

Foundations for California's Water Security in a Changing Climate**

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Summary

California's water supplies are facing unprecedented stresses, and the state's water-management systems are struggling to meet both environmental and human needs (agricultural, municipal, industrial). Supplies are highly vulnerable to climate variability and extreme events, limiting options to respond to the combined stresses of a changing climate, population, and land cover. Strategic, coordinated investments in California's water infrastructure, institutions, and information will provide the foundation for a secure, equitable, and efficient water future. The cornerstone of water security, and priority need for California, is a modern, robust water-information system that enables accurate, timely, and transparent accounting through the water-supply and use cycle. This system must extend from mountain headwaters through valley groundwater. Investments are also needed in capacity building for use of water information among institutions and stakeholders across the state. Priority infrastructure improvements are needed for central elements of the state's "green" infrastructure: restoration of Sierra Nevada and other forests in source-water areas, and additional groundwater recharge on farmland and expanded floodplains. With better-informed management, California's existing water supplies could go further to meeting the state's urban, agricultural, ecological, and industrial needs.

Current realities

California's water supplies are facing unprecedented stresses from the combined effects of drought, a warming climate, population growth, increasing resource demand, and changing land cover. Being highly exposed to climate variability and extreme events, options to respond to these combined stresses and reliably meet demands for urban and agricultural supply, hydropower, recreation, and ecosystems are complex and expensive. For example, much of the state's water system was thought to be capable of withstanding a seven-year dry period without severe damage to the economy and environment. However, in the multiyear dry period that began in 2012, some areas struggled to supply adequate water after only one or two dry years (Calif, 2016).

Many of California's water-system services and assets are managed or operated locally and regionally. Surface and groundwater are largely managed and regulated as separate resources, when they are, in fact, a highly interdependent system of watersheds and groundwater basins (Calif, 2014). This heterogeneous approach is an outgrowth of the state's history, with parallel but largely independent mining, agricultural, and urban development. Water rights and the state's hundreds of water-management entities constitute the institutional framework that aims to balance public interest with private claims. The current drought has illuminated weaknesses in both the institutions and data needed to efficiently and fairly allocate water. The state acknowledges unmet data needs to characterize groundwater conditions, operate water-supply infrastructure, achieve water-conservation goals, reduce energy use, and promote water transfers (Calif., 2016). With better management, California's existing water supplies could go further to meeting the state's diverse needs.

Water security can be defined as the reliable availability of an acceptable quantity and quality of water for ecosystem and human health, livelihoods, and production, coupled with an acceptable level of water-related risks, (e.g. flooding, pollution). Sustaining the state's water security in the face of unprecedented changes requires investments in three tightly linked areas: *infrastructure*, *institutions*, and *information* (Figure 1).

Scientific opportunities and challenges

California's water *infrastructure* extends from its headwaters in the Sierra Nevada and other source-water areas through dams, conveyance facilities, groundwater wells, and treatment plants. The first requirement for a sustainable water future is to plan, invest and maintain both this "green" and "grey" infrastructure (i.e., natural versus human engineered infrastructure respectively). Our source-water areas have unsustainable forest densities, as evidenced by increasing high-intensity wildfires that threaten downstream water uses (e.g., greater erosion, loss of snowpack). Adequate water-supply storage is also key to water-security infrastructure, with the state's major stores being surface reservoirs, groundwater, and snowpack. Climate warming is causing declining snowpack storage, and is projected to reduce usable storage behind dams for seasonal water.

The second requirement for ensuring water security is the integration of disparate or individual government efforts into a regional commitment in which the sum becomes greater than any single piece (Calif., 2016). *Institutions* can be broadly defined as the rules, norms, and conventions that influence decisions in society. This includes organizations and agencies, as well as legal, social, cultural, and other influences on decisions. Water-management institutions in California have not evolved to keep pace with yesterday's scientific and engineering developments, let alone the capacity to adapt to 21st century stressors.

The third foundational investment needed is better water *information* to guide decision making, design and maintain infrastructure, and improve water-supply reliability (CCST, 2014). Salient, credible, and legitimate information is increasingly a critical bottleneck for making sound decisions and managing risk. Development and application of innovative, quantitative water accounting and analysis will provide the foundation for better decisions under increasing uncertainties. Tools for high-resolution and real-time monitoring of major water stores and flows (e.g., precipitation, snowmelt, evapotranspiration, recharge, surface and subsurface flows, changes in groundwater storage) will provide accurate, timely feedback in support of adaptive management and infrastructure investments. The power of an informed public with ready access to water-resources information is central to water security.

Policy issues

Strategic, coordinated investments in California's water infrastructure, institutions, and information will provide the foundation for a secure, equitable and efficient water future:

1. a modern, accurate, timely and transparent water-resources information and accounting system that covers the extent from mountain headwaters through valley groundwater;
2. capacity building for use of water information among stakeholders across the state;
3. restoration of Sierra Nevada and other forests in source-water areas to sustainable conditions; and
4. additional groundwater recharge on farmland and expanded floodplains.

While some efforts in these areas are underway, more-aggressive and comprehensive approaches are warranted.

Water-information system. Existing technologies can be adapted to more-effectively manage our limited water resources. A modern water-resources information system can simultaneously enhance flood protection and improve water storage, allocation and delivery by:

- establishing a network of low-cost, strategically placed snow, snowmelt, rainfall and soil-moisture, and groundwater sensors throughout a basin;
- incorporating satellite and aircraft imaging that can better determine snow, soil-moisture, and vegetation status;
- integrating data to more accurately estimate evapotranspiration, across both headwaters and agricultural areas, and to predict runoff; and
- generating real-time data and information that will reduce key uncertainties, make water-supply forecasts more reliable, and inform water-resource decisions.

Three immediate policy changes and investments can advance this program across the state.

1. Make requirements for basin-scale water accounting much more explicit in the Emergency Regulations for Groundwater Sustainability Plans and Alternatives, under the state's Sustainable Groundwater Management Act.
2. Provide incentives for Integrated Regional Water Management programs to build core elements of a new water-information system through Proposition 1, the Water Quality, Supply, and Infrastructure Improvement Act, proposals and funds.
3. Develop and demonstrate a prototype cyberinfrastructure system for integrating and serving existing and emerging data in the American River basin as a core element of a new scalable water-information system, through a partnership between agencies, non-governmental organizations and researchers.

Capacity building. Two sustained programs are needed to build the support among institutions and stakeholders for the information and infrastructure investments along with the institutional changes needed by the state to provide a secure water future.

1. Strengthen requirements and provide incentives for water agencies to become primary sources of information within their communities for the priorities and investments needed to: (i) mitigate climate warming (e.g. Assembly Bill 32), and (ii) adapt to climate warming.
2. Expand the state's programs to adapt to climate warming, through: (i) greater technical support from the Department of Water Resources' climate program, and (ii) additional legislative action as outlined in the 2014 Little Hoover Commission report on the topic.

Forest restoration and management. State, federal, and private-sector partnerships can accelerate restoration of source-water areas and provide a foundation for a new era of sustainable management. Three immediate actions are needed.

1. Form a high-level working group to plan and advocate for sustainable watershed management in source-water areas, as a partnership between the California Resources Agency, water providers and university; and engage other stakeholders in the process.
2. Expand the vision and plan for sustainable forest management in the next update of the State Water Plan (due in 2017).
3. Sustain ongoing partnerships between land managers, water providers, and researchers to build the knowledge base for predicting and verifying the water implications of forest restoration, management, and disturbance, through multiyear commitments by the Bureau of Reclamation, U.S. Forest Service and California Resources Agency.

Groundwater recharge. Groundwater storage and conjunctive use are potential measures to provide both seasonal and multi-year storage. Two actions can advance these programs.

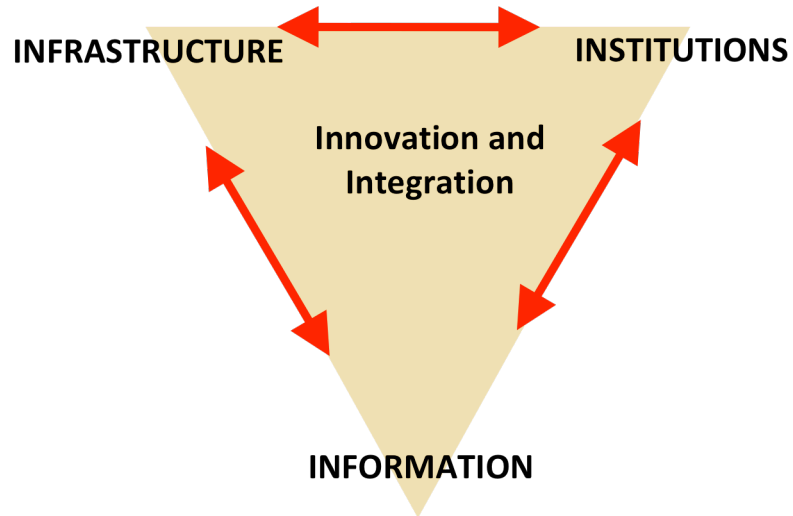
1. Administrative action can enable federal support through drought-response and grant programs within the Bureau of Reclamation, the Natural Resource Conservation Service, and other agencies.
2. The California Department of Water Resources can partner with water agencies and researchers to develop and sustain testbeds to build the knowledge base for expanded groundwater recharge, storage, and recovery.

References

- California Natural Resources Agency, Department of Food and Agriculture, and Environmental Protection Agency (2016). *California Water Action Plan, 2016 Update*.
- California Department of Water Resources (2014). *California Water Plan, Update 2013*, Bulletin 160-13.
- California Council on Science and Technology (2014) *Achieving a Sustainable California Water Future through Innovations in Science and Technology*.

*** A policy position paper prepared for presentation at the conference on Water and Fire: Impacts of Climate Change, convened by the Institute on Science for Global Policy (ISGP), April 10–11, 2016, at California State University, Sacramento*

Figure 1



Three key elements of water security are “green” and “grey” infrastructure, institutions that organize water decisions, and water information to guide decision-making. Integration of these can foster innovation, and lead to maintaining and improving water security.