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The modeling policy-maker. On decision support systems in water management

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Computer models play an important role in modern water management as decision supporting tools to assess effects of possible measures in water systems. An important aspect in building these models is the selection of elements of the real world that should be incorporated in the model. For decision support tools, this selection depends on the policy measures and the effects to be evaluated. As some of these selections are strategic decisions, the policy-maker should be involved in the modeling process. In practice this is often not the case. Decisions, including the strategic ones, are usually all made by the modeling expert. This often leads to the situation that promising measures are not evaluated and sub optimal decisions are taken. This article focuses on the role which the policy-maker and the modeling expert should play in the modeling process. We formulate recommendations with respect to their communication by analysing the gap between this ideal situation and the day to day reality.

1. Introduction

Modern water management, on policy level, is about deciding on what measures to take and which interests to serve. Examples of these interests are environmental and agricultural aspects, safety and recreation. Measures are, for instance, building a pump or weir, improving the operation of the system. Policy making in the Dutch tradition includes participation by many groups. Due to the fact that many parties play a role in policy making support by these parties is essential. Thus to gain this support the decision making process must be well-founded.

In practice the decision process can reach a deadlock when the foundation of certain measures breaks down. In this article we argue that a possible reason for this lies in the way decision support systems are used. First we will go into the complexity of the decision process in integrated water management. Next we will present the ideal communication between the policy-maker and the water system specialist in the form of a caricatural dialog. Finally recommendations are given to improve the involvement of the policy maker in the modeling process.

2. Integrated water management

The concept of integrated water management is the basis of the water management in the Netherlands. The "water system approach" is an important element of integrated water management. The approach means that the goals of water management are dictated by the user functions, or the so called interests. Interests are, for example, recreation, agriculture or nature. These goals are met by providing, for instance, the appropriate water levels, soil moisture content and water quality conditions.

The object of water management is the water system: "A geographically defined, related and functioning whole of surface water, ground water, subsurface beds, embankments and technical infrastructure, including all related physical, chemical and biological characteristics and processes". Hence, water systems consist of various elements (e.g., paved areas, unpaved areas, polder canals, storage canals) in which multiple processes such as flow, sediment transport, dispersion, decay, etc. take place.

What makes integrated water management complex is that interests are related to multiple elements and multiple interacting processes. Recreation may, for instance, require a good water quality and a constant water level while agriculture may demand a low water level in the canals and a soil moisture content within certain boundaries. Since the different interests may lead to conflicting demands on processes in the elements of the water system weighing of these interests may be needed.

Another aspect of water management is the question how to "steer" the water system in such a way that all interests are served eventually. This steering can be done through infrastructural measures (e.g., building a weir or a pumping station) or via the manipulation of the system actuators such as sluices, weirs and pumps. A complicating factor in deriving the right steering is the occurrence of side effects of measures in neighbouring areas. Another complicating factor results from the fact that there are often many alternative measures. The water levels in a storage canal can be controlled by increasing the storage capacity in the upstream areas which reduces the flow towards the canal, but also by increasing the discharge capacity of the canal.

3. Policy decisions

Policy making and the Dutch tradition of participation by many parties within the process does not allow a decision today to result in a fact tomorrow. Planning is an important instrument for organising commitments at the different governing levels as well as in the short and long term. For harmonisation with other policy fields, such as spatial planning and environmental policy, planning is important too.

The planning process requires the recognition of problems, formulation of alternative options for solving the problems, presentation of the impact of the actual situation and the alternative options as well as the selection of strategies. Good planning requires insight into the above mentioned complex relations between measures and interests.

4. The role of decision support systems

A decision support system (DSS) can be used to provide the insight necessary for the planning procedure. In practice DSS are, for example, used to present alternative measures and to quantify the impact of these measures on the different interests. Furthermore, they can be used for the analysis of the cost effectiveness of alternative measures. Studying the effects of alternative measures may also provide insight into the extent to which different interests can be supported by the measures. The DSS can provide the policy-maker, for instance, with information on:

- the cost of measures;
- which measure serves best the various interests;
- the extent to which a measure to support one interest affects another;
- which interests are conflicting and cannot be served simultaneously;
- ....

To use this information in an appropriate way for planning you must also have an understanding of the structure and the processes included in the decision support system. This will be illustrated in the following subsection. For clarity the problem to be discussed focuses on one aspect of modeling: the selection of the processes to include in the model.

4.1. About commonly applied models

Basically, a computer model is nothing more than a set of mathematical equations, written down in computer code, describing real life processes in simplified terms.

In water management, many different types of computer models are applied to describe all the relevant processes in a lumped or distributed fashion. Of all models, the so-called deterministic simulation models are the most commonly used to estimate effects of measures in water systems.

An example of such a model is a groundwater model which describes the relation between the groundwater level in an area due to precipitation, evaporation, the inflow and outflow to that area and the abstraction of groundwater for domestic and industrial use. These models provide insight in, for instance, the change of groundwater levels as a result of reducing the extraction of groundwater, changing the land use or other measures. Other commonly applied models are so-called rainfall run-off models describing the flow in paved and unpaved areas and the one-dimensional hydraulic models in which the flow through channels can be simulated. These types of models can be applied to formulate measures to reduce flooding or the frequency in which extreme water levels occur. The simulated flow patterns can serve as a basis for the modeling of water quality processes. Additional modules describing water quality processes may lead to insight in effects of toxic loads on receiving waters, etc.

5. Building models for decision support – the ideal building process

The policy-maker must be provided with alternative measures and be aware of the costs, effects and side effects of those measures whilst at the same time considering the public support for a certain strategy. Apart from technical aspects, emotional aspects can play an important role here.

Models contain a limited number of processes in the form of mathematical equations. An important aspect of modeling is, therefore, the identification of the processes that should be included. As mentioned above in this identification process the policy-maker should be involved. The role which he or she should ideally play in this process is illustrated in the following example which is written in the form of a dialog, which is, for clarity sake, caricatural.

The policy-maker in the example considers creating a nature reserve in a section of a polder. He wants to use a computer model to study the alternative measures to realise it and to get more detailed information on the required measures. The dialog starts with the water system expert trying to find out which effects are to be studied with the model.

Policy-maker: “We want to create a nature reserve in a specific section of a polder. According to the consulted biologist this means that the groundwater level in this area should be at n meters below ground level”.

Water system expert: “I'll design a model to see whether it is possible to achieve that groundwater level. By the way, are you interested in effects on surrounding sections?”

Policy-maker: “What do you mean?”

Water system expert: “I mean that changing the groundwater level in one section influences both the groundwater levels and the surface water levels in other sections.”

Policy-maker: “What is the problem with that?”

Water system expert: “A change in groundwater level in the surrounding areas might lead to a decrease of agricultural yield. A change in surface water level has no real consequences, but the people in the area may not like it.”

Policy-maker: “Well, in that case it is important to know how much the reduction of agricultural yield will be. I really want to create a nature reserve, but if I have to pay the farmers a lot of money to compensate for loss of yield, things might become too expensive. And people should not complain about the change in surface water level because it will not affect them. I'll convince them of this.”

Water system expert: “So I will make a model involving groundwater processes in all the relevant areas.”

This example shows the benefit of involving the policy-maker in the modeling process. If the water system expert would have built a model for only modeling the nature reserve, it would not have been possible to estimate the negative impact of the changed groundwater level on the agricultural yield. Through the input of the water system expert, the policy-maker becomes aware of this possible negative impact which allows him to change his policy or to work out measures to compensate the reduction of income of the farmers. It also gives him insight into the fact that changes in surface water levels do not cause any problem, which is important information in the process of gathering public support for a certain measure.

The second piece of dialog focuses on the possible measures to take.

Water system expert: "Look, the model I made enables you to evaluate the changes in groundwater level in all relevant sections caused by measures like: increasing the area of surface water, improving the control of the weirs in the area and other actuators (introducing Real Time Control), building weirs on several places and improving the drainage system."

(The policy-maker starts evaluating the effect of some measures, but becomes disappointed with the model.)

Policy-maker: "The number of combinations of measures to evaluate is too numerous. I can't possibly evaluate them all. Which measures are in your opinion the cheapest for creating the nature reserve whilst keeping negative effects in other sections to a minimum?"

Water system expert: "Based on my experience and the insight gained in this water system, I expect improving the operation strategy by introducing Real Time Control (RTC), with or without simultaneously building some weirs, is the most promising candidate measure."

Policy maker: "So I want you to make a model that enables me to evaluate RTC in combinations with weirs in several places in the water system."

In the model the number of possible measures is reduced to the adjustment of the operation of the water system with or without simultaneously building some weirs. The decision space of the policy maker is reduced and he has the confidence that this reduction does not exclude promising measures.

As shown above, building a model to support policy making in water management has several aspects of significance to the policy-maker. It is important for him to reduce the number of possible measures in order to maintain overview. Furthermore the modeling process helps him or her to address the effects which should be evaluated and shows how such an evaluation can be carried out, how these effects can be evaluated.

6. Risk of not being involved

In cases where the policy-maker is not involved in the building of the DSS the following problems may occur:

(1) the policy-maker cannot "defend" a suitable measure;

(2) someone presents a better measure which had not been evaluated in the preliminary analysis;

(3) unexpected side effects come up during the discussion and presentation of the measures, or worse during the implementation.

The first problem might come up when the policy-maker has been provided with a good model like the model that was built by the water system expert and the policy-maker in the former paragraph, but where the policy-maker does not know the foundation of the selection of the alternative measures included in the model. If he had been involved he would be aware of the foundation.

In the second and third case the model is not suitable. Certain promising measures and or side effects may, therefore, not be identified. Involvement of the policymaker in the building process might have provided the water system expert with a better understanding of the kind of things the policy-maker must decide on.

In all situations discussed the consequence can be that carefully organised planning is slowed down which is fatal to the policy making.

7. Organising involvement

Improvement in the co-operation between policy-maker and water system expert requires first of all a change in the attitude of both specialists towards the modeling process. Such a change can be stimulated by showing that improved communication may avoid above mentioned problems.

Next it is important to structure the involvement of the policy-maker in the modeling process. A way to accomplish that is to develop a guideline which can be used to structure the communication process. The guideline should describe the different types of decisions to be made and should address the specialists responsible for the decisions. Furthermore, it should contain a clear description of reports in which the process and decisions are written down.

The authors contributed to the development of such a guideline for the design of real time control (RTC) of urban drainage systems. This guideline was incorporated in the "Leidraad Riolering", a standard for the design of urban drainage systems in the Netherlands. It gives advice as to which specialists should be involved in the different stages of the decision making process and the contents of the various reports to be written. Furthermore, it stresses the need to maintain clarity in the decision structure. Today the "Leidraad Riolering" is used as guideline in the communication between the parties involved.

8. Conclusions

The policy-makers should participate in the process of building decision support systems. When he or she is not involved carefully organised planning may be slowed down.

To accomplish improved communication, guidelines should be developed describing the different types of decisions to be made and the specialist responsible for the decisions. Furthermore, they should contain a clear description of reports in where the process and decisions are written down.