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A comprehensive framework for integrated water quality management

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A comprehensive methodology for integrated water quality management has to address two fundamental aspects of uncertainty: The first one consists of the prediction uncertainty about the future development of the system to be studied and falls into the domains of natural and engineering sciences. The second one relates to the decision analytical side of the problem and tackles the question of how to choose in a rational manner between alternative strategies given the uncertain outcome of any selected option.

In this contribution, we present a decision analytical and modelling framework for handling these issues in the context of managing water quality and its impact on the ecological status of rivers in the Swiss Plateau. Therefore, we use methods of the multi-attribute value/utility theory. The stepwise procedure starts with the formulation of an objectives hierarchy that contains measurable attributes (e.g., nutrient concentrations) at its lowest level. These attributes link the valuation and predictive part of the procedure. Next, the current and predicted statuses of the riverine system are assessed by means of value functions of these attributes and their hierarchical aggregation which can be elicited from stakeholders and/or experts. We will illustrate this step by concrete examples from our case study. On the other hand, the future states of these attributes are predicted for future boundary conditions (e.g., climate change). We illustrate which kind of input, parameter and model uncertainty may affect these predictions for our specific study areas in the Swiss Plateau and present a framework for dealing with them in a consistent way. The suggested Bayesian approach includes for example probabilistic input error terms for the hydrological part and stochastic model bias corrections to account for model uncertainty. Because this framework accounts for major sources of uncertainty it yields realistic estimates of prediction uncertainty. For specific boundary conditions, like specific management options, the model delivers probability density functions of the attributes mentioned above. They can be finally translated into probabilistic predictions of the overall status of the system. The final step links the probabilistic predictions of the attributes with the value function to calculate a ranking of alternative management options that can be provided to decision makers. If necessary, the risk attitude of the decision makers can be taken into account by the use of a utility function. Such a ranking can be easily updated once new knowledge or data get available or upon future changes in real boundary conditions. Hence, the approach lends itself to adaptive management.