



Water Managers' Strategies for Addressing Uncertainty in Their Use of GIS for Decision-Making

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Abstract

Water managers in the Phoenix area must cope with uncertainty on a continuous basis. The levels of uncertainty in terms of data, climatic variability, global climate change, political context, and social environment are distinctively complex for water providing organizations. Knowing how water managers address uncertainty is important in understanding how large-scale uncertainties with water supply are addressed at the institutional level. Water managers need access to the right tools to help them assess conditions and data where a better picture of reality may be obscured by inaccurate or incomplete data. Geographic Information Systems (GIS) is a tool that can be directed toward that end. In order for GIS to be used effectively in that respect, it is important to understand how it is currently used by water managers. This research is guided by three questions:

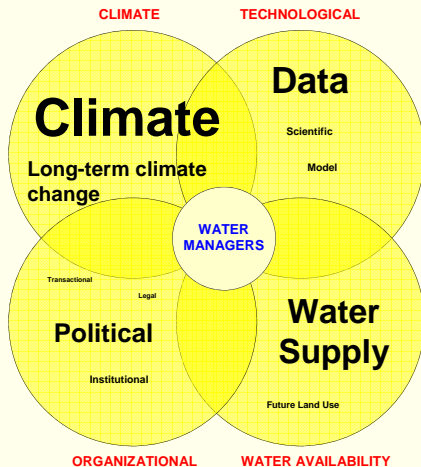
- How do water managers address uncertainty in decision-making?
- How is GIS used by water managers in decision-making?
- How do water managers deal with uncertainty in their use of GIS?

Qualitative analysis of twelve interviews conducted with Phoenix-area water managers in 2005 was used to discover themes within the water managers' discussions of uncertainty. Preliminary findings of this research are presented here.

Uncertainties in Water Management

Water managers revealed a number of uncertainties they face in managing water resources. The uncertainties are summarized in Figure 1. The size of the text in Figure 1 is relative to the number of references made to each type of uncertainty by water managers. The uncertainties described by water managers are grouped into four high level categories of uncertainty.

FIGURE 1. Uncertainties faced by water managers



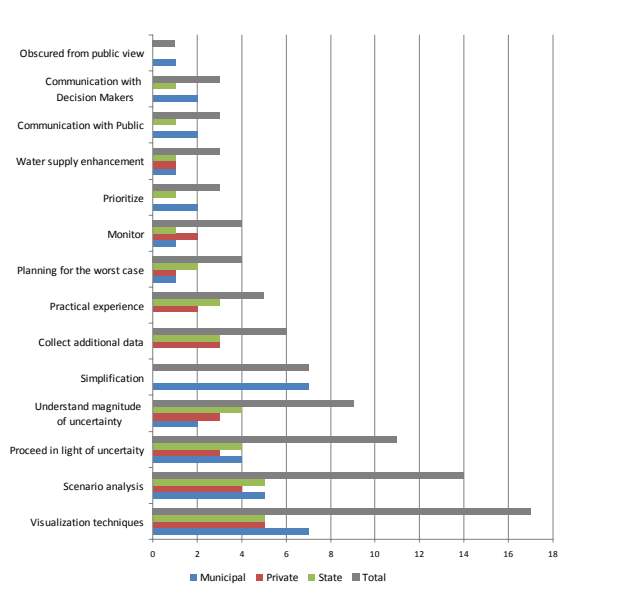
Acknowledgment

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Decision-Making and Uncertainty

Water managers cited a variety of methods for addressing uncertainty. These are summarized in Figure 2. Responses are charted by the number of references within the Interviews to each of the themes. The references are further divided into references by the organization type of the respondents to highlight any differences that may exist among water provider types. An initial analysis of the data shows that municipal and state water providers take a greater interest in communication of uncertainty, communication with decision-makers, as

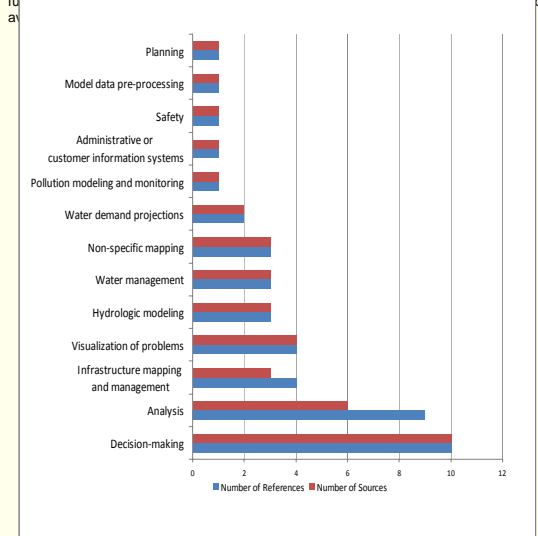
Figure 2. Water Managers' Methods of Coping with Uncertainty



GIS and Decision-Making

Water managers cited a variety of uses of GIS within their respective organizations. These uses are summarized in Figure 3 by the number of sources (individual interviews) and the total number of references within all interview referencing particular methods. Specific use of GIS as a decision-making tool was stratified into general and specific references. The majority of references to GIS as a tool for decision-making were not specific to any particular use.

Figure 3. GIS Uses Cited by Water Managers



GIS and Uncertainty

Visualization of uncertainty emerged as a prevalent theme among water managers, although the use of GIS toward that end appears to be less well developed or known among water managers. Of the respondents acknowledging that visualization techniques were used, two indicated that GIS was specifically used toward that end. One water manager listed visualization along with other tools: "Depends on the type of uncertainty we're dealing with. Spatial uncertainty we may deal with maps and spatially. If it's time scale, you may just simply use a chart. The different techniques for doing risk analysis that sometimes you'll deal with it. It varies pretty widely depending on what the issue is and what the nature of the uncertainty is."

The second interview subject responded along similar lines, noting that "We use a variety of tools. On well development, well projects, we use tools on infrastructure sizing. Another big one that we use in the city is GIS, we use extensively here. Not as a mapping tool, or just a mapping tool, but really an analysis tool." For these water managers, the GIS is one visualization tool in a larger toolset. These comments also highlights the existence of spatial uncertainty in the operational setting of this organization. Spatial uncertainty is mostly absent from water managers' discussions of uncertainties they face, but here is tacitly acknowledged by these water managers, particularly the first manager quoted.

Conclusions

The goal of this research is to understand how water managers cope with uncertainty in their line of business, how GIS is used within water management organizations, and finally to understand how GIS is used by water managers, particularly with respect to how they use GIS to address uncertainty. With regard to the first two research questions, results are relatively straightforward. Water managers address uncertainty using a variety of tools and techniques, most prominently visualization tools and techniques and scenario analysis. Within water management organizations GIS is used by water managers as a decision-making tool and analytical tool more than as a strictly map-production or data maintenance tool, although mapping is still a key role for GIS within these organizations. Less straightforward is the use by water managers of GIS as a tool for addressing uncertainty. The initial results from this research would tend to indicate that this particular use of GIS is not widely adopted by water managers.