Adapt, Flee, or Perish: Responses to Climate Change for California's Water Sector

S'adapter, fuir ou périr : réponses au changement climatique pour le secteur de l'eau en Californie

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RÉSUMÉ

Les gestionnaires de l'eau californiens se préparent à faire face à l'inévitable incertitude provoquée par le changement climatique et ses effets sur les ressources en eau de l'État. La science dit que même si les émissions de gaz à effet de serre cessaient demain, le climat changerait encore pendant des siècles. Pour réagir à ces impacts, il s'agit de s'adapter en trouvant les façons dont notre culture et nos infrastructures devront changer pour gérer les extrêmes dus au réchauffement climatique. En Californie, nous constatons ou prévoyons déjà des impacts tels qu'une baisse du manteau neigeux, des variations dans le calendrier saisonnier du ruissellement, des événements météorologiques plus extrêmes (des périodes de sécheresse plus profonde et des pointes de crue plus élevées) ainsi qu'une hausse du niveau de la mer. Pour un État aussi varié que la Californie, la meilleure façon de réagir face au changement climatique est d'appliquer des plans stratégiques variés à l'échelle locale et régionale, traitant de la conservation, du stockage de l'eau, du recyclage des eaux usées, du dessalement, de la gestion des plaines d'inondation et des eaux pluviales et de l'aménagement du territoire. Alors que les défis, complexités et incertitudes liés au changement climatique menacent l'avenir de l'eau en Californie, les bons choix et investissements permettraient aux réseaux de distribution d'eau de s'adapter aux changements.

ABSTRACT

California water managers are planning for the inevitable uncertainty that climate change brings to the state's water resources. The science tells us that even if greenhouse gas emissions were to cease tomorrow, the climate would continue to change for centuries. Responding to these impacts is called adaptation, which refers to the ways our culture and infrastructure will have to change in order to successfully manage the extremes that global warming brings. Impacts that we already see or expect in California include: a reduction in snowpack; shifts in the seasonal timing of runoff; and more extreme weather events (deeper droughts and higher flood peaks); and rising sea levels. For a state as diverse as California, adapting to climate change is best addressed by implementing diverse portfolios of strategies—such as conservation, water storage, wastewater recycling, desalination, floodplain and stormwater management, and smart land use planning—at the local and regional level. While the challenges, complexities, and uncertainties of climate change indeed loom large over California's water future, with the right choices and investments, the state's water systems can adapt to climate change.

KEYWORDS

Climate, adaptation, California, water

Like southern France, much of California enjoys a Mediterranean climate, a key part of the foundation for the state's economy, natural heritage, and way of life. Indeed, California's largest river, the Sacramento, shares much in common with the Rhone River, in terms of hydrology, ecology, competing (and often conflicting) uses, stakeholders, multidisciplinary scientific study, and mutli-objective management.

Spatially, water availability in California is highly variable, with most of the state's precipitation—whether rain or snow—falling in the northern part of the state, and in the east, along the Sierra Nevada Mountains. As in the Mediterranean, temporally the vast majority of precipitation arrives between December and April, and then for many months, there is little rain.

In contrast, California's water demand patterns are exactly the opposite of its precipitation patterns, in terms of both time and space. For example, most of California's water is needed by farms in the arid central and southern portions of the state, and by its large cities that are mostly along the Pacific Coast. Likewise, urban landscaping and agricultural needs peak during the long, dry months of summer and early fall.

In order to match supply and demand, federal, state, and local governments constructed large-scale infrastructure during the 20th century. These schemes generally transfer water, a very long way, from north to south, and east to west—and in the case of Southern California, in both directions. Groundwater is the state's other major water supply, though this source is often limited by contamination, overdraft, and institutions. Though the state is currently in the fourth year of a drought, too much water actually poses a far greater danger to Californians. Accordingly, governments at all levels have also constructed extensive infrastructure to defend against flooding. While State and federal water projects are vitally important to California, most of the state's water is managed at the local level, by literally thousands of water and wastewater utilities, irrigation districts, flood control agencies, reclamation and levee districts, and cities and counties.

Due to its snowpack-dominated hydrology, California's water sector is highly vulnerable to climate change, and also due to the increasing frequency, magnitude, and duration of extreme events (such as flooding and drought). In the last century, California experienced a 0.6 degree Celsius rise in average temperatures, about a 10% reduction in snowpack storage in the Sierra Nevada, changes in runoff timing, and an average sea level rise of 0.2 meters.

Specific consequences to the state resulting from climate change are that higher temperatures will melt the Sierra Nevada snowpack earlier, resulting in less natural storage for water supply. California's rivers are, in fact, already exhibiting changes in runoff timing, reflecting changes in the snowpack. For instance, spring runoff on the Sacramento River declined from constituting approximately 45% of annual runoff at the beginning of the 20th century, to about 33% at century's close. A reduction in snowpack storage in the Sierra Nevada also affects water quality, hydropower generation, and infrastructure integrity.

At the same time, California's rivers are also experiencing larger flood peaks. California's geography makes it susceptible to flooding, due to its mountainous topography, and proximity to the Pacific Ocean. For example, on the American River—a major tributary of the Sacramento River—the five largest flood peaks on record have struck since 1950. More intense rainfall events emerging from the Pacific will continue to strike the state, resulting in more frequent and/or more extensive flooding. Indeed, storms and snowmelt may coincide and produce higher winter runoff, while accelerating sea-level rise will produce higher storm surges during coastal storms.

A warming climate also warms the oceans, which causes water to expand, and melts land ice, which transfers water to the ocean, both resulting in sea level rise. Over the course of the 20th century, tide gages and satellite altimetry showed that global sea level has risen about 0.2 meters. A recent National Research Council report estimates sea level rise (relative to 2000 levels) along the California coast (south of Cape Mendocino) of 4 to 30 cm by 2030, 12 to 61 cm by 2050, and 42 to 167cm by 2100. Rising sea levels increase susceptibility to coastal flooding and threaten levee integrity and water quality in the Sacramento-San Joaquin Delta, an important inland delta at the confluence of the Sacramento and San Joaquin Rivers. Together, higher winter runoff and sea level rise will increase the risk of levee failures in the Delta, and will also place additional constraints on water exports from the Delta, upon which 25 million Californians depend for their drinking water, and 1.2 million hectares of farmland rely on for irrigation water.

By mid-century, it is projected that California will experience an increase in average temperatures between 0.6-2 degrees Celsius, a 25-40% reduction in Sierra Nevada snowpack storage, and sea level rise of 0.1-0.6 meters, along with less summer and fall runoff, and more intense wet and dry periods. Given four years of drought, Californians are obviously currently most concerned that droughts may become more frequent and persistent this century. Water quality of streams, lakes, and oceans will also change, affecting biodiversity and public health. A changing climate will also impact not just water supply but also water demand. For example, warmer temperatures are likely to extend growing seasons and also increase evapotranspiration, thereby increasing the amount of water that is needed for crops, lawns, and ecosystems.

California's current water resource infrastructure is already strained to meet competing objectives, for water supply, flood control, environmental protection, water quality, hydropower, and recreation. The current system of reservoirs, canals, floodplains, and levees must be modified and managed differently for greater flexibility to adapt to the greater uncertainty brought by climate change. Flood systems, in particular, must not only be improved to accommodate higher variability of flood flow magnitude and frequency, but to also take advantage of the many benefits flooding provides to ecosystems. In a changing climate, long-standing issues related to water supply, water quality, fisheries, and public safety in the Sacramento-San Joaquin Delta beg even further for resolution as well.

Because California encompasses multiple climate zones, each region of the state will experience a combination of impacts from climate change unique to that area, including watershed and forestry health, water supply reliability, flooding, sea level rise, and saltwater intrusion. Because economic and environmental effects depend critically upon location, adaptation strategies must be regionally suited; a "one-size-fits-all" approach simply will not work for a state as diverse as California. That said, scientific detail is not yet available for small-scale, localized precipitation and temperature changes—and especially for precipitation extremes. This means that projections for future water supply and flooding at the local and regional levels are far from definitive. Nonetheless, regions that depend heavily on water imports will need robust strategies to increase regional self-reliance and cope with greater uncertainty in their future supply.

Fortunately, water managers in California have multiple tools and institutional capabilities to limit vulnerability to changing conditions, which can serve as response strategies for a wide range of climate changes. Implementing a portfolio of diverse of strategies at the local and regional level is already a fundamental part of the California Water Plan Update 2013, the state's strategic plan for water resources In all, climate change underscores the importance of an integrated and regional approach for addressing future uncertainties about California's water resources.

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