A Dynamic Decision Support System: Linking Water Resource Simulation and Decision Analysis [Project #4074]

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OBJECTIVES:
The primary research objective was to develop a Dynamic Decision Support System (D2S2) focused on best alternative analysis for water supply and capital improvement planning. The tool was intended to offer new concepts in decision analysis to utilities by linking diverse variables, including the following:

- Linking two powerful tools: multi-criteria decision analysis (MCDA) and the Water Evaluation and Planning (WEAP) model
- Using scenario-based planning methods to evaluate select alternatives under different combinations of future population and climate projections
- Testing in a series of stakeholder meetings designed to develop a shared understanding of the trade-offs in the complex decisions faced by the utility and water managers and to solicit input in model development, selection of decision criteria, and in the weighting of the relative importance of the criteria

BACKGROUND:
Water supply planning is fundamental to economic vitality, environmental sustainability, and regional growth management. Even along the lower east coast of Florida, where annual rainfall averages 60 inches per year, constraints on water supply are emerging as populations grow, demand structures change, environmental reservations are allocated, and sources are regulated. As water utilities are increasingly asked to identify and develop alternative sources of water, throughout South Florida and elsewhere, it has become evident that comprehensive and integrated planning assistance tools are missing from the tool boxes of water supply executives.

APPROACH:
This research began with a goal to develop an Integrated Resource Plan (IRP) for utilities and water managers. However, in discussion with the Palm Beach County Water Utilities Department (PBCWUD), the sponsoring utility, it became apparent that the natural, regulatory, and economic factors driving their water supply were all in flux. The South Florida Water Management District (SFWMD) had recently instituted a mandate for a shift to new or alternatives sources of water supply in order to protect groundwater resources, trying to better balance environmental, agricultural, and urban demands. Meanwhile, the U.S. Army Corps of Engineers (USACE) was changing the regulation schedule for Lake Okeechobee (the regional back-up water supply) due to concerns for the structural integrity of the Herbert Hoover Dike.

Shifts or changes in demand trends due to development of agricultural lands were in consideration and policies regarding disposal of re-use and wastewater were subject to change. In retrospect, these were just the beginning of a series of changes that no one could have foreseen or forecasted at the time.

Therefore, a static report would not be useful in this context. The IRP needed to capture not just the dynamics of these elements, but also their complex interactions that would lead to the adaptable and robust planning process. This called for a systems dynamics approach. The initial concept was to build an executive level planning model of the water budget elements that could simulate interactions between key hydrologic, ecosystem, and economic drivers. Further, the tool would be designed to fill a common gap between modelers and decision makers—offering methods to quickly summarize and rank results across multiple decision criteria.

RESULTS/CONCLUSIONS:

The results of the model runs indicated preferences and ranked alternatives for given sets of assumptions and future trends. It allowed the evaluation of the conditions under which various supply and demand side alternatives were effective and how sensitive capital decisions can be in response to changes in future conditions. The utility is left with a living tool that allows it to adaptively manage and assess investments in a dynamic framework. These methods are relevant and useful to utilities in both demand and supply side planning, in developing strategies that are resilient and robust in the face of future uncertainties, in "climate-hardening" plans and designs to adapt to changes in hydrologic conditions, and in creating a shared awareness and understanding of the risks and benefits of alternatives under various sets of possible future trends. The tools and methods developed here provide new approaches for utilities to explore questions related to decisions such as the following:

- Are the projects included in the utility Capital Improvement Plan (CIP) still justified as conditions change over time?Are the CIP and other projects needed under all sets of future demand trends?
- Can critical decision nodes be identified for re-assessment of trend directions?
- Is this analysis useful for optimizing the timing of initiating captial projects?
- What un-intended consequences might result from effective conservation, and can pricing balance them?
- What are the top ranked projects? What are the trade-offs?
- Which multiple criteria are important in decisions affecting natural resource assets?
- Are more reserves needed to buffer unplanned increases or decreases in population?
- Are pricing increases justified to cover uncertainty in population trends and demand?
- What strategy supports sustainable water supply management under conditions of future uncertainty? What strategy keeps decisions open without sacrificing time needed for build-out to meet needs? What strategy is most flexible and does not preclude the future use of resources?

The success of long-term water supply capital investment depends on maintaining the natural self-sustaining systems of the source and in incorporating these values into capital decision analysis. Similarly, external financial and demographic (social) variables significantly impact water supply demand projections, bonding, and reserves. Risks and uncertainty in these variables are also important considerations in long-term capital investment. Thus, consideration of environmental, economic, and social criteria are important in developing a defensible and sustainable capital improvement plan.

APPLICATIONS/RECOMMENDATIONS:
The methods used by PBCWUD can be used by water utilities as a "new tool in the toolbox" of water supply and capital improvement planning. The new tool supports the integration of

- systems dynamics modeling,
- interactive shared vision planning,
- scenario-based planning under future uncertainties,
- multi-criteria decision analysis (linking simulation and decision support), and
- triple bottom line accounting in sustainable planning.

In addition, the MCDA interface and result screens offer some the following options in stakeholder facilitation and consensus building, including:

- Stakeholder consensus on performance criteria and decision methods
- Calculating individual decision maker or stakeholder weighting preferences and a facilitating total group set of weights
- Comparison of differences between stakeholders allowing focused mediation only on points of divergence; and consensus building through collaborative modeling (i.e., bringing stakeholders to common understanding through what-if demonstrations and interactive system modeling)
- Quantitative ranking based on diverse social, environmental and financial criteria, leading to a defensible and traceable decision framework

Overall, this research demonstrates the benefits of a dynamic tool in capital improvement planning and offers water utilities new methods of exploring the complex impacts of trend assumptions on the timing and risks of capital investments and supply reliability assessment.

RESEARCH PARTNER:
Palm Beach County Water Utilities Department