Climate Change in Water Utility Planning: Decision Analytic Approaches [Project #3132]

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PRINCIPAL INVESTIGATORS:
David Yates and Kathleen Miller

OBJECTIVES:
The purpose of this project was to engage a select set of municipal water providers and related regional coordinating bodies in the development of a structured assessment process to facilitate an evaluation of water utility vulnerabilities and response options to prospective climate changes. This project focused on the problem of planning in the context of uncertainties surrounding the local-scale hydrologic changes that will result from global climate change.

BACKGROUND:
There is strong evidence that climate change consistent with greenhouse-gas-induced warming is already occurring and that it is affecting hydrologic processes in many parts of the world. These changes are expected to accelerate with the continuing accumulation of carbon dioxide and other greenhouse gases in the atmosphere. These facts, coupled with the typically long lead times in water resource planning, suggest that it is not too early to begin considering the potential effects of climate change when developing long-run resource management strategies and plans for infrastructure investment.

APPROACH:
In August 2007, a two-day workshop was held at the National Center for Atmospheric Research (NCAR). The workshop focused on articulating project goals and methodologies, documenting the status of the collaborative projects, and exploring opportunities for synergy in the research efforts of the participating utilities. Three dozen participants attended the workshop, and all participants actively engaged in the discussion of research methods, problems to be addressed, and collaborative roles of the participating utilities and the NCAR research team.

The project adopted a case-study approach to engage utility partners in a set of collaborative assessment efforts. The individual assessments differed in terms of the utility partners' immediate planning needs, the technical issues encountered, and the utility's interest in particular elements of the analysis. Utility partners focused their efforts on those elements of the full structured process that they found most relevant to their own information needs.

RESULTS/CONCLUSIONS:
A central project goal was to develop and demonstrate a structured assessment process to help the drinking water industry conduct scientifically sound and cost-effective

assessments of utility vulnerabilities and adaptation options in the context of climate variability and change. There are four key elements in the recommended structured assessment process:

1. A problem-definition phase focused on identifying goals, information needs, utility vulnerabilities, and possible adaptation options in the face of climate and hydrologic uncertainty
2. Developing and/or modifying system-specific Integrated Water Resource Management (IWRM) models and conducting sensitivity analysis to identify critical variables
3. Developing probabilistic climate-change scenarios that focus on exploring uncertainties identified as important in the sensitivity analysis in step 2
4. Implementing the structured process to examine alternative investment and adaptation strategies in light of the likely range of future climate-related changes in local hydrologic conditions

While the case studies applied some of the same approaches and used some of the same models, datasets, and assumptions, the nature and "flavor" of the results are quite different. A general lesson that can be drawn from this project is that to be most useful, a climate change assessment must be tailored to the specific circumstances and information needs of the utility involved.

Lessons From the Case Studies

Colorado Springs Utilities (CSU)

- It is important to understand and model the impact of competing water demands in a utility's source region on the availability of water to the utility. In particular, the priority rankings and other details of critical water rights in a basin will determine how changes in the timing and total quantity of stream flow will affect a utility's ability to divert water and its options for managing stored water.
- Given those interactions, it is also important to understand how climate change might affect the value of water to competing users—especially those with higher-priority water rights. Such information would be useful for negotiating mutually beneficial water exchanges or other agreements to modify diversion schedules or storage operations.
- Considerable modeling work will be needed to understand the response of a complex interlinked system of water diversions, reservoirs, and water uses to a change in temperature and precipitation patterns. This is especially true where mountain snow packs are now an important part of the hydrologic regime.
- Even seemingly modest changes in temperatures and precipitation can have substantial impacts on reservoir storage and water deliveries, especially if operating rules and objectives remain unchanged.
- Lower average annual stream flows may make it more difficult to recover from the impacts of individual dry years on reservoir storage. The degree of difficulty will depend on the characteristics of the watershed and reservoir as well as on the reservoir operating rules.

Palm Beach County

- Higher-level "whole system" decision support tools are more useful for long-range system planning than are the highly detailed process models that are typically employed to evaluate day-to-day utility operations. However, it is frequently the case that the "whole system" models have not yet been developed.
- Climate is only one of several sources of uncertainty for long-range water system planning. In addition to considering the effects of different climate futures, it is also important to consider societal, technological, economic, ecological, and political developments—summarized as a "STEEP" analysis.
- The most useful approach is to develop a small number of scenarios (or storylines) that bracket the "STEEP" uncertainties. These can then be coupled with a small number of climate change scenarios that similarly bracket the range of currently-available climate model results. The performance of the candidate planning alternatives can then be analyzed under this set of scenarios.
- Any planning option will have multiple effects and possible outcomes. The various outcomes of a project or management strategy can be estimated in terms of performance with respect to a set of criteria. Care must be taken in defining these outcome criteria to avoid confounding desired ends with means for achieving those ends.
- The case study applied Multi Criteria Decision Analysis to a capital improvement process. To evaluate the desirability of different mixes of outcomes, it is necessary to apply relative value weights to the estimated outcome criteria, and these will differ across individuals. Thus each individual may come up with a different ranking of the desirability of the planning options.
- By comparing these rankings, stakeholders can gain a better understanding of the implications of their different perspectives, the extent of common ground, and potentially fruitful avenues for negotiations. In addition, this information may suggest mutually acceptable design modifications or a need for further analysis.

Massachusetts Water Resources Authority (MWRA)

- A single, integrating model of both water supply and demand that could be driven by climate proved useful in evaluating an important measure used by MWRA-Safe Yield.
- MWRA has used the historic period of 1950 through 2000 in which to evaluate the Safe-Yield of their Quabbin and Wachusett reservoir systems, which includes the severe drought period of the 1960s, leading to an arguably conservative estimate of Safe-Yield of approximately 300 million gallons per day.
- Given the inherent uncertainty in future climate change scenarios, ascribing weights to future scenarios for computing an expected value of Safe-Yield based on individual model performance did produce a different estimate than if future scenarios are given equal weight.

Inland Empire Utility Agency (IEUA)

- The IEUA study made use of Robust Decision Making (RDM) to explore how the agency can reduce its exposure to adverse climate-change effects by taking advantage of the favorable economics of local resource development in the region. The study found that different climate scenarios can have very different implications for the performance of a management strategy.

- In particular, when the warmest and driest scenarios are coupled with possible reductions in the availability of imported water from Northern California, the reliability of IEUA's existing supply strategy would decline dramatically by the 2031–2040 period. Wetter scenarios and those with no reductions in imports suggest continued supply reliability, with a considerable buffer of surplus supply.
- Aggressive promotion of water-use efficiency in the near term and investments in recycled water via tertiary treated wastewater and stormwater capture for groundwater recharge would be robust and cost-effective strategies for reducing vulnerability to future climate change.
- If current IEUA regional leadership expects that future water managers and city planners will respond to decreasing reliability, some actions may be deferred. However, if the region were to implement only the 2005 Urban Water Management Plan (UWMP) now and wait before augmenting its plans, the region would remain vulnerable to scenarios calling for significant precipitation declines, reductions in basin percolation, and strong reductions in imports due to climate change.

APPLICATIONS/RECOMMENDATIONS:
This project represents an attempt to both articulate and implement a structured analytic approach to incorporate consideration of climate change into long-term water utility planning efforts. The participating utilities had different planning needs and therefore emphasized different aspects of the structured approach in their work as part of this project. Experience with these initial efforts illustrates the need to treat climate-change adaptation planning as an ongoing process in which scientific advancements will be routinely incorporated in a rolling process of evaluating vulnerabilities and considering options to address those vulnerabilities. This process fits well within the emerging paradigm of adaptive resource management, which tries to be structured, iterative, and responsive to evolving issues with the aim at reducing the uncertainty over time. Interestingly, with the exception of MWRA, none of the utilities had "climate enabled" water resource planning models by which their water system could be analyzed to investigate climate change implications to their system or management options. Developing such a model that was both relevant and responsive to the particular needs of the utility proved to be difficult. However, it was greatly aided through the use of the Water Evaluation and Planning (WEAP) water resource planning model.

WEAP is an object-based, user-friendly decision support system that includes all major elements of a water management system. In the cases of all the partnering utilities, WEAP was used as the decision support tool to help quantify climate change impact and adaptation options. WaterRF Project #2853 advanced WEAP to aid utility strategic planners to effectively evaluate options for managing and developing reliable, adequate, and sustainable water supplies for their customers for the next 50 to 100 years.

RESEARCH PARTNER:
National Center for Atmospheric Research