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Technical Briefing Paper (7):

Water Resources Planning: Climate Change and Water Supply Reliability

Synopsis Climate change is expected to impact water supply reliability by: increasing the length and/or severity of droughts; enhancing evaporative losses from surface reservoirs; reducing aquifer recharge and declining groundwater levels; reducing water storage in snowpacks and glaciers and resulting changes in seasonal runoff timing – with earlier peak runoff and lower flows in late summer.

Overview

— For the Northern Hemisphere, climate models project a broad pattern of drying in the subtropics, including the Mediterranean Basin and the U.S. Southwest. The models project wetter conditions north of about 50^{o} latitude, but for other temperate areas, projected changes in total precipitation and runoff in remain inconsistent across models.

— Higher temperatures will increase potential evaporation, which may diminish water availability.

— Changes in water supply reliability will broadly mirror the changes in regional precipitation and runoff, although changes in seasonal runoff patterns and the intensity and frequency of precipitation events will also affect supply reliability.

— Longer dry spells and heavier precipitation events appear likely in most temperate areas including all of Europe, and the contiguous states of the U.S. The supply reliability effects of such changes will depend upon the capacity of surface and groundwater systems to capture and store water from the heavier precipitation events for subsequent supply augmentation.

— The impacts of warmer temperatures on seasonal flow timing will be especially significant in areas that currently depend on melting mountain snowpacks for summer water supplies, such as Western North and South America. Impacts on supply security will likely be greatest for water users depending on direct streamflows in small watersheds, who also have limited access to storage capacity, or alternative sources of supply.

Explanation Some hydrologic changes affecting supply reliability are already occurring. For example, warming temperatures have caused earlier snowmelt and peak streamflow in most mountainous areas of the Western United States, where the spring runoff peak was about one to four weeks earlier in 2002 than it had been in 1948. Warmer temperatures have also led to widespread reductions in the volume of water stored in glaciers. The IPCC Technical Paper on Water notes that in recent decades "… *considerable mass loss occurred on the majority of glaciers and ice caps worldwide.*" (Bates et al., 2008:19).

In addition, the global extent of serious droughts (measured as the percentage of land area with a Palmer Drought Severity index below -3.0) has more than doubled since the 1970s. In Europe and the Continental U.S., greater precipitation variability is evidenced by an increasing trend in the proportion of total precipitation concentrated in heavy rainfall events.

Other changes in precipitation and runoff patterns are projected to occur more slowly, with changes becoming evident in many areas by mid-century and more pronounced changes occurring by the end of this century. Actual patterns of hydrologic change will reflect both natural variability and the effects of global warming, with warming playing an increasingly significant role at longer time horizons. Paleoclimatic reconstructions from tree-rings, lake sediments, pollen analysis or other biophysical evidence can provide useful indications of the natural frequency, severity and duration of droughts. Where such evidence is available, assessments of future water supply reliability should consider the paleoclimatic record in conjunction with a range of climate model projections for future climate. For example, a projected percentage decline in streamflow could be applied to a flow sequence based on the paleo-record to evaluate drought resilience.

Case Study Severe droughts can occur at any time, but their frequency and severity may increase in areas such as the U.S. Southwest, where the majority of climate model projections suggest a hotter and drier future climate. The recent extended drought in that region may, thus, provide a foretaste of conditions likely to become more prevalent in the future.

Beginning in 1999, the Colorado River Basin experienced five consecutive years of below-normal precipitation. Annual Colorado River flow during that period averaged approximately 50% below the long-term mean. Throughout those years, the U.S. Bureau of Reclamation operated the major storage reservoirs in the basin to meet interstate compact and international treaty water delivery obligations, but by 2004 those operations had caused precipitous drops in the levels of the major main-stem reservoirs. The elevation of Lake Powell fell by 130 feet, and the volume of water in storage fell to 38 percent of capacity, while storage in Lake Mead fell to 54 percent of capacity. Although Basin precipitation was above normal in 2005, serious drought conditions returned in 2006 and 2007, and 2000-2007 proved to be the driest eight years in the 100 year period of record. When it became clear that continuing drought conditions could imperil the security of water supplies for the 25 million people and 3.5 million acres of cropland that use Colorado River water, the U.S. Secretary of Interior initiated a multi-agency, multi-stakeholder effort to develop new procedures for managing the Basin's water resources during times of shortage. That process led to the recently-adopted shortage-sharing agreement and guidelines for the coordinated operation of Lakes Powell and Mead that will better balance risks of supply shortages against other objectives.

Supporting materials

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