Drought Planning and Urban Water Affordability & Access

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Background

While access to drinking water is a common problem throughout developing countries, few people realize it affects many communities in the United States as well. In California alone, 1 million people lack access to clean, reliable, affordable water.[1] Affordability is a challenge in many US cities, where one third of water systems in low-income areas have unaffordable rates,[2] and water costs are rising faster than inflation.[3,4] Lack of affordability and access disproportionately impact people of color and other disadvantaged groups.[5]

Droughts further threaten both water access and affordability for vulnerable communities by stressing water supply availability and utility finances. When utilities invest in additional water supplies to mitigate droughts, they pass costs on to rate-payers through drought surcharges or rate increases.[8,9] Counterintuitively, demand-side curtailment can also lead to rate increases during droughts: less water sold brings less revenue. Additionally, curtailment requirements disproportionately impact low-volume, and often low-income, residential users, as even small cutbacks may lead to insufficient water for basic domestic uses.[10] Given the diverse portfolio of water supply and demand management activities that utilities use to mitigate droughts, a comprehensive assessment of the impact of drought response on household water affordability and access is needed for the human right to water in vulnerable communities.

Our Team

Our team at Stanford is composed of engineers, scientists, and policy analysts **designing comprehensive and adaptive management approaches that enable greater resilience under uncertain climate conditions with less infrastructure and lower cost.**

We have expertise in developing computational models of water resource systems and their management. We use these models to explore how water systems can balance system-level goals like drought resilience and system reliability while minimizing cost in the face of an uncertain future climate. Our previous work has developed new, adaptive water supply augmentation strategies that enable drought resilience across a range of uncertain futures at lower cost.[11,12] For example, a study of drought planning in Melbourne, Australia demonstrated that a modular approach to desalination development can save 30% in costs where new infrastructure is built in smaller increments over time as more information about future supply and demand becomes available.[13]

Research Objectives

Our research aims to understand how droughts and drought response measures impact household water affordability and accessibility. We are working to integrate metrics of household water affordability and access into computational decision-support models for water supply planning (Figure 1). Our goal is to build a new generation of water resource system models that disaggregate utility-level cost and reliability assessment to understand household-scale water affordability and access. This research

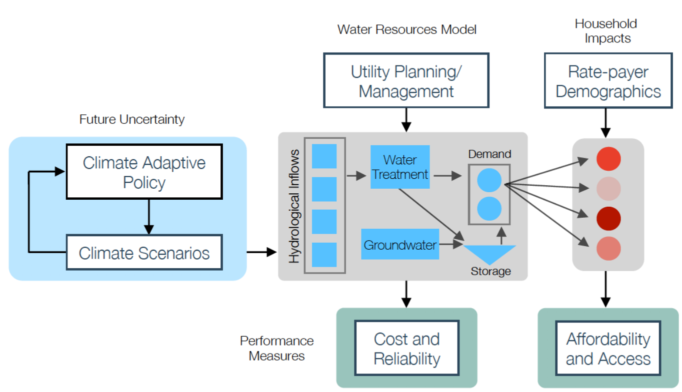

Figure 1: Computational Simulation Modeling Framework

moves beyond empirical studies of water equity to assess how management decisions will impact the human right to water under future scenarios. Our current research in this area has three main objectives:

(1) *A retrospective analysis of 2012-2016 drought in California*

Presently, we are assessing historical droughts in the state with contrasting drought impacts and responses. First, we assess how past droughts and drought management decisions made in each city impacted both utility-level cost and reliability, as well as household-level affordability and access. Then, we simulate how household level impacts would have changed with alternative approaches including: (1) demand management, (2) new water supply infrastructure development, and (3) short-term alternative water sourcing. Our early findings have demonstrated the substantial impact alternative drought management approaches can have on household water affordability. For example, our initial experiments have tested curtailment programs which begin earlier with smaller cutbacks and have found that they mitigate affordability increases particularly for low-volume users (Figure 2). We also hypothesize that permanent infrastructure solutions perform better for longer, milder droughts compared to shorter, more severe droughts. We are currently working to quantify how specific attributes of urban water systems — sociodemographics, hydrology, built infrastructure, and rate design — contribute to water affordability, accessibility and drought resilience.

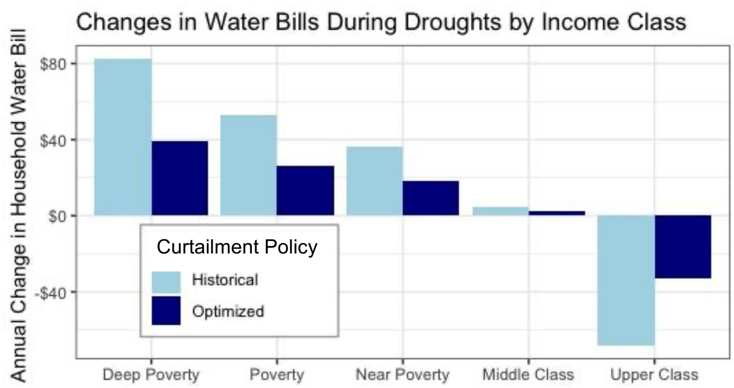

Figure 2: Impact of droughts and alternative drought management approaches on affordability for different income groups

(2) *Developing a decision-support framework through a detailed urban case study*

In parallel, we aim to develop a more granular decision-support modeling framework in partnership with water providers. Through these partnerships, we aim to evaluate the affordability and accessibility implications of alternative future water supply and demand plans they are considering and develop targeted, context-specific solutions to both improve drought resilience as well as ensure that drought solutions address the affordability and access needs of their populations. We can quantify the capacity of current demographics and rate-structures to meet revenue needs without exceeding affordability targets. In water-stressed areas which may not have the financial or institutional capacity to meet future water demands, we can propose how state and federal grants or assistance programs could be designed to maximize system reliability while maintaining affordable water rates. Leveraging our team's specialized expertise in planning under uncertainty, we can identify drought indicators for when to implement curtailment policies that maintain affordability and access goals across a range of different drought conditions. Additionally, via partnership we hope to overcome data limitations necessary to empirically assess household-level metrics instead of modeled estimates.

References

1. Petek, G. *Expanding Access to Safe and Affordable Drinking Water in California: A Status Update*. https://lao.ca.gov/reports/2020/4294/drinking-water-access-111020.pdf (2020).
2. OEHHA. *The Human Right to Water in California*. https://oehha.ca.gov/water/report/human-right-water-california (2021).
3. Hanak, E. *et al.* Water and the Future of the San Joaquin Valley: Overview. 16.
4. Wescoat, J. L., Headington, L. & Theobald, R. Water and poverty in the United States. *Geoforum* **38**, 801–814 (2007).
5. Meehan, K., Jurjevich, J. R., Chun, N. M. J. & Sherrill, J. Geographies of insecure water access and the housing–water nexus in US cities. *Proc. Natl. Acad. Sci. U. S. A.* **117**, 28700–28707 (2020).
6. Goddard, J. J., Ray, I. & Balazs, C. Water affordability and human right to water implications in California. *PLoS One* **16**, e0245237 (2021).
7. Teodoro, M. P. Measuring Household Affordability for Water and Sewer Utilities. *Journal AWWA* **110**, 13–24 (2018).

8. Feinstein, L., Phurisamban, R., Ford, A., Tyler, C. & Crawford, A. Drought and Equity in California. 80.
9. Pierce, G., Chow, N., Gmoser-Daskalakis, K., Roquemore, P. & Heil, N. Analyzing Southernn California Supply Investments from a Human Right to Water Perspective. (2019).
10. Enqvist, J. P. & Ziervogel, G. Water governance and justice in Cape Town: An overview. *WIREs Water* **6**, e1354 (2019).
11. Fletcher, S., Strzepek, K., Alsaati, A. & Weck, O. de. Learning and flexibility for water supply infrastructure planning under groundwater resource uncertainty. *Environ. Res. Lett.* **14**, 114022 (2019).
12. Fletcher, S., Lickley, M. & Strzepek, K. Learning about climate change uncertainty enables flexible water infrastructure planning. *Nat. Commun.* **10**, 1782 (2019).
13. Fletcher, S. M. *et al.* Water Supply Infrastructure Planning: Decision-Making Framework to Classify Multiple Uncertainties and Evaluate Flexible Design. *Journal of Water Resources Planning and Management* **143**, 04017061 (2017).