Stanford University
Woods Institute for the Environment
Solution Brief

Developing Strategies to Promote the Viability of Long-term Freshwater Supplies for People and Ecosystems

By Steven Gorelick

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The Challenge: Global freshwater supplies

While the demand for water is increasingly driven by global forces (e.g., urbanization, climate change, population growth and food trade), water supplies are often managed by decentralized local authorities who fail to meet the needs of people and the environment.

Here in the arid western United States, we are no strangers to drought. However, with effective institutions and good infrastructure, we have, for the most part, managed to limit economic losses during times of drought and preserve critical ecosystem functions.

Severe drought is plaguing many locations around the world like here in Australia.

But for much of the developing world the reality is very different. Rapid urbanization, combined with poor management and insufficient investments in infrastructure, have resulted in short-term crises with disproportionate impacts on poor, vulnerable populations, as well as long-term declines in freshwater availability that have threatened livelihoods and the sustainability of entire economies.

About the Author

Steven Gorelick's research spans both scientific and engineering aspects of groundwater resources. Investigations typically involve field sites and focus on topics ranging from the analysis of environmental remediation schemes to the study of paleoclimate and paleohydrology. The scales of physical processes studied range from small pores to vast regional subsurface flow systems. Among all of these different scales, Gorelick is developing conceptual and quantitative predictive models. Such models enhance our understanding of groundwater flow behavior and provide means for resource evaluation and management. Gorelick is the Cyrus Fisher Tolman Professor of Environmental Earth System Sciences in the School of Earth Sciences.

Foundation of Success: India and Mexico

At Stanford, we have established a foundation of "solution-oriented" water research as demonstrated by successful projects in two regions of India and Mexico that routinely experience multi-year droughts.

Chennai, India: Chennai (formerly Madras) is home to more than 7 million people. Although the region has experienced rapid urbanization in recent years, the water-supply infrastructure has not kept pace. A piped network supplies the inner city but not the suburban areas. In 2003-2004, the city suffered from a crippling water crisis. Reservoirs dried up, the piped supply system shut down and most private wells went dry, forcing city residents to rely primarily on expensive imported water brought in by tanker trunks operated by private vendors. One long-term solution proposed by the local utility is to build desalination plants. But desalination is a costly process, and in Chennai, water is unmetered and thus practically free to residents.

Our research team studied the Chennai water crisis and determined that there was a more cost-effective solution. In densely populated metropolitan Chennai, much of the water comes from consumers' private wells in addition to the piped network. We determined that improving efficiency of the existing piped network, along with harvesting rainwater to recharge the aquifer, could meet Chennai's growing water needs at a much lower cost than desalination.

The team recommended metering and raising the price of treated potable water to reduce the demand for piped water and provide public funds to fix the crumbling piped supply system. The researchers also recommended establishing a dual-quality system in which all water pumped into the piped network is treated at a central facility, while community wells continue to supply lower quality, untreated water for non-potable purposes. The aquifer would be recharged through rooftop rainwater harvesting to ensure that wells would not go dry.

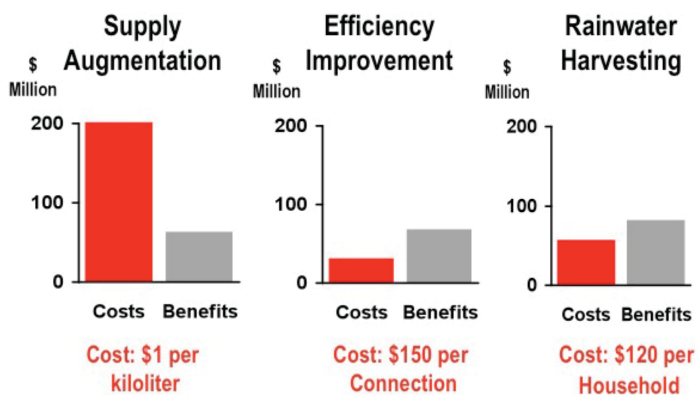
The average Chennai resident uses 26 gallons of water per day, or less than 1/4 of that in the U.S.

Rainwater is harvested to recharge groundwater supplies.

Steven Gorelick (center), researcher Veena Srinivasan (third from right) and staff from a well drilling business.

These recommendations draw on a key theme in urban water management: namely, that high-quality treated water is only necessary for drinking, cooking and hand washing. In fact, most water used domestically goes to toilet flushing, bathing and laundry, for which lower-quality water could be used.

Economic comparison of different policy scenarios.



Yaqui Valley, Mexico: Situated on the west coast of mainland Mexico on the Gulf of California, the Yaqui Valley comprises 850 square miles of irrigated wheat-based agriculture. It is the birthplace of the Green Revolution for wheat and one of Mexico's most productive breadbaskets. Today, population growth, agricultural intensification, water diversions, groundwater pumping, land-use changes and aquaculture growth threaten agricultural yields and household incomes.

In 2004, an eight-year period of low rainfall caused all three surface-water reservoirs to dry up. Wheat production dropped to zero in a region that produces 40 percent of Mexico's wheat. Our research team studied the impacts of the crippling drought by developing a simulation model of the irrigated agricultural system. Our results showed that the impact of the historic eight-year drought could have been significantly reduced without affecting farm profits by better management of surface water and groundwater supplies.

Lessons Learned from Mexico and India: We gained three valuable insights from our work in India and Mexico. First, water supplies in developing regions are on the vulnerable edge of sustainability, because people tend to forget past water crises. In other words, when droughts end, the incentive for dealing with future supply problems disappears. Second, central water managers have been ineffective in addressing water crises. Third, integrated predictive models enable policymakers to better manage future crises.

There are more than 420,000 wells in Chennai.

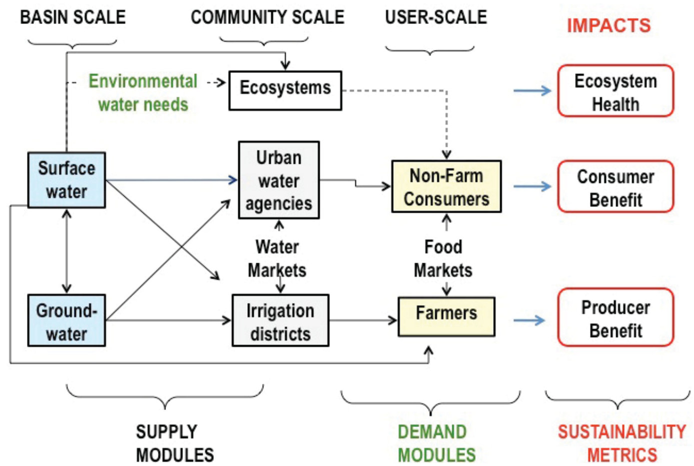
Woods Institute for the Environment

As a neutral third-party convener and trusted source of research and information, the Woods Institute for the Environment brings business, government and NGO leaders together with experts from Stanford and other academic institutions to create practical solutions on key environmental policy issues.

Solutions to Future Global Water Supply Needs

Different regions of the world will need locally relevant solutions focused on incentives, technology, conservation, markets and trade. To tackle this global challenge on a regional scale, the Woods Institute for the Environment is launching a **Global Freshwater Initiative** with the goal of developing implementable strategies to promote the long-term viability of freshwater supplies for people and ecosystems threatened by climate change, shifts in land use, increasing population and decaying infrastructure.

Overview of modular regional investigation model.



Taking advantage of the multidisciplinary expertise at Stanford, we have formed a "solution-oriented" team of global freshwater researchers led by hydrologist Steven Gorelick (School of Earth Sciences), economist Scott Rozelle (Program on Food Security and the Environment), attorney Buzz Thompson (Law School) and research associate Veena Srinivasan (Earth Sciences). Our focus is on developing effective policy responses for improved sustainability in targeted regions with critical water supply challenges.

Using our insights from Chennai and the Yaqui Valley as a foundation, we will turn our attention to other regional water challenges in India, China, Australia, sub-Saharan Africa and the western United States. In each regional investigation, Stanford scientists will collaborate with local scholars, water managers, public and private decision-makers, and nongovernmental

For more information on Gorelick's research:
http://pangea.stanford.edu/hydro

organizations to identify workable policies. These projects will incorporate information on natural resource drivers (climate, water availability and land cover), engineered resource drivers (infrastructure and technology) and human resource drivers (socioeconomics, institutions and regulations) to develop innovative models that provide insight into the policies required to address regional water supply issues, including water markets, taxes, water rights and quotas.

The interaction of forces controlling water vulnerability:

- Natural Resources: climate, water availability, land cover
- Engineered Resources: infrastructure (dams), technology
- Human Resources: population, economy, institutions (e.g. regulations, environmental needs, trade barriers, etc.)

For information on the Global Freshwater Initiative and additional freshwater research: http://woods.stanford.edu/freshwater

Local and regional water managers need innovative ways of assessing water management options to prevent water disasters like the drying of the Aral Sea.

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