Geophysical Research Abstracts, Vol. 9, 10831, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-10831

Indicators for Integrated Water Resources Management

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Integrated water resources management (IWRM) recommends that the planning and management activities of surface and subsurface water resources are carried out at the lowest appropriate level. Decentralizing these activities implies that various stakeholders, including water users and managers, will have a seat at the negotiation table when it comes to allocating the scarce resources. Decision support systems (DSS) can facilitate the emergence of a consensus between stakeholders about the allocation rules, by providing comprehensive, relevant, understandable, and timely information. In addition, the information should help water users to understand interests of both public and private stakeholders. To achieve this, we follow a participatory approach that allows stakeholders to define which information is presented in a DSS in order to evaluate different allocation alternatives. This approach is illustrated with a coastal aquifer in Almeria, Spain, which is the test site of the EU project ALERT. The overexploitation of the aquifer together with the uncoordinated management of the resource has led to saltwater intrusion which threatens the economic development of that region and the integrity of the environment.

The DSS is based on indicators that allow to evaluate the multiple aspects of water use in the catchment. After selection of a core list of indicators during a field campaign, indicator protocols are programmed and quantified partly through optimization over a 20 year planning period, partly through empirical relationships established for the different development scenarios in the catchment. In this sense, we adopt a hybrid approach in the DSS. First, operational decisions (pumping and water transfers) are determined by an optimization model which minimizes the operational costs of the system while meeting physical constraints and water demands formulated by the water users. This min-cost optimization problem corresponds to a coordinated management of the aquifer. Then, broader environmental and socio-economic issues, which cannot easily be captured in the operational model are dealt with through soft operational research methods, such as inquiry based empirical relationships, established for the different development scenarios.

Both approaches are linked in a management model that returns indicator results for aquifer cells at the different time steps of the planning period. Information is stored in a database that will be consulted for multi-criteria evaluation through an interactive interface. Prior to multi-criteria analysis of different allocation scenarios, indicators have to be temporally and spatially aggregated. Different procedures of data aggregation are explored to obtain critical indicator values. The different modules of the DSS are coupled in a Python environment. The modular structure of the DSS software allows to allocate the MCA module and interface in a web based environment, while input database and optimization modules have developer access only. The interactive web based interface allows maximal diffusion of information to the stakeholders.

The scope of this contribution is twofold: first, to present details of the definition, selection, quantification, interpretation and communication of indicators for different water management scenarios in the Andarax catchment, Almeria. And second, to show how different types of indicators quantification are coupled in a software environment and processed for geo-statistical interpretation. We aim to demonstrate how a coupling of 'hard' modeling indicators and indicators obtained through 'soft' operational research methods can deal with the various aspects of IWRM.