Water Research Foundation & Sponsors

Authors: Kathy Miller & Rob Wilby

Date: 30 April 2009

Technical Briefing Paper (6):

Decision Support Tools for Adaptation Planning

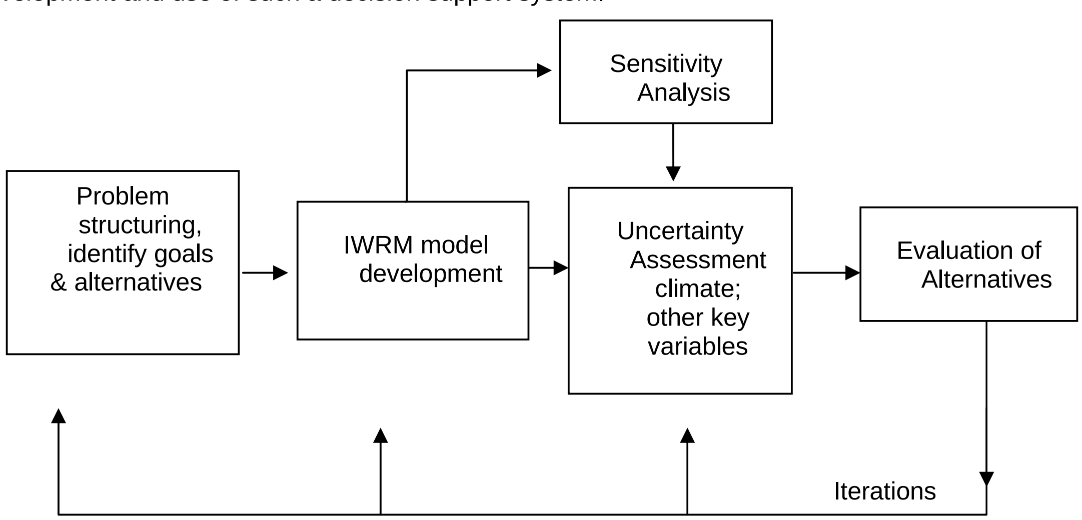
Synopsis Decision support tools can help utilities develop planning strategies for dealing with the possible effects of climate change. Such tools must be tailored to the system characteristics, location and planning needs of each utility. Given unavoidable uncertainties surrounding regional climate change projections, decision support systems should give explicit attention to assessing the implications of uncertainty and to managing the associated risks.

Explanation Various guidance documents and decision support tools are available to help water supply and wastewater utilities plan for climate-change adaptation. The available resources range from simple lists of planning principles, and cookbook formulae for modifying engineering designs, to fully articulated decision support systems designed specifically to evaluate the relative desirability of planning options in the context of climate change. This note focuses on the latter type of tool sets.

A decision support system typically consists of a set of models, data and methods for incorporating alternative projections of future conditions, together with a structured process for evaluating alternative proposed actions. A decision support system should be capable of providing guidance on the strengths and weaknesses of the decision alternatives, and the sensitivity of projected outcomes to uncertainties about future climate and other key variables. Key elements in the design of a decision support system for climate-change adaptation planning for water and wastewater utilities include:

- a process for articulating objectives and identifying alternatives;
- integrated water resource planning and management models that are capable of simulating the effects of a climate change on system performance;
- projections of future climate and of other variables likely to affect decision outcomes;
- methods for estimating decision performance given alternative realizations of future climate and other variables
- methods for evaluating the desirability of the decision alternatives given the range of uncertainty about key variables, including future climate.

Figure 1 provides a simple diagrammatic representation of the sequence of activities in the development and use of such a decision support system.



Applications

Water utilities typically have several objectives, including providing cost-effective and reliable service to current and future customers; adhering to regulations; protecting the environment and avoiding conflicts with other watershed interests. A decision support system should be able to shed light on how each objective is likely to be affected by the decision alternatives under consideration, given the effects of climate change in conjunction with likely changes in other variables. A rough understanding of future climate changes and the utility's vulnerabilities can help to guide the selection of options to consider. For example, a utility serving a coastal city would want to consider water supply options that are not vulnerable to the effects of sea level rise and saline intrusion into coastal aquifers.

An integrated water resource management model is a highly useful tool for evaluating the effects of each adaptation option. For example, models constructed with WEAP allow the analyst to simulate interactions among multiple water users and the effects of alternative policies, while tracking the impacts of changes in precipitation and other climate variables on the movement of water through the interconnected surface and groundwater systems.

One of the key issues confronting water planners is uncertainty – not only about the details of future climate changes, but also about other important variables such as population projections. In addition, there is uncertainty inherent to the water resource model structure and parameters too. Such uncertainties must be incorporated in the analysis, so that the planning options are evaluated in light of their ability to help the utility cope with the associated risks. In particular, it is important to evaluate the effects of a range of climate change scenarios, and to consider possible changes in variability and extremes along with changes in mean conditions. A final issue related to uncertainty is the selection of an appropriate decision rule. Decision analysis methods are widely used for water industry planning. The approach is useful when the probability distributions of uncertain variables are well understood and can be estimated with some confidence. Typical applications focus on maximizing the expected net present value of an objective function – which may encompass multiple objectives. Use of these methods in the context of climate change is somewhat problematic, because while there have been some attempts to quantify probability distributions for regional climate changes, substantial uncertainty remains, especially for precipitation. Other approaches may be more appropriate in such cases. For example, the "robust planning" approach favors options that are relatively insensitive to uncertainty, in that they will perform adequately over a wide range of future climates. A slightly different angle is taken by the "real options" approach, which emphasizes choosing alternatives that maintain flexibility to react to new information as it becomes available. Thus, uncertainty might be accommodated selecting water supply options with modular elements that could be implemented quickly to respond to drought emergencies, or phased in over time as the need develops.

Case Study

The Water Research Foundation is supporting the development of decision support systems to help water utilities consider the implications of climate change for their long range planning. One project is working with water providers and regional planning organizations to develop WEAP based models of their systems, and to run the models with simulated high-resolution future climate scenarios. As part this study, a group of Florida stakeholders have been engaged in a multi-objective evaluation exercise that is using the regional water system model to assess the performance of planning alternatives under a range of future climates.

Supporting materials and links

CCSP, 2009. *Best Practice Approaches for Characterizing, Communicating, and Incorporating Scientific Uncertainty in Decisionmaking*. Final Report, Synthesis and Assessment Product 5.2. Morgan, G., Dowlatabadi, H., Henrion, M. et al. (eds.). National Oceanic and Atmospheric Administration, Washington D.C., USA.

David G. Groves, 2006. New Methods for Identifying Robust Long-Term Water Resources Management Strategies for California. Pardee RAND Graduate School Doctoral Dissertation Series The Rand Corporation, Santa Monica, CA. Available at: http://www.rand.org/pubs/rgs_dissertations/RGSD196/

Hall, J. 2007. Probabilistic climate scenarios may misrepresent uncertainty and lead to bad adaptation decisions. *Hydrological Processes*, **21**, 1127-1129.

Wilby, R.L. 2005. Uncertainty in water resource model parameters used for climate change impact assessment. *Hydrological Processes*, **19**, 3201-3219.

Yates, D., J. Sieber, D. Purkey and A. Huber Lee (2005) WEAP21, A demand, priority, and preference driven water planning model: Part 1, model characteristics. *Water International*, 30, 4, pp. 487-500.