Decision-support systems for groundwater protection: Innovative tools for resource management

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Abstract: Governmental authorities are forced by law to take decisions within the framework of European, national and regional directives in the fields of spatial planning, ground water and environmental protection. These tasks can be supported by a decision-support system, which integrates data from various sources and helps to make decision processes more effective and transparent. Basic work for such a decision support system has been done in a transnational and interdisciplinary project (Interreg IIc: KATER), including metadata definition, metadata system, cartographic tools and GIS tools. The direct integration of these tools and information in the decision process will be implemented in the next years (project KATER II).

Key words: water management, decision-support systems, KATER

Water management issues: problems and measures

Water management is a central issue in the 21st century, because water is rapidly becoming a scarce resource. The focus in dealing with water resources on a global scale thus has to shift from a water development perspective to one of water management (World Bank, 1998). Water plays a vital role in human development, as the necessary basis for nutrition, a central factor for health and a resource in agricultural and industrial development.
The issues involved seem at first sight to differ quite strongly between developing countries and industrialised countries. In the developing countries studies in the last years usually agreed on the main issues (Lee & Bastermeijer, 1991). Nevertheless they still apply in many respects to industrialised countries as well:

- Need to address water source protection more systematically
- Lack of reliable information
- Legislation not enforced
- Lack of awareness

The Interreg IIc project KATER was set up to provide solutions to some of the problems named above – especially the information gap and the systematic treatment of water issues. In the project period 1999-2001 information systems were developed to allow a comprehensive and integrative view of water measurements and their environmental conditions. KATER II – which has started in April 2003 – will concentrate on the knowledge base of decision making and on tools for technical support of decision making process. KATER II thus provides an information base and a knowledge-network which is in line with the current developments of the 'World Water Portal', which also focuses on water information sharing and cooperation. KATER II and the "World Water Portal" share many common objectives (see also: United Nations: World Water Development Report, 2003).

Scientific paper

THE LEGISLATIVE FRAMEWORK

On the European level the base of legislation is the water framework directive. This directive has to be transformed into national legislation by all EU member states by the end of 2003. It is also part of the general provisions of becoming member states of the accession countries.
The key objectives of the directive at European level are general protection of the aquatic ecology, specific protection of unique and valuable habitats, protection of drinking water resources, and protection of bathing water. All these objectives must be integrated for each river basin. On the effects side, it co-ordinates all the environmental objectives in existing legislation, and provides a new overall objective of good status for all waters, and requires that where the measures taken on the source side are not sufficient to achieve these objectives, additional ones are required (see: http://europa.eu.int/comm/environment/water/water-framework/overview.html).
The framework also addresses the need of public participation and informing the public as well as the problem of pricing. This includes the principle of recovery of the costs of water services, including environmental and resource costs.

DECISION PROBLEMS IN WATER MANAGEMENT

The basic tasks of water management can be divided into administration, crisis management and planning activities.
A detailed analysis of tasks shows that the nature of decision-making and the time scale of decisions is clearly different between task categories. Planning needs long-term decisions under conditions of low time-pressure, whereas administration and above all crisis management need immediate decisions. The support of decisions in water management must take into account the differing information needs and tailor the decision support system (including the structuring of data access, the way of data presentation and the system functionality) according to user needs.

SUPPORTING DECISIONS: INFORMATION NEEDS (KATER I)

Regarding the objectives of KATER and KATER II project, the main goal is the development of a decision support system to handle the main tasks of water management: administration, crisis management and planning. But before starting the actual application development process, it was necessary to collect details about the actual workflow of users and their information needs. A detailed analysis of the workflow gives on the one hand the possibility for optimisation of the workflow (avoiding duplicate work, etc.), on the other hand it is the basis for the conception of any support by tools like GIS. In order to satisfy the information needs of user groups the following steps were taken in KATER I:

DATA COLLECTION AND INTEGRATION IN GIS DATABASE

The first step was to integrate data sources of various disciplines. These include geology, hydrogeology, meteorology, vegetation mapping, pedology, remote sensing, surveying etc. The data was transformed into one consistent system of spatial reference, including the activities of assessment of data quality and plausibility.

Data documentation via metadata

Metadata are regarded as the main key for successful and lasting multidisciplinary work (e.g., Streit & Bluhm, 1998). They present users with information about data availability and – even more important – about the possible use and usage restrictions of this data. The development of metadata have become an important step in most integrative research projects in the last years.
As the basis of the metadata definition international standards were chosen and a database application built. This tool serves as the metadata management tool for all partners involved in the project.

System development

The development of the information system concentrated on the following objectives:
- Adaptability to the needs of different user groups, above all water suppliers, spatial planners, environmentalists and scientists.
- Conformity with the provisions of the European Water Framework Directive in respect to maps, plans and GIS usage.
- Ease-of-use for non-expert users.
- Integration of map data and its attributes with measurement data and statistical data in a variety of presentation forms.
- Analytical and modelling capabilities.
- Possibility for model implementation on the basis of the available information sets.
- Cartography and reporting.

Supporting decisions: decision support systems (KATER II)

Basically Decision support systems are computer-based systems, which help decision makers to make „optimal“ decisions in uncertain decision environments. The methodological basis for organising the decision process starts with the definition of basic functional roles in the decision-making process and the corresponding methodological, data and application requirements:
- decision-maker
- analyst (“intermediary”, ”translator”)
- decision support system (DSS) builder (uses a DSS generator)
- technical supporter (for the definition and integration of new elements into the system)
- tool-smith (developer of the underlying technology)

The development of the decision support system will be based on the following steps:
- Definition of formal methods for the decision making process including multi-criteria decision-making and techniques of fuzzy evaluation.
- Formalisation of rules and guidelines which describe the complex interactions between land-use and water and environmental protection (knowledge-base).
- The system architecture of the decision support system includes the following basic components:
  - database and data models (DBMS)
  - models for data retrieval, rules usage and analysis (EXPERT SYSTEM)
  - evaluation methods (EVALUATION)
  - presentation module with cartography and report generator (DISPLAY)
  - user interface

- Reference will be made to sources of additional external data relevant to the decision-making process (natural disaster information systems, online early warning systems, etc.)
- System development for the defined user groups with attention paid to the following basic principles:
  - use and support of (thematically and technically) relevant national and international standards
  - end-user friendliness
  - presentation and direct use of expert system (rules)
  - use of specifically adapted methods to define evaluation measures
  - extendable and easily deployable system development (component technology, web-based services, XML standard, etc.)

OUTLOOK

The discussion above and the experiences of many transnational and international projects allow to define a list of basic steps how to proceed in the development of a water management system, including

· A common language, to integrate the views on water issues of the diverse actors in the water management process.
· Metadata have been proven to be of highest priority to make the results of any project and data collection process usable. The metadata issue is in many respects directly related to point
· A multi-disciplinary approach has to be taken, to integrate the heterogeneous problem views of scientists, authorities, technicians and users.
· Decision support systems have to be simple in use but allow integrating a wide range of data (of very heterogeneous data quality) and presentation facilities with well developed functions.

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