes an obligatory level of participation which corresponds to information and consultation. MoST can support quality assurance in model-based water management at a level of participation corresponding to "interaction", which belong somewhere between the WFD levels of consultation and engagement. Interaction, i.e. to allow stakeholder to give advice to water manager and modeller in the modelling process is appropriate for obligatory public participatory processes in relation to harmonized quality assurance of water resource models covering different domains. If stakeholders are satisfied with their options, if acceptable decisions emerge from the traditional decision-making process, and if there are no major controversies and differences in frames, values and understandings, then the obligatory forms fully supported at the level of interaction will be sufficient. In such cases MoST can be used as a quality assurance tool for the modelling construction, the

modeler–manager dialogue and for information provision and consultations of stakeholders and the general public.

When it comes to opportunities and threats of enhancing MoST to supporting the needs for engagement of stakeholders in the modelling process these forms are not included in the modelling process described by MoST. There is a potential for enhancing using MoST for engagement of stakeholders and the public but it will require development of a new knowledge base dedicated to engagement. This appears to be far from trivial when considering the model construction process, but feasible when considering engagement of stakeholders in the simulations, where the model is used in an exploratory way as a tool for scenario development, predictive analysis and visualisation.

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