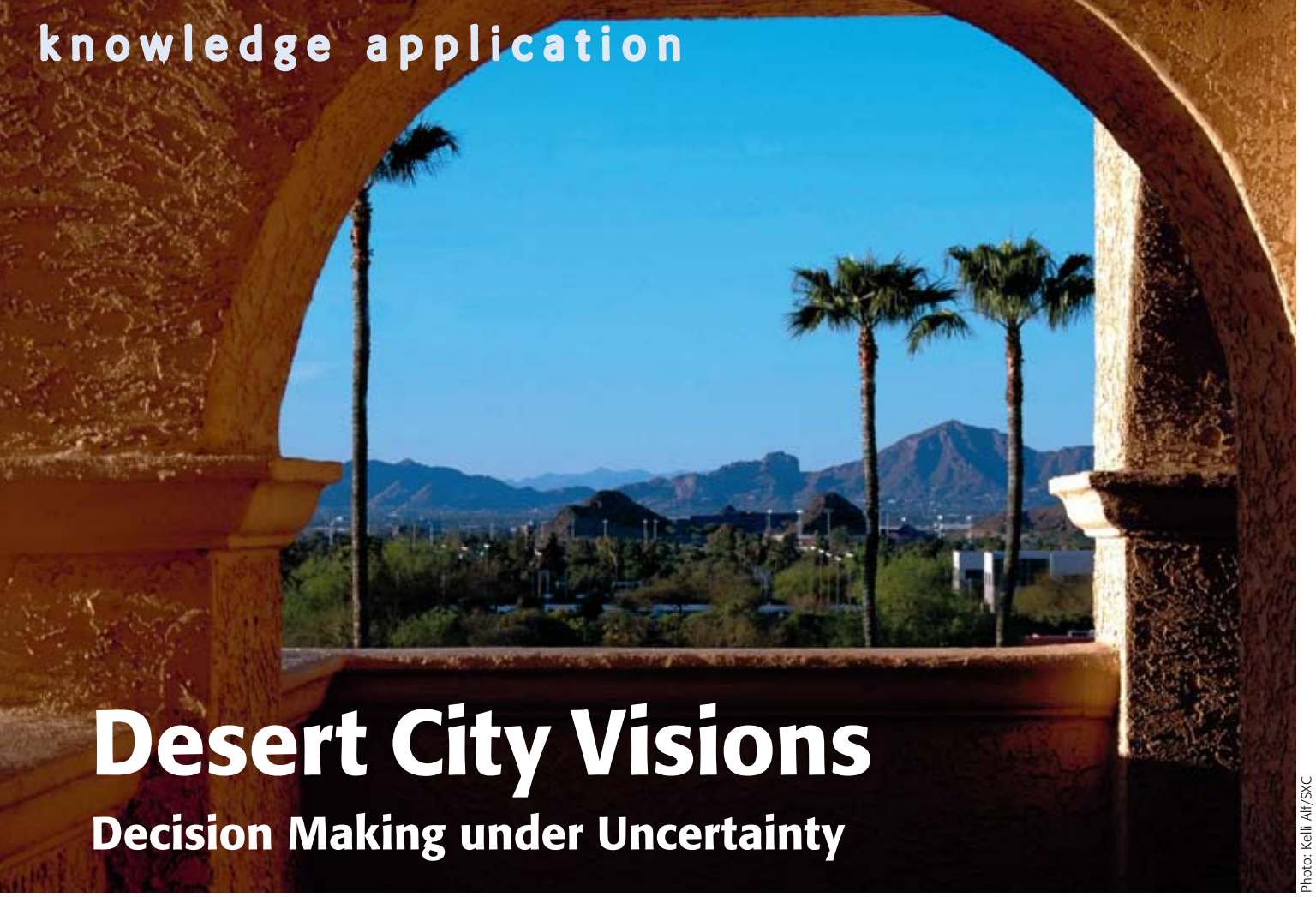

Desert City Visions

Decision Making under Uncertainty

Photo: Kelli Alf/SXC

Since 2000, the "desert city" of Phoenix Arizona has welcomed more than one million residents and now boasts a population of more than 4.3 million people. Water is the critical resource driving urban growth, economic development and ecosystem function.

Phoenix has historically had access to ample water. It is located at the base of the Salt River and Verde River watersheds and within a large hydraulic reach that includes the Colorado River Basin via the Central Arizona Project and rests upon vast sedimentary aquifers. Nevertheless, with a population projected to mushroom to over 8 million by 2040, and climate change expected to the make the region warmer and drier, the current system of water allocation and management faces daunting challenges.

Facing uncertainty with Watersim

Phoenix, like many other urban centres, must plan for rapid growth with finite water resources and future climate conditions that may profoundly differ from those of the past. Meanwhile, Phoenix water managers' expertise in managing seasonal and interannual variability of rainfall and runoff is based upon a deep understanding of, and faith in, the cycles historically governing water availability. Conventional wisdom is deeply set and proven, but it may not be sufficient to confront an uncertain climatological future.

WaterSim, a systems-dynamics model of water supply and demand in Phoenix under various scenarios, is a tool that enables users to explore how alternative climate conditions, rates of population growth and policy choices interact to affect future water conditions. It provides a means of moving urban water planning away from finding the optimal solution based on past data to considering the full range of possible futures.

"Conventional wisdom is deeply set and proven, but it may not be sufficient to confront an uncertain climatological future."

These "what-if" scenarios support the exploration of how key variables interact in a complex system, strategies to avoid unacceptable or regrettable outcomes, costs of delaying decisions, and trade-offs between these costs and the risks of making unnecessary expenditures. WaterSim links submodels representing surface and groundwater supply to those representing residential, commercial and agricultural demand, while also incorporating the rules that govern reservoirs, aquifer use and land-use changes. Users manipulate controls that alter future climate conditions, population growth rates, the speed of agriculture-to-urban land conversion, and policies, trying to achieve sustainable groundwater use and a more sustainable urban form.

Land use and density strongly influence sustainability in Phoenix. Currently, depending upon the provider, between 60 percent and two-thirds of residential water is used for outdoor purposes, such as landscape treatments and swimming pools. Denser urban development spreads climate-sensitive outdoor use over a larger population, reducing per capita water use. WaterSim's interface can simulate the effects of changes in, and tradeoffs between, public policies regarding pools, landscaping and the density of future development to demonstrate their potential impacts to decision makers.

Enormous uncertainties persist in estimating future runoff from the Salt and Verde systems, with predictions ranging from 19-123 percent of historical flows. Decision scientists argue that these uncertainties call for near-term, robust solutions. Water managers cannot afford to wait for uncertainties to be resolved, but must instead use tools to plan and implement new infrastructure and make necessary changes to adapt to worst-case future climate conditions. WaterSim can provide outcome or decision

spaces that facilitate discussion about the range of possible futures. Assuming sustainable groundwater and continued population growth, for example, the most dire climate model predictions would require reductions in residential water use in Phoenix to below 450 litres per capita daily (GPCD) – about half the current usage rate. These levels are altogether feasible with a shift in outlook and lifestyle. Phoenix's residents need to shift from today's "oasis culture" to one more befitting a true desert city. Local policies are critical – single-family residential use in 2005 was estimated to be 416 litres in Albuquerque, 432 in Tucson and 659 in Las Vegas (Hutchins-Cabibi et al. 2006).

"Phoenix's residents need to shift from today's oasis culture to one more befitting a true desert city."

Water-management decisions in Phoenix are not, however, made at the regional level by a centralised water authority. They are decided by some 50 municipal and private water providers – each with its own water portfolio, population trajectory, land use goals, conservation plans and water pricing schemes. Downscaling WaterSim to this provider level reveals that some parts of the city are highly vulnerable to the risk of future shortage. Situated on the urban fringe, these communities are both heavily reliant on groundwater and are liable to experience massive growth as the urban frontier marches outward.

Embracing the desert

Twenty-first century water management requires new tools and new ways of thinking about decision-making under uncertainty. WaterSim facilitates a water planning process that considers multiple possible futures and decisions that avoid socially and politically unacceptable outcomes. Preliminary results reveal, in fact, that the urban region of Phoenix could sustain growth under even the most pessimistic future climate conditions were it to evolve into a denser form and embrace the landscapes and lifestyles of a true desert city. The risk of water shortage is unevenly spread across the urban region, and without fundamental institutional change, urban-fringe communities will be first to experience water shortages. They will be the canaries in the coalmine. To avoid these crises, we must foresee the consequences of near-term decisions, or the lack thereof, for future water sustainability. WaterSim is one tool that can help.

By Patricia Gober, Decision Center for a Desert City, Arizona State University

Photo: Decision Center for a Desert City

The Policy Tradeoffs screen function of WaterSim allows the user to manipulate policy and water use to achieve the goal of sustainable water use.

Further Reading

Gober, P., C. Kirkwood, R. Balling, A. Ellis and S. Deitrick. In review. Analyzing and visualizing the uncertain impacts of climate change for water system risk management: The case of Central Arizona. Annals of the Association of American Geographers.

Hutchins-Cabibi, T., B. Miller, and A. Schwartz. 2006. Water in the urban Southwest: An updated analysis of water use in Albuquerque, Las Vegas Valley and Tucson. Boulder, CO: Western Resource Advocates.

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