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Climate Change and Water

PPIC WATER POLICY CENTER

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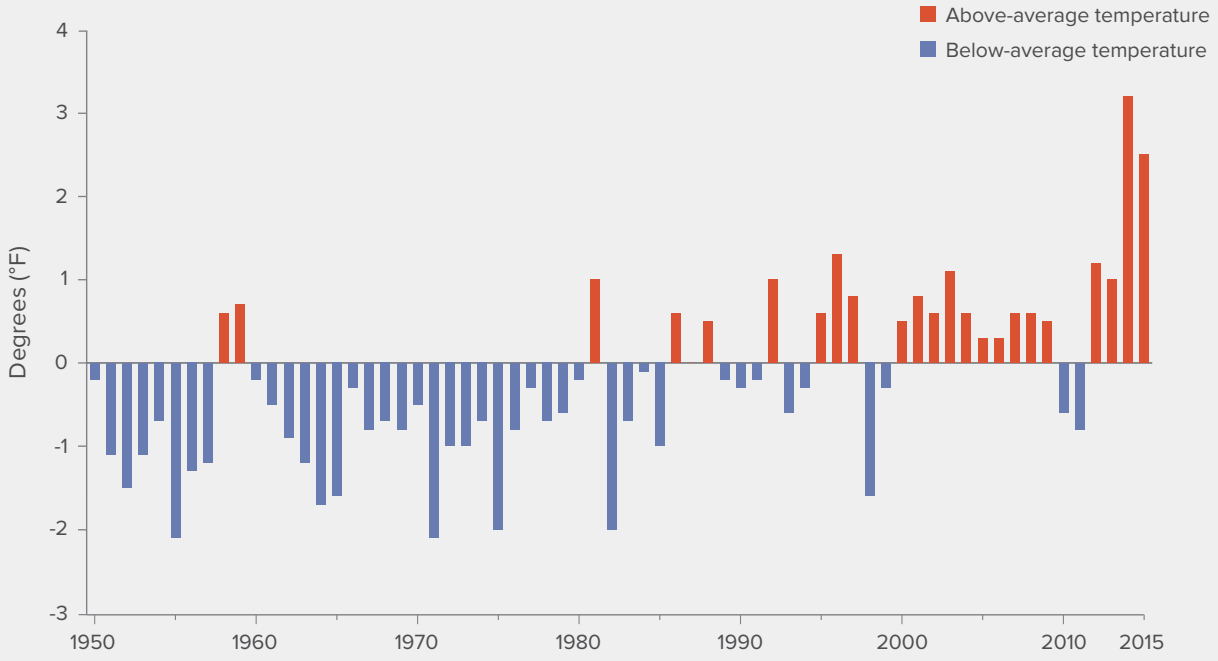
Climate change will affect California water management in many ways

California's climate is highly variable, with frequent droughts and floods. Climate models predict significant changes: warmer temperatures and more variable precipitation, with short, concentrated wet periods and more frequent and intense droughts.

Warming is already a reality for California. Since the early 1980s, average temperatures have been significantly higher than they were during the previous 50 years. The year 2014 was the warmest on record, and 2015 was the second warmest. Warming has complex and interrelated effects: it reduces the share of precipitation that falls as snow, causes earlier snowpack melting with higher winter runoff and winter floods, raises water temperatures, and amplifies the severity of droughts. Meanwhile, the sea level has been rising, which increases pressure on coastal flood defenses. Sea level rise and larger freshwater floods threaten fragile levees in the Sacramento–San Joaquin Delta, an important hub of the state's water supply.

California has been a national leader in addressing greenhouse gas emissions that contribute to climate change. However, the state is only in the early stages of developing water policies that help it adapt to a changing climate in areas such as supply, flooding, and ecosystem management. California's water management systems were designed for the conditions of the past century. Reconfiguring them to respond to climate change—against the background of growing population and rising demand for healthy ecosystems—is a major challenge. Meeting this challenge will require a concerted public- and private-sector effort that involves all levels of government.

CALIFORNIA IS GETTING WARMER



SOURCE: National Oceanic and Atmospheric Administration.

NOTE: The figure reports degrees above or below the average statewide temperature for 1981–2000 (58.3° F).

Water supply management must adapt to a warmer, more variable climate

California's mountain snowpack has historically provided critical seasonal storage for meeting summer irrigation needs. A smaller spring snowpack—along with possible increases in California's already high climate variability—will stress supply. Meanwhile, rising temperatures are likely to raise demand for irrigation water and to increase the volume of water natural landscapes use.

- **There are no easy substitutes for lost snowpack.**
  New surface storage can increase flexibility, but it is costly and unlikely to provide abundant new supplies. Given its high costs, seawater desalinization is also unlikely to yield large new supplies, though it could be a useful part of some urban water portfolios.
- **Adaptation will require changes in storage management.**
  To address snowpack loss and high climate variability, managers will need to improve coordination of water storage in surface reservoirs and groundwater basins. "Conjunctive use"—the movement of some water from reservoirs into groundwater basins for use during dry periods—will be especially valuable. Making conveyance across the Delta more reliable will allow more storage for drought in the southern half of the state.
- **Urban water managers can adapt in many ways.**
  Options include expanding connections between urban systems with different supply sources, trading water with other cities and farmers, and using more treated wastewater and captured stormwater. Urban areas can also reduce water demand through pricing and other incentives, such as rebates for adopting water-saving technology or replacing lawns with less-thirsty landscaping.
- **California's agricultural sector can also adapt ...**
  Farmers will continue shifting to higher revenue crops and will rely increasingly on water markets to meet irrigation demands. Some land will probably have to come out of production—particularly if average precipitation falls. Even with these changes, farm revenues can continue to rise.
- **... but adaptation will be more difficult without better groundwater management.**
  Farms—particularly in the Central Valley—will become increasingly reliant on groundwater to manage droughts. Excessive groundwater pumping today will make it harder to manage aquifers in the future. Rapid implementation of the 2014 Sustainable Groundwater Management Act (SGMA), the first statewide effort to manage groundwater, can reduce the impacts of climate change on farms.

Managing water to preserve ecosystems will become more difficult

Rising temperatures and changing runoff patterns are likely to stress many native riverine and wetland species whose populations are already depleted by habitat loss, water operations, and other factors.

- **Approaches based on entire ecosystems will be needed.**
  Past approaches to managing environmental water have focused on improving habitats for one species at a time, typically once a species gets listed under state or federal endangered species acts. These efforts will need to give way to more flexible approaches that focus on ecosystem health.
- **Competition for water will probably increase.**
  Difficult trade-offs are likely, for instance, when keeping cold water in reservoirs to protect downstream salmon habitat means less water for farms and cities. Reusing treated wastewater—a growing strategy for stretching supplies—can have the unintended consequence of reducing water available to the environment.
- **State and federal policies will need to address trade-offs.**
  State policy—along with federal and state environmental laws—may need to be modified to manage difficult trade-offs both *between* human and environmental water uses and *among* environmental uses. For example, in warm, dry years there are trade-offs between maintaining cold water in reservoirs for salmon late in summer and increasing outflows earlier in the year for native fish in the Delta.

SEA LEVEL RISE THREATENS BAY AREA COMMUNITIES

SOURCES: Map from San Francisco Bay Conservation and Development Commission; inundation data from N. Knowles, "Potential Inundation Due to Rising Sea Levels in the San Francisco Bay Region" (California Climate Change Center, 2009).

NOTE: The map illustrates potential inundation with 16 inches and 55 inches of sea level rise, toward the upper end of the range expected by 2050 and 2100, respectively.

Flood planning must anticipate population growth and changing hydrology

Rising sea level, bigger and more frequent floods, growing population, and more building in vulnerable areas will increase the economic and social risks of flooding.

- **Major new investments will be needed.**
To manage future urban and coastal flooding, state and local agencies will need to invest a minimum of $34 billion to improve dams, levees, coastal defenses, and urban stormwater systems. These infrastructure investments should be part of an integrated approach that also improves water supply and ecosystem health.

- **Regional flood management tools must be updated.**
Regional flood management will require coordinated, forecast-based reservoir operations. These can be carried out as part of conjunctive use strategies that make more room for floods in reservoirs by moving water into groundwater storage. Modest investments to improve forecasting—and better use of existing forecasting tools—will significantly cut the costs of managing supply and responding to floods.

- **Nonstructural approaches will become more valuable.**
California must do more than improve its flood protection infrastructure. To reduce risk, managers should also emphasize land use planning, flood insurance, flood-proofing of buildings, and emergency preparation. The state should require local hazard mitigation plans to include these nonstructural approaches and to anticipate future conditions.

Climate change will affect the water-energy relationship

In-state hydropower is a clean energy source that provides 15 percent of California's electricity on average. Snowpack changes will reduce the output of some hydropower reservoirs. Warming will also boost energy demand.

- **The effects of warming on energy production will vary.**
The state's large, multipurpose reservoirs have enough storage in most years to adapt to changes in the timing of snowmelt runoff. The outlook is different for California's high-altitude hydropower reservoirs, which are among the most important sources of peaking power during hot summers. As temperatures rise, power availability from these reservoirs will shift to late winter and spring. If the climate becomes drier, total hydropower production will fall. In 2014 and 2015—critically dry years—production fell by half, requiring a significant increase in the use of fossil fuels to make up the difference.

- **Some water management changes could increase energy demand.**
Climate change is likely to make surface water scarcer, particularly in agricultural areas. Farmers may respond by using more groundwater and switching to more efficient, pressurized irrigation systems. Both of these responses will increase farm energy use. Meanwhile, in urban areas, increasing temperatures will likely boost demand for cooling. Increased efficiency in urban water use and development of local sources can potentially offset these trends, reducing overall energy demand while helping communities adapt.

Looking ahead

California needs to adopt water supply, flood control, and ecosystem management strategies that will prepare the state for a changing climate and rising sea level.

Integrate climate change into water supply management. Strategies should increase flexibility by promoting conjunctive use; more flexible, forecast-based reservoir operations; water trading; and improved conveyance. Conveyance investments are most critical to maintain water supplies now drawn through the Delta, which could be disrupted by sea level rise, seasonal flooding, and earthquakes. Conservation will continue to be important, especially in urban areas.

Upgrade information systems. Federal, state, and local agencies should upgrade information technology for water and ecosystem management. One priority is enhancing decision makers' ability to use existing information, such as weather forecasts. In addition, strategic investments are needed in modeling of weather and water supply and demand.

Incorporate climate projections in flood planning. To reduce flooding's economic and social risks, state and local agencies need to incorporate climate change projections into land use planning decisions, flood insurance programs, and the design and construction of new flood infrastructure. Legislation may be required to encourage adoption of important risk reduction strategies such as insurance.

Adopt a riverine and wetland biodiversity strategy. Such a strategy is needed to manage aquatic and wetland biodiversity changes as the climate warms and becomes more variable. This strategy should inform water supply and flood management decisions.

Consider energy implications. Given the links between water and energy use, it is important to consider how California's water strategies affect energy demand, costs, and greenhouse gas emissions.

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