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GEOHYDROLOGICAL INFORMATION SYSTEMS FOR WATER MANAGEMENT

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ABSTRACT

The increasing complexity of water management has generated a rapidly growing demand for information and also for Geohydrological Information Systems (GhIS). An information system for water management must relate directly to the water manager's tasks. To be able to implement these tasks effectively the water manager requires information about the properties of the water system and about society's interests and needs. As well as providing information, a GhIS for water management should have analytical tools for interpreting and analyzing data and information, so it also has functions for acquiring, storing, processing, checking, interpreting and analyzing data. TNO Institute of Applied Geoscience is developing GhIS that have these functions and in which the integration of information and functionality, the flexibility, and the transferability and utility for different user groups are also important aspects.

KEYWORDS

Analytical tools; GhIS; need for information; information system; integrated water management; water system.

DEVELOPMENTS IN WATER MANAGEMENT

The water manager's task is to manage the water system in his area in such a way that the aims relating to land and water use are pursued optimally. In recent decades these aims have changed in The Netherlands. The most important developments are integration of different aspects of water (groundwater/surface water, etc.); integration of policy and management; and increasing interest in water's functions for the environment and nature. These developments have fuelled the water managers' demand for information (in The Netherlands, these water managers include ministries, provinces, municipalities, water boards and water treatment companies), which in turn has increased interest in Geohydrological Information Systems (GhIS) for water management.

THE WATER MANAGER'S TASKS AND THE DEMAND FOR INFORMATION

The information required for water management relate directly to the water manager's tasks. Van Bracht (in preparation) describes a functional conceptual model about the water manager's duties, with respect to integrated water management. This model consists of two systems: a water system and a water management system (see Fig. 1). The systems are interrelated. The water management system is presented as a process of elements related to each other. Each element contains a water management task that can be distinguished as independent to some degree. The water management system works as follows: The water manager establishes the functions that the water system must fulfil (Task F). These functions are based on the potential uses (U) of the water system, the demands made by various interest groups (I) – such as agriculture, industry and conservationists – and on economic, social and political motives (political policy (P)). The potential uses of the water system depend on the properties of that system. After assigning the functions, the water manager ascertains the conditions under which the water system will best satisfy the demands made by these functions. Target scenarios (S) for the water system are drawn up for this. Management measures (M) are applied to achieve these target scenarios. After implementing these measures the water manager evaluates (E) to what extent they have achieved the desired effect, and adjusts his management, if necessary.

Figure 1 shows the conceptual model. The circles show the tasks formulated above, as the elements of the water management system. The arrows show the relationships – in this case the flows of information. A distinction is made between a flow of information with which water management is refined or new water management is developed, and a flow of information with which existing water management is evaluated.

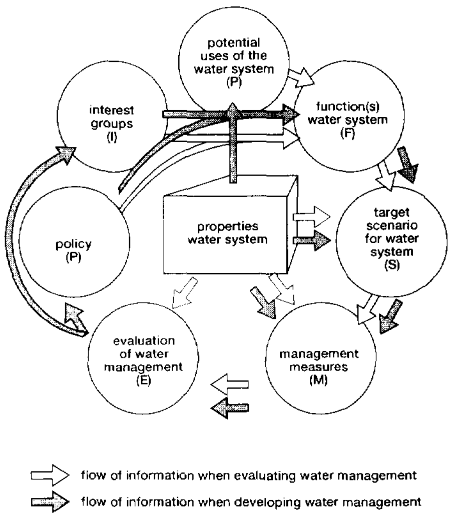

Figure 1. Schematic representation of the water manager's tasks.

The conceptual model of management tasks, presented in Fig. 1 is, in principle, applicable to both strategic and operational water management.

Information is needed for each of the water management tasks. The type of information and its quantity and quality depend on the task the water manager wishes to carry out. As described in this section, water management consists of a cycle of activities, with information as the linking element. In order to function properly, each water management activity needs information as an input. Each element then generates new information as output, which is then used as input for the next element in the water management system. Each element contains several processing and analytical steps, which convert the input information into output information.

The water management model depicted in Fig. 1 clearly indicates that the need for information on the part of integrated water management consists of a very broad range of types of data, in which information on the water system is only one component. Figure 2 gives a schematic overview of information important for integrated water management, relating to water systems.

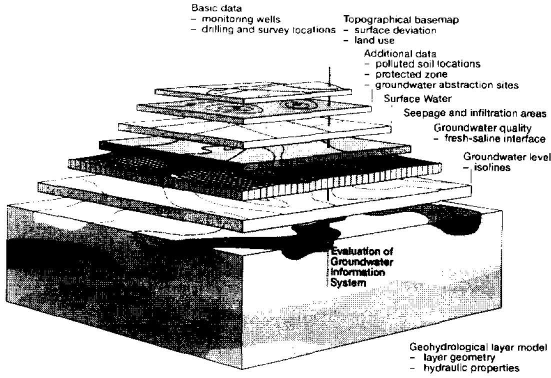

Figure 2. Schematic overview of the demand for information relating to water systems.

The quantity and quality of the required information vary per water management task and according to the level at which the water management is being implemented. As noted before, the tasks to be implemented by a strategic or operational water manager are, in principle, similar. However, the demand for information at each water management task depends on the decision-making level. Each such level requires information of a different level of abstraction. Strategic water management requires generalized information at a high level of abstraction and covering relatively large areas. Operational water management mostly requires concrete and precise data at a low level of abstraction.

Combining the demands per water management task with the demands linked with the decision-making level yields an overview of the types of data needed, and the associated qualitative and quantitative requirements they must satisfy.

As well as data and information, an information system for water management also comprises tools for analysis and processing. The analytical tools are needed to transform data into information.

Models are the most important tools for analysis in water management. According to Freeze *et al.* (1991) there are three types of models: simulation models, decision-supporting models and uncertainty models. An analysis often involves professional know-how as well as models. It is important to apply this know-how in a systematic and structured way.

INFORMATION SYSTEMS FOR THE WATER MANAGER

A conceptual functional model of the main functions of a GhIS can be created on the basis of the water manager's needs (see Fig. 3). These functional building blocks are: a database (DB) containing all the data and information relevant for the water management; a Data Acquisition System (DAS) for inputting data into the DB (digitizing and data entry functions), a Data Interpretation and Visualization System (functions for processing, checking, interpreting and visualizing data); an Analytical System (AS) comprised of all the analytical tools required (simulation models and decision-supporting models, and also a knowledge system for the structured incorporation of professional know-how); and a Quality Control System (QCS) to assure the information system's integrity (quality of the basic data, margins of uncertainty, etc.).

When a GhIS is being designed, three important aspects (after Deckers, 1993) have to be taken into consideration to ensure it can be applied rapidly and efficiently: integration (integration in data/information, functionalities and use interface); flexibility (in scale and applicability) and supporting facilities for different types of user (technicians, hydrologists, administrative staff, etc.).

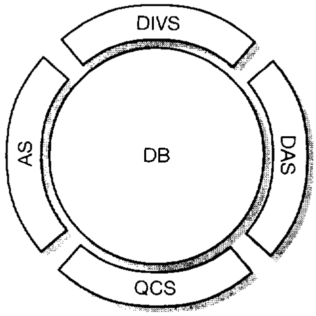

Figure 3. Conceptual model of the functions of a GhIS (cf. Deckers, 1993).

DISCUSSION

From the preceding sections it is clear that setting up GhIS is a complex matter. One of the reasons is unknown, or unclear, information requirements (Ward and McBride, 1986; van Bracht, in prep.). This means that information systems contain on the one hand redundant or irrelevant data and information and on the other hand unreliable, inadequate or partial data and information. Examples of structured approaches for setting up information systems are given by Freeze *et al* (1991) with respect to hydrological decision analyses, and Luiten (1995) who describes a dutch project for combining monitoring research and policy analysis for integrated water management.

Due to differences in water systems, uses of water, legislation and social and political aspects the information requirements will differ from country to country and area to area. That is why "multi purpose" GhIS should be flexible, and easy to customize. An example of such a system is given by Deckers (1993). Deckers describes the GhIS developed by TNO Institute of Applied Geoscience. This institute designs information systems according to the concept discussed in preceding sections.

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