Using Advanced Scenario Analysis as an Anticipatory Tool: Exploring the Uncertainty of Urban Water Demand and Supply within Central Arizona

Ray Quay, David Sampson, Dave White, Craig Kirkwood, and Pat Gober

Anticipatory Governance

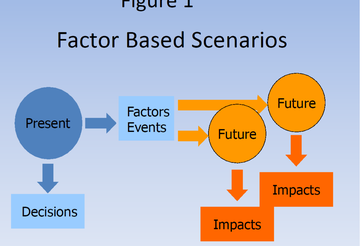
Anticipatory Governance is emerging as an alternative approach for planning under conditions of high uncertainty such as climate change (Quay 2010) and regional planning (Holway et al, 2012). Key to this approach is the use of foresight to anticipate a wide range of possible futures. Scenario planning is one method that is used to anticipate a range of futures.

Traditional Scenario Planning

With traditional scenario planning, key factors that are critical to an issue are analyzed as to their possible future state or trends. Using this analysis, several future scenarios are constructed. For each scenario the implications of this future on the issue are assessed. These assessments are then compared and contrasted to identify key heuristics that can be used to guide decisions about the issue at hand (Figure 1) . This works well for issues that can be limited to 1 or 2 factors or 4 or 5 scenarios. However as issues become more complex and the number of factors increases, human cognition limits our ability to adequately compare and contrast large sets of scenarios.

Figure 1

Factor Based Scenarios

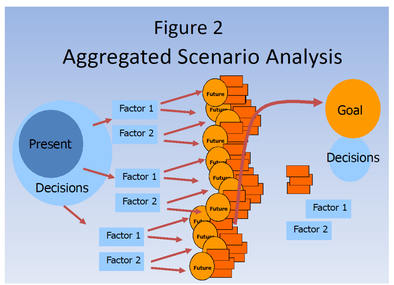


Advanced Scenario Analysis

Advanced Scenario Analysis follows the same structure of traditional scenario planning to identify key issue factors, create scenarios, and develop heuristics for decision making, but is not limited a small set of scenarios. Rather a large set of scenarios, and ensemble of scenarios, is created and quantitative and/or qualitative methods are used to analyze patterns within the scenario ensemble (Figure 2). Such methods include identification of critical decision space boundaries using factor sensitivity analysis, failure points (worst case) for essential services, robust decisions, and flexible incremental pathways.

Figure 2

Aggregated Scenario Analysis



Central Arizona Water Supply and Demand

The Decision Center for a Desert City (DCDC) is applying advanced scenario analysis to explore the complexity and uncertainty of water supply and demand within Central Arizona. Using WaterSim and its Scenario Ensemble Builder and Analyzer (SEBA), DCDC is analyzing a number of scenario ensembles to identify key heuristics that can be applied to regional and local water resource planning.

Complexity and Uncertainty

Water Resource Planning in Central Arizona is highly complex and subject to high uncertainty.

- Central Arizona has access to four major water supplies: surface waters of the Colorado River, surface water from the Salt Verde River systems (Figure 3), substantial aquifer water supplies, and reuses high levels of effluent.

Figure 3

Colorado River Basin And Salt Verde Basins

- The region has over 33 individual water utilities, each of whom have a unique portfolio of water supplies they manage to meet the demands of over 4.2 million people,
- The region also has a significant amount of agricultural water use.
- The rate and location of the region's growth is subject to uncertainty.
- The region has a highly complex water regulatory system administered by the Arizona Department of Water Resources (ADWR) that limits groundwater pumping and requires all water providers to have a 100 year assured water supply.
- The Southwest as a whole is subject to a highly uncertain high variable climate where extremely dry years can be flowed by extremely wet years (Figure 4),
- The future of climate change is highly uncertain with GCM estimates of future precipitation range from 120% to 50% of existing averages.

Figure 4

Colorado and Salt Verde River Flows

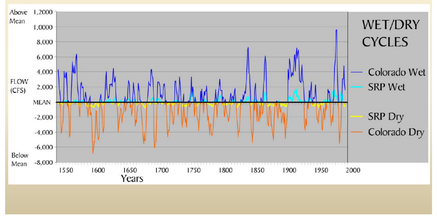
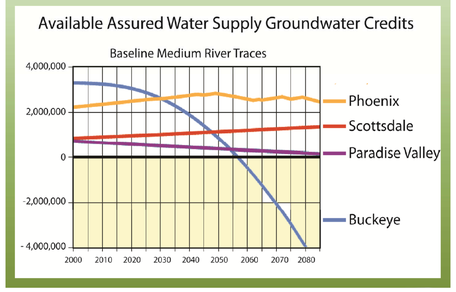


Figure 5



Advanced Scenario Analysis

Under some extreme scenarios of climate change it is likely that some water providers will not be able to maintain the water supply / demand standards needed to meet the requirements for their ADWR assured water supply designations without extreme additions to their water supply portfolios. Under one possible future policy scenario, if they are unable to make such changes, ADWR could choose to withdraw their ADWR assured water supply designation (AWSD). In this case the community would no longer be able to approve new subdivisions of land within their community, effectively stopping future growth. Given growth occurs within a regional market, new growth would likely shift to other providers who still have their assured water supply designation. Using WaterSim and SEBA DCDC explored this policy scenario under a range of future possible climate change conditions:

- Three river traces (high, medium, and low).
- Multiple Global Climate Model estimated impacts on river flows (Colorado: 6 levels from 60% to 120%, Salt Verde: 10 levels from 20% to 120%)
- With and without applying the Assured Water Supply Rule.

Creating a total of 360 scenarios.

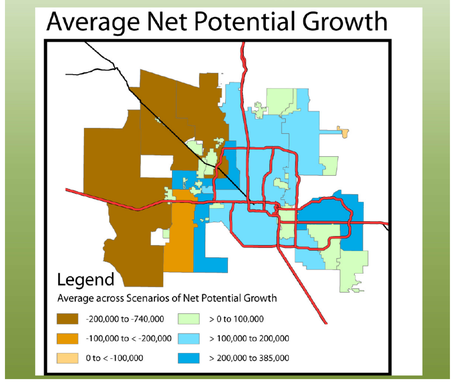
Results

An initial advanced scenario analysis of this 360 scenario ensemble revealed a number of key spatial and functional heuristics.

- Water Providers (WP) fit into five general profiles:
  1) WPs with primarily groundwater supplies not affected by the climate change scenarios.
  - Among these were two classes, WPs that would likely lose their AWSD, and WPs that likely would not (Figure 5).
  2) WPs with diverse water portfolio that can sustain supplies under the less extreme climate scenarios.
  3) WPs, who due to surface supply restrictions and limited groundwater reserves, lost their AWSD under some of the more extreme climate scenarios
  4) WPs who lost their AWSD due to increased growth from regional shifts (ie., they would have done fine otherwise) under the more extreme climate change scenarios
  5) WPs who did well under even the most extreme climate change conditions.

Figure 6

Enforcement of AZ Assured Water Supply for Groundwater



- Spatial patterns emerged in the degree to which communities were impacted by climate change and possible population shifts due to some communities losing their AWSD.
  1) WPs that had the largest average shifts in population from their community across all scenarios (they lost their AWSD) had a tendency to be more in the west valley while those gaining population were in the central and east part of the valley (Figure 6).
  2) Almost half the cities experienced scenarios with an average of less than 5 years where they were unable to maintain their AWSD designation.
  3) The average length of years of not maintaining an AWSD increases from east (0 yrs) to west (>20 yrs) across the valley. (Figure 7).
- Impacts on overall regional groundwater supplies, which have been very slowly declining, were also assessed. Figure 8 shows the impact of applying the Assured Water Supply rule under all 360 climate change scenarios. Applying the rule has little impact on regional groundwater levels for the first 35 years, and has less than a 5% improvement in the later years. This improvement is less pronounced under the most extreme climate change scenarios.

Figure 7

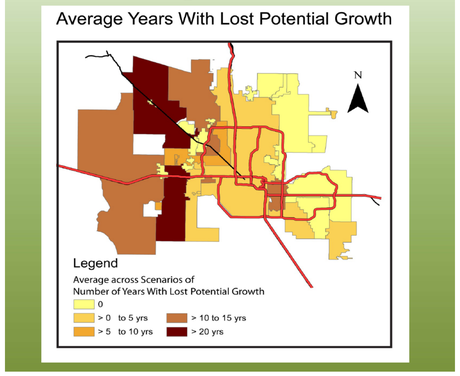
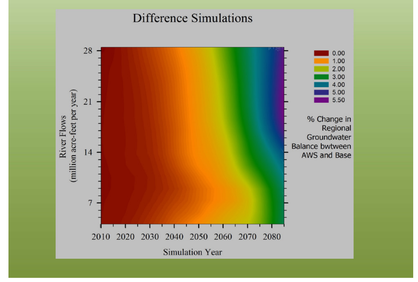


Figure 8

Potential Impact of Policy



It should be noted that there were a number of responses most communities could have implemented to address in balances between supply and demand that were not reflected in this scenario ensemble.

Future Research

DCDC will continue to explore similar policy issues such as:

- Shifting agricultural water rights to urban water providers,
- Increasing the use of water banking
- Use of reclaimed water for potable water supplies,
- Limiting groundwater recharge to areas of influence, and
- Enhanced water conservation.

References

Holway, Jim, Gabbe, C.J., Hebbert, Frank, Lally, Jason, Matthews, Robert, & Quay, Ray. (2012). Opening Access to Scenario Planning Tools Policy Focus Report (pp. 60). Cambridge, MA: Lincoln Institute of Land Policy and Sonoran Institute.

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Acknowledgments

This material is based upon work supported by the National Science Foundation under Grant No. SES-0951366 Decision Center for a Desert City II: Urban Climate Adaptation (DCDC). Any opinions, findings and conclusions or recommendation expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation (NSF).

Decision Center for a Desert City, Global Institute of Sustainability, Arizona State University, PO Box 878209, Tempe, AZ 85287-8209 For more information email ray.quay@asu.edu