Please refer to this article as: P.W.G. Bots, R. Bijlsma, Y. von Korff, N. van der Fluit, H. Wolters (2008). Defining rules for model use in participatory water management: A case study in The Netherlands. In: O. Varis, C. Tortajada, P. Chevallier, B. Pouyaud, E. Servat (Eds.) *Global Chances and Water Resources: Confronting the expanding and diversifying pressures.* Proceedings of the IWRA XIIIth World Water Congress, Montpellier, France, 1-4 September 2008.

Defining rules for model use in participatory water management: A case study in The Netherlands

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Abstract

In this paper we investigate how existing hydrological models may be used effectively in a multi-stakeholder setting even when stakeholders question their validity. We address this problem by analyzing an empirical case study in the Vecht river catchment area in The Netherlands using concepts from the literature on participatory policy making, process management, and the science-policy interface. We focus in particular on the procedural choices that were made during the process of developing a 'balanced ground- and surface water regime' (GGOR in Dutch), and on the role of different actors in this process. This leads us to propose a set of 'rules of the game' that, to our eyes, will contribute to appropriate development and use of hydrological models in a participatory policymaking process. We illustrate how these rules have been put into practice in the case study and reflect on conditions that seem to favor their effectiveness.

1. Introduction

Article 14 of the European Water Framework Directive (WFD) requires stakeholder participation and the use of expert knowledge in water management decision processes (WFD 2000). While the benefits of stakeholder participation for a policy process are advocated on theoretical grounds in the literature (Fiorino 1990; Laird 1993), with regard to empirical findings Delli Carpini *et al.* (2004) note that: "Although the research … demonstrates numerous positive effects of deliberation it also suggests deliberation under less optimal circumstances can be ineffective at best or counterproductive at worst." The policy literature also makes clear that the use of expert knowledge may likewise be problematic (Hoppe 1998; Van Buuren & Edelenbos 2004).

Implementing the WFD therefore poses a challenge for water managers. First of all, water managers face a system that is physically complex. Expert knowledge, for a large part embodied in computer models, is often partial and rife with uncertainties. Moreover, the water system is intricately linked to virtually all types of human activity. This means that water-related decision processes must deal with competing values, preferences and perspectives of many different stakeholders. As water is a vital resource, the stakes are high.

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Meanwhile, the knowledge about the socio-economic system is distributed over different scientific disciplines, as well as locally over these stakeholders. By consequence, the available knowledge, physical and socio-economical, is often contested by stakeholders.

In this paper, we present some of our experiences within a participatory decision-making process on ground water and surface water management in The Netherlands. Our research – still very much 'work in progress' – focuses on the role of knowledge in this process, in particular knowledge about the physical water system that is embodied in hydrological computer models. By analyzing how decisions to use (or not use) these models came about and how this influenced the policy process and its eventual outcome, we aim to define rules that can guide these decisions. Webler (1995: 56-58) provides convincing arguments why such rules will contribute to the quality of the process.

Van Daalen *et al.* (2002) show that in environmental policy development, computer models can play different roles: they can serve as eye-openers (drawing attention to a specific issue), as arguments in dissent (advocating a particular world view), as vehicles in creating consensus (accommodating alternative perspectives), and as management tools (assessing the effects of policy measures). The hydrological models that we have observed figured in the fourth role.

Although hydrological models represent but a limited range of aspects of the physical world, they nevertheless are 'black boxes' in the sense that the decision makers and stakeholders cannot verify whether the predictions these models make are realistic. They will have to rely on the competence of the modelers to produce reliable images of future states of the world. This makes *trust* in models a key factor in policy processes (Shackley 1997; Saunders-Newton & Scott 2001). Lack of such trust can hamper the process. When the validity of a model is contested, it may be discarded in its entirety even when stakeholders could potentially agree on the validity of part of the information that it produces. This information is then lost to the process. Developing (new) models in search for better information is costly in time and resources, and even when these are available (which often is not the case) the results may eventually be contested again.

One strategy to avoid such stalemates is to involve stakeholders in the process of model development with the aim to increase trust by making the 'black box' transparent (Pahl-Wostl 2002, 2006; Smith Korfmacher 2001; Van Eeten *et al.* 2002). A second, complementary and less resource-intensive strategy is to determine in interaction with stakeholders for what purposes the model could still be used.

In our case study, the second strategy was adopted. We therefore focus on the question how existing hydrological models can be used effectively in a multi-stakeholder setting even when their validity is questioned. Our specific aim is to complement the guidelines for good practice in hydrological modeling that have been proposed by other authors (Jakeman & Letcher 2003; Refsgaard *et al.* 2005; Smith Korfmacher 2001). We do this by reflecting on our experiences and translating what we see as 'good practices' into a detailed set of 'rules of the game' that provide specific guidelines for actors in particular roles in the process as to how to behave insofar as hydrological models are concerned.

In the next section we present the water management policy development process that we have been involved in as action researchers. After a presentation of this case, we focus on when and how models were used in this process. We then propose a general set of 'rules of the game' that we believe to represent the social 'codes of conduct' that were implicitly driving what we have observed as constructive cooperative behavior. As our analysis is still ongoing, these rules are tentative. We therefore conclude with only a brief discussion of the potential and limitations of these rules.

2. The Bargerveen water policy process

2.1 Case study context

The Bargerveen is a nature area in the east of the Netherlands that has been designated a Natura 2000 status. The case study focuses on the process of defining a so-called 'balanced groundwater and surface water level regime' (*Gewenst Grond- en Oppervlaktewater Regime*, or GGOR for short) for the Bargerveen (outlined in yellow in Fig. 1) and its surrounding area (outlined by the dashed white line in Fig. 1). If, as is the case in this area, different land use functions require different regimes, the GGOR should strike a balance between competing interests.

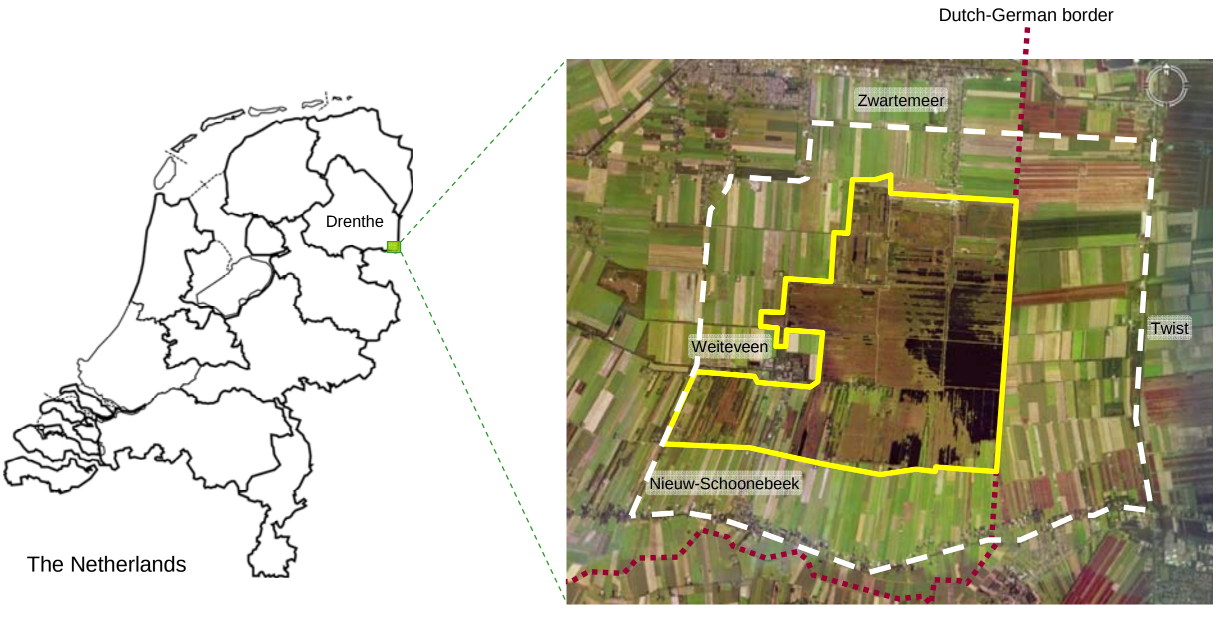

Figure 1. Situation of the Bargerveen water management area

The Dutch government requires that a GGOR is formulated for all Natura 2000 areas by the end of 2007. The water authority responsible for the GGOR Bargerveen is the water board *Velt en Vecht*. The Dutch national administrative agreement on water requires a GGOR to be defined in close cooperation with municipalities, groundwater managers and stakeholders, but it does not specify any particular level of participation on the ladder of Arnstein (1969). The water board has opted for an approach that reflects what Laird (1993) calls 'pluralism' (as opposed to 'direct participation') as it involves a 'sounding board group' whose members have been selected such that all stakes are represented. An external consultant acts as process manager. In close interaction with stakeholders, and supported by a team of water board employees, the process manager develops a GGOR, which is then to be approved by the board of directors of the water board, and ultimately also by the province.

The Bargerveen area is situated at the border with Germany in the Dutch province of Drenthe. It harbors a type of living high peat that is unique in Europe. In the nineteenth century, the complete region was covered by peat. The peat has been excavated and exploited, after which the remaining sand grounds have become agricultural land. In the 1950s, the Dutch government became aware of the nature value of the peat vegetation and acquired – after a period of intensive negotiation – the 20 km^2 Bargerveen area for nature conservation. A conflicting water management situation exists ever since. As the Bargerveen area lies higher than the surrounding excavated agricultural area, the groundwater level should be raised to benefit nature, whereas for optimal agricultural use the bordering area needs to be strongly drained. Thus, the water-related interests are strongly competing. The stakeholders in the area are highly organized and share a long history of negotiation. The last attempt to settle the conflict for the south side of the Bargerveen failed in 2001.

The recent Natura 2000 status of the Bargerveen has re-opened the negotiations. The Bargerveen has received priority status as nature conservation area. The Dutch ministry for Agriculture, Nature and Food (*Landbouw, Natuurbeheer en Voedselkwaliteit*, or LNV for short) has defined nature conservation goals for the Bargerveen. The most important goal is to increase the area of living high peat. Under the current ground water level regime, the area of living high peat vegetation will decrease. To preserve and to increase the area of high peat vegetation a significant rise in groundwater level is required.

LNV and all water boards in the northern part of the Netherlands have agreed on a general procedure for developing a GGOR. The first step in the procedure is to define the *optimal* ground- and surface water regime (OGOR) for all land use functions (different types of agriculture, housing, industry, nature, ...) in the selected area. These are compared to the *actual* ground and surface water regime (AGOR) that is currently in practice. What follows is an iterative process of defining and assessing alternative ground- and surface water regimes, converging to a regime that realizes a certain percentage (for example 70%) of the theoretical OGOR. If a satisfactorily regime cannot be realized for the present land use functions, using the available means for water management, changing land use and/or taking hydrological measures are to be considered.

2.2 Stakeholder context

The key actors in the GGOR process Bargerveen are the water board, the farmers and the national nature conservation agency (*Staatsbosbeheer*, or SBB for short). Additional stakeholders are the local residents and entrepreneurs, the neighboring municipalities, the German water authorities, the province of Drenthe, and the ministry LNV. The water board invited the authors to take part in the stakeholder participation process design, implementation and evaluation.

The water board is responsible for the regional ground water and surface water regime and faces the requirement of defining a GGOR. They realize that this is a difficult task. Firstly, the water board has been involved in the negotiations about the water levels of the agricultural area in the past. These negotiations comprised several costly model exercises based on which no decisions have been taken. Secondly, a fully-fledged Natura 2000 management plan for the Bargerveen is to be developed before 2010 by the province, and this plan includes water management. The GGOR is likely to be rejected in the provincial planning process unless it has broad stakeholder support. Hence, the water board's first priority has been to get the stakeholders involved and committed to the process in order to arrive at a broadly supported solution. With regard to the use of models, the managers of the water board have made clear that sufficient information is available from past studies and does not intend to finance new costly model exercises.

SBB is responsible for the Bargerveen and therefore aims for a healthy ecosystem that has potential for living high peat development and has a diversity of peat related species. The new status of the Bargerveen as Natura 2000 area, gives them a strong position in the GGOR negotiations. There is no model available that relates the Bargerveen hydrology to its ecology. SBB searches financial resources to develop such a model in support of their operational management of the area.

The farmers are organized in the national agriculture and horticulture organization LTO. Agriculture is the dominant land use at all sides of the Bargerveen. In the last negotiation round, the farmers north and west of the Bargerveen have reached an agreement with SBB. The water board has decided to leave this undisputed and restrict the new negotiations to the agricultural land south and east of the Bargerveen. The farms in these areas are mostly family businesses. The land is alternately used for intensive crop growing and dairy farming. The current water management regime is already quite wet for intensive agricultural use. The conflict between nature and agriculture brings about uncertainty for the farm management. The farmers are apprehensive to get involved in yet another indecisive negotiation process, and call for clarity and action. Besides LTO, an agricultural land consolidation commission (HAK+) is represented in the sounding board group.

The Bargerveen is surrounded by some small villages (cf. Fig. 1). The local residents are organized in municipality councils. The local entrepreneurs are the firma Griendtsveen and the Dutch petrol company NAM (a subsidiary of Shell). Griendtsveen is a regional peat processing company, still active at the German side of the Bargerveen. The firm is landowner of some historically excavated land. The NAM plans to construct a petrol pipeline south of the Bargerveen. The villages and the Bargerveen are under the administrative authority of the city of Emmen and the province of Drenthe. The province must ensure integrated assessment and incorporate the GGOR plans in their provincial policy and regional planning documents. The municipalities must do the same for their zoning plans. The Dutch ministry LNV is responsible for the implementation of the European Natura 2000 legislation in the Netherlands. In this capacity, LNV is the initiator of the GGOR process and has the final voice in approval of the developed plans.

The transnational character of the process is a complicating factor. Germany has a different organization structure and decision culture, and a different integration of the European legislation in its national legislation. The water board has set up a separate German sounding board group. The possibilities to coerce the German government to take action are unclear, and decisions depend upon cooperation.

2.3 Global overview of the process and the modeling activity

The GGOR project team (process manager plus support staff) started in June 2006 by performing a stakeholder analysis and developing a plan for defining the GGOR Bargerveen. The sounding board group was installed in October 2006. The process manager urged the participants to make suggestions regarding the composition of the sounding board group and the proposed plan, and to share their knowledge regarding activities in and around the Bargerveen. The project activities until April 2007 were aimed at the development of a common knowledge base by sharing, verifying and co-producing knowledge about the Bargerveen's geo-hydrological, ecological and socio- economic system. The process manager organized bilateral meetings with SBB and with the farmers. These meetings resulted in a shared view on the actual ground water and surface water regime (AGOR) and the optimal regime (OGOR) for the three primary interests: nature, agriculture and housing. In a second sounding board meeting in April 2007 these results were shared with the other participants.

The difference between the average ground water levels for the optimal regimes for nature and agriculture turned out to be several meters. The actual regime was far from the optimal regime for either of the stakes. The participants discussed possible measures. Technical measures such as watercourse works or an impervious screen in the subsoil were judged to be insufficient or of high risk due to the partly unpredictable effect. The remaining alternatives were to create a buffer zone around the Bargerveen at the expense of agricultural activities, or to accept the loss of the peat vegetation. A buffer zone would require the buy out of several farmers. Apart from the desirability and feasibility of a buffer zone, its effect is not straightforward and the participants judged the value of available information differently. Not wanting to fund a new modeling activity, the water board aimed for a fundamental political decision to favor either nature or agriculture, based on the available information. By contrast, SBB demanded accurate model calculations on the effects of a buffer zone as they feared ending up with a buffer zone too small to be really beneficial for nature. The farmers were not interested in another model study; they just wanted clarity on the prospect of continuation of their farm.

The available hydrological models for ex ante evaluation of the effects of a buffer zone were MIPWA and Microfem. The MIPWA model has been developed especially for supporting GGOR processes in the northern part of the Netherlands. Its development is a joint initiative, co-financed by the water boards and governments in this part of the country. MIPWA was the first choice of the modelers, but proved to be inadequate because the representation of the Bargerveen's peat soil layer and the German input data were insufficient. Enhancement would have taken at least one year. The Microfem model was also considered to be inadequate. Built for the evaluation of agricultural water management, the Microfem model is too small for accurate calculation of the effect of a buffer zone on the Bargerveen. Moreover, it describes a stationary winter situation, while the low groundwater levels in summer are most critical to the Bargerveen ecosystem. The hydrologists evaluated whether the model could be of any use for the process. They concluded that Microfem is able to give a rough indication of the effects and effectiveness of a buffer zone in a winter situation.

The financial resources and therefore the political decision for a buffer zone lie with the province and the ministry of LNV. The water board principal contacted the provincial executive in October 2007 for a decision about the buffer zone. The provincial executive made clear that she needed more insight and underpinning of the buffer zone's effectiveness to decide about its desirability and size. The province agreed as to a rough indication of the effects. The Microfem model calculations indicated a buffer zone with a width of 500m or more to be reasonably effective and to be of substantial benefit for nature. Based on this information, the province gave green light for negotiation about a buffer zone in February 2008 and facilitated the search for funding. The farmers stated their willingness to give up land in return for near-optimal circumstances for the remaining agricultural land. In its next meeting (April 2008) the sounding board group will probably reach consensus on the desirability, feasibility and implementation details of the buffer zone.

3. The role of hydrological models and expertise in the process

In this section we describe events related to hydrological models and expertise, highlighting factors that affected the progress of the participation process. We focus on decision points in the process, trying to uncover the implicit 'rules of the game' according which these decisions came about and were dealt with by the process manager.

Following the generic GGOR procedure, the first decisions that the process manager introduced concerned the determination of the OGOR for each land use. This required definition of both the land use functions and their optimal water regimes. The modelers had defined the land use in the agricultural area based on satellite data of 2003. The farmers falsified this method, arguing that the land use varies each year; the satellite data provided a random snapshot. They suggested basing the OGOR for agriculture on the most demanding land use. Although partly a strategic move of the farmers, the process manager agreed and determined OGOR agriculture for the whole area based on potato production.

The information needed to define the OGOR for nature was not available. To determine the land use in the Bargerveen, the Natura 2000 objectives had to be operationalized in more (spatial) detail. Moreover, the relation between the water regime and the ecology was uncertain. The process manager consulted a team of experts identified by SBB. The team filled the knowledge gap to the satisfaction of all stakeholders, despite differences in scientific insights and opinions. This best available expert opinion was introduced in the process to move to the next step.

Having established the OGORs for nature and agriculture and the large gap between these two in the sounding group meeting of April 2007, the uncertainty about effects, desirability and feasibility of measures prevented progress. This called for a decision about what hydrological model to use. The executive board of the water board was against a costly model exercise. The modelers suggested using MIPWA to explore the effects of measures. The process manager asked them to prepare MIPWA for calculations. The modelers thought MIPWA to be readily applicable, but soon identified shortcomings. In the following months some shortcomings were solved, but additional serious shortcomings were identified that would delay the process severely. At the same moment, the project sponsor brought the process to a standstill for strategic and financial deliberation. The original budget had run out and they were still not convinced of the necessity of any model exercise. Before allocating money for model calculations, they wanted to know whether the province was prepared to finance a buffer zone.

Faced with this decision, the provincial executive requested information about the effectiveness of a buffer zone that would warrant the significant costs of this type of measure. Sensitive to the argument that time and resources for obtaining detailed information were lacking, the provincial executive accepted to base her decision on the best possible prediction with the available models. Thereupon, the executive board of the water board decided to provide the financial means to continue the process and apply the Microfem model.

This decision induced a series of model-related activities and decisions. The process manager and modelers discussed with the stakeholders how best to develop information for the provincial decision. The process manager decided to have the effects of a buffer zone of various types and sizes (widths ranging from 250 to 1500 meters calculated with Microfem. The stakeholders thought strange of spending resources on the exploration of a measure without first determining whether this measure was feasible and desirable. However, the information about the possible range of impacts of the buffer zone allowed the process manager to give more direction to the discussion about its feasibility and desirability.

The process manager organized meetings with each of the key stakeholders and the provincial representative of the sounding board group to discuss intermediate model results. During these meetings, the modelers explained the structure, parameters and the model scenarios evaluated. They presented the model outputs visually by maps of the area. These maps showed the ground water level related to the OGORs. During these meetings, the process manager stressed the (im)possibilities of the model and urged the participants to make clear what in their opinion could be decided on the basis of the Microfem model. SBB critically reflected on the model and scenarios calculated. They suggested a few changes to the model, but agreed that it could be used to determine whether a buffer zone would have significant effects on the ground water levels in the Bargerveen. When the modelers suggested using the Microfem model for prediction of the effects of a buffer zone in a summer situation, SBB firmly contested the validity. The process manager decided not to continue with this type of model calculations. The farmers suggested extra scenarios to evaluate the effects of the OGOR for agriculture on the Bargerveen, which the process manager agreed to have calculated. Furthermore, they communicated to the process manager that, next to the groundwater level, the drainage possibility on parcel level is important to their activities. Both SBB and the farmers urged the process manager to explain to the province not only the calculated effects but also the opinions that they, as stakeholders, had given on these effects.

As an alternative measure, the farmers proposed to evaluate the application of an impervious screen in the subsoil. The hydrologists explained that the effectiveness of this measure could barely be evaluated ex-ante. Such a screen is to be placed upon a completely impervious boulder clay layer. Complete knowledge of the boulder clay layer is impossible to obtain, which makes the risk of ineffectiveness of the measure high. The process manager discussed this information with the farmers, who then accepted that an imperious screen was not an option.

4. Towards 'rules of the game'

In our analysis we have largely ignored the wider political context of rural policy in The Netherlands (cf. Boonstra & Frouws 2005), so we can only offer a global explanation for the outcome of the process. In terms of the advocacy coalition framework proposed by Sabatier (1988), the buffer zone option can be seen as a significant policy change that can be explained (1) as a result of an external event: the designation of the Bargerveen as a Natura 2000 area which gave the 'nature conservation coalition' considerably more power, and (2) as a result of policy-oriented learning: both the 'nature conservation coalition' and the 'agriculture coalition' gained knowledge not only of the Bargerveen as a hydrological system but also of the range of measures that are feasible – both technically and economically. Our focus has been on this policy-oriented learning, in particular on the role of models therein. Considering the Bargerveen GGOR process as an effective way of coping with contested models, we try to draw transferable insights from our experience in this process. Our aim is to capture as much as possible of the activities and decisions that we observed in the previous section as rules that specify what is 'proper behavior' for participants in the decision-making process.

As we stated in the introduction, the research we report in this paper is still 'work in progress'. The 'rules of the game' that we propose in this section have been defined in a highly qualitative manner and have not yet been rigorously analyzed. We have defined them while bearing in mind what De Bruijn *et al.* (2002) propose as the four core elements for the design of an effective policy process:

1. *Openness*: the process is open in terms of participation (all stakeholders have access to the process), problem definition (broad in scope, flexible) and solution space (no pre-set restrictions as to what constitutes a good solution).
2. *Protection of core values*: the process does not lead participants to act against their own interests.
3. *Substance*: the process makes use of relevant substantive knowledge, drawing on the expertise within the stakeholder network to generate variety as well as to making selections.
4. *Speed*: the process gains and maintains sufficient momentum to achieve significant results in the end.

Obviously, tensions exist between these elements. For example, if (new) stakeholders may at any moment add new considerations into the process, the process will not converge to a conclusion (*openness* versus *speed*). If decisions are based on a particular model, some stakeholders may opt out for fear of for them unfavorable results (*substance* versus *protection of core values*). A good set of 'rules of the game' for a process strikes a balance between all four elements.

As will become clear when we present rules for agenda management, information transparency, model transparency and the proposal of policy measures, a 'rule of the game' is strictly procedural and does not impose particular choices. They describe what type of behavior is considered appropriate for, and expected from, participants in a process.

The 'rules of the game' that we propose in this section as a means to improve model-supported policy processes use the following vocabulary:

– *stakeholders*: actors whose interests may be affected by the policy decisions that will result from the policy process that is being investigated

- *decision makers*: actors with the authority to make these policy decisions
- *modelers*: actors who have the technical competence to develop and operate computational models
- *experts*: actors whose knowledge on a particular topic is acknowledged by all participants
- *process sponsor*: actor who has commissioned the management of the policy process to the process manager and who can decide on the resources that are allocated for this process
- *participants*: actors who take an active part in the policy process
- *process manager*: actor responsible for managing the policy process by planning and facilitating the interaction between participants

Note that these roles need not be mutually exclusive. Modelers, for example, usually are (or become) experts, while experts may be (or become) stakeholders.

We also distinguish the following entities:

- *system*: the part of the real world that is the object of the policy process for which the 'rules of the game' are defined
- *measure*: a course of action that is expected to produce desirable changes in the state of the system
- *option*: a particular course of action that may be implemented
- *decision*: a choice from among several alternative options; a decision may be substantive, i.e., part of the policy (e.g., on what measures to take, or on budget limits) as well as procedural, i.e. on the way to proceed in the policy process (e.g., on what model to use, or on whom to invite for and what to discuss during the next meeting)
- *agenda*: an overview that shows all decisions that are relevant for the policy process and specifies for each decision whether it is still 'open' (no choice has been made among alternative options and new options can still be proposed), 'near closure', (no choice has been made but sufficient information on options and consequences is available to make a choice), or 'closed' (the choice for a particular option has been made)
- *model*: a representation of the system that can predict (with some degree of accuracy) the consequences of implementing a particular measure; the set of variables and their computational relationships constitute the *structure* of the model; we distinguish between *input variables,* i.e., variables to which are assigned values ('inputs') to represent measures (e.g., man-made changes in the surface layer) and exogenous factors (e.g., precipitation levels), *parameters*, i.e., variables whose constant values represent invariable system characteristics (e.g., the geometry and hydraulic conductivity of soil layers), and *output variables*, i.e., variables whose values ('outputs') are computed when the model is executed and are of interest to participants (e.g., minimum, maximum, and average ground water levels)
- *scenario*: a set of inputs that when the model is executed is expected to produce outputs that predict the effects of a measure as accurately as is possible, given the model's structure and parameters

The diagram in Fig. 2 reflects some of the assumptions we make with regard to the position of some of these actors and entities:

- Modelers develop the model by modifying its structure and/or parameters, and 'translate' proposed measures into scenarios.
- The agenda is determined by stakeholders, decision makers, process manager and process sponsor. The open decisions on the agenda correspond to an information need. Model output and expertise are expected to satisfy this need to some extent (the 'match' between

supply and demand of information), but may also be irrelevant to the decisions on the agenda (the ‘surplus’ information).

The diagram in Fig. 2 does not reflect the dynamics of the policy process. The implicit assumption is that the actors will affect the agenda by their actions (either directly, or indirectly by provoking actions of other actors). Building on the premise that actor behavior can be constrained by ‘rules of the game’, we expect that the following ‘rules of the game’ will enhance the quality of the policy process in terms of the four elements (openness, protection of core values, substance, and speed) that we presented at the beginning of this section.

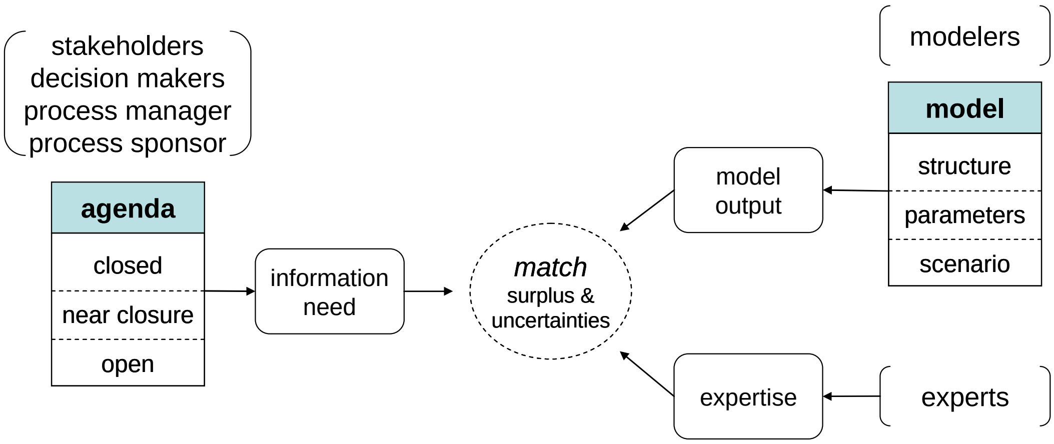

Figure 2. Elements of a model-informed policy process

Agenda management rules

AM-1 The process manager prioritizes the decisions on the agenda, motivates why the decisions need to be made (in the proposed order) to progress towards the final policy decision, and determines which actors are ‘decision maker’ for which decision.

AM-2 For each decision on the agenda, the stakeholders indicate ‘near closure’ (i.e., when they find the available information sufficiently complete and reliable for making the decision), or they indicate what uncertainties exist that prevent closure.

AM-3 For each decision on the agenda that is ‘near closure’, the associated decision makers choose an option and explicate their deliberation while referencing the available information. The process manager marks these decisions as ‘closed’.

AM-4 When uncertainties prohibit progress (i.e., no high priority decisions are ‘near closure’), the process manager consults with the process sponsor on the availability of resources, and with the modelers and experts on possible additional analysis. The process manager then develops alternative options for dealing with the uncertainties and places this procedural decision on the agenda.

The agenda management rules mainly favor speed, but rule AM-2 allows stakeholders to protect their interests. Rule AM-4 makes that the process cannot ‘block’, allowing the process manager to diagnose the lack of decisiveness and frame the problem as a procedural decision. The alternative options for this decision will be either ‘accept uncertainty’ (the decision makers take their responsibility and accept the risk that may be involved), ‘reduce uncertainty’ (additional information is sought – cf. the information search rules), or ‘reduce decision scope' (the decision options are modified – cf. the measure proposal rules). Rules AM-1 and AM-2 ensure that the information that is needed to make this procedural decision will be sought before a choice is made. The obvious catch is that it may be difficult to identify a legitimate decision maker for this procedural decision. It is typically at this point that the process manager will have to make a trade-off between the four core elements, and powerful actors (e.g., the process sponsor or decision makers) are likely to exert their influence at these moments.

Information transparency rules

IT-1 The participants communicate what information they consider to be relevant, specifying the decision(s) that should be based on this information.

IT-2 The participants report when they obtain new information that may be relevant for decision making.

IT-3 The process manager maintains and shares with all participants an overview of the information that has been identified as relevant and/or available.

IT-4 The participants take notice of the information that is available and notify the process manager of information that appears to be contradictory or missing. These instances are noted as uncertainties.

IT-5 The participants identify which people they consider to be knowledgeable on a subject that has been noted as uncertain. The process manager verifies with these people to see whether they can indeed contribute relevant information. If so, these people are invited to participate in the process as experts.

IT-6 If different experts are proposed for the same subject, these experts determine whether their views conflict. If so, the experts clarify their differences in opinion. These differences are noted as uncertainties.

The decisions referred to by these rules may be substantive as well as procedural. Likewise the information may be substantive as well as 'meta-information' (e.g., information on where other information can be found, or information on the quality of other information). The information transparency rules mainly favor openness and substance, but rules IT-1 and IT-6 also allow stakeholders to protect their interests. Rule IT-5 is an 'entry rule' in the sense that it allows new actors to become participants. By rule IT-2, persons who accept the invitation to participate as expert on a subject share their knowledge on this subject with all participants.

Model transparency rules

MT-1 The stakeholders explain which phenomena in the system are of particular interest to them in such manner that the modelers can assess whether or to what degree of accuracy these phenomena can be predicted by the model.

MT-2 The modelers explain the structure and parameters of the model, as well as the scenarios that are evaluated in such manner that the stakeholders can assess which phenomena in the system are represented in what detail, and what this means for the accuracy of the model output.

MT-3 The process manager maintains and shares an overview of the aspects that are known to be (not) represented by the model and clearly relates this to the information that has been identified (by rule IT-1) as relevant for some decision(s) on the agenda.

MT-4 When there are alternative models, or alternative ways of representing an aspect in the model, the modelers communicate the options and their consequences in terms of what the model can and cannot do to the process manager. The process manager then adds this procedural decision to the agenda.

The model transparency rules follow the same principles as the information transparency rules, but expand these by making explicit the joint responsibility of modelers and stakeholders to make 'black box' models transparent.

Measure proposal rules

MP-1 The participants propose a measure first as a generic option, i.e., as a class of possible options, leaving design parameters and implementation details unspecified.

MP-2 When the effects of a generic option have been noted as uncertain, the modelers calculate these effects using different scenarios to reveal the range of impacts of this class of options.

MP-3 The process manager communicates the results of this impact assessment with all participants. The stakeholders then express their opinion with regard the option's desirability and feasibility. By rule IT-2 and IT-3, the impact assessment results together with the stakeholder opinions are added to the information set.

MP-4 During formal meetings, participants refrain from discussing options for which the impacts are still being assessed.

The measure proposal rules mainly favor openness, substance and speed. From rule AM-2 (in combination with rule IT-2) it follows that participants can propose a new policy measure at any time in the process. Rule MP-2 mitigates the risk of losing time and resources on model exercises that are unlikely to produce relevant new information, while rule MP-4 avoid losing time on premature discussions. The interaction between measure proposal rules and information transparency rules ensure the protection of core values (IT-4 provides guidance in the event that actors disagree on the option's effects). The agenda management rules provide guidance in the event that the impact assessment requires additional model development. They likewise guide the process of developing generic measures into more specific measures because actors will not indicate 'near closure' until information on the impacts of sufficiently detailed option variants is available.

5. Discussion and conclusion

At a first glance, some of the 'rules of the game' we have proposed in the previous section may seem so obvious that they hardly need to be made explicit. This lies in the nature of behavioral rules when they are close to what would seem to be 'natural' or 'rational' behavior in a given context. But in our experience with participatory processes, many of the rules that we propose do not come 'naturally' to participants in these processes. Moreover, there may be strategic reasons for actors not to follow rules. For example, actors may wish to ignore rule IT-2 when they have information on negative side effects of a measure they prefer. In our case study, it was largely due to the effort and skill of the process manager that the actors abided by these rules.

We expect that in policy processes similar to the GGOR process our explicit set of 'rules of the game' can help to structure the interaction between actors and thereby enable effective participation. How much it will help will depend on the context. A set of explicit rules that defines a social 'code of conduct' they express is an artifact that will perform its intended function only in a suitable environment (Bots, 2007). The rules that we propose may not function in an unruly context where actors continuously challenge them, either implicitly (by not observing a rule) or explicitly ("I see no reason why we shouldn't we discuss this detailed option right now!").

To be functional, a social artifact must not only be adapted to, but also firmly anchored to its environment. A policy process and the roles of the participants (in particular the decision makers) must be legitimate. In our case study, the institutional context for the process was structured and firm: the global GGOR procedure was properly embedded within large policy processes, and the decision-making responsibilities of the government agencies at different levels were established. Even so, the process manager put continuous effort in clarifying these responsibilities to participants. This not only affirmed the process, but also revealed important uncertainties that needed to be resolved in order to move on. Thus, a strong guiding principle has been to explicitly decide what to decide and who is to decide.

Acknowledgement

This research is part of the Integrated Project *AquaStress* (http://www.aquastress.net) financed by the 6th EU Framework Programme for Research and Technological Development (FP6).

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Note: The authors have submitted a more elaborate research paper on this case study to *Ecology & Society*.