
Credit: Courtesy Terranova Ranch Inc.

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# New Modeling Framework Guides Managed Aquifer Recharge Under Climate Change

*Combining a climate-informed hydrological model with new basin classifications leads to better quantification and management of water available for groundwater recharge.*

## Background

Current and future climate change effects are intensifying the hydrological cycle, leading to increased variability of both precipitation and runoff. This heightened pattern results in more frequent and severe droughts and floods, as well as more recurrent swings between these two extremes. Harvesting floodwaters using managed aquifer recharge to replenish depleted groundwater aquifers can simultaneously reduce flood and drought risks. However, the uncertainty around how much water will be available for recharge has made it difficult to determine where efforts to deploy this approach will have significant benefits – both at present and in an unpredictable future climate.

Managed aquifer recharge (MAR) provides an innovative way to achieve integrated water management by improving the connections of surface-built infrastructure (e.g., reservoirs or canals) and underground infrastructure (e.g., groundwater aquifers or wells) to

## POINTS FOR POLICY MAKERS

▶ **Managed aquifer recharge or Flood-MAR is a relatively underutilized management strategy compared with traditional surface water infrastructure such as reservoirs.** Growing evidence has demonstrated the large potential for underground water storage solutions such as Flood-MAR, particularly when facing climate change uncertainties. Flood-MAR augments groundwater supply while also providing multiple benefits, including flood risk reduction and ecosystem services enhancement. As additional burdens are placed on California's aging water infrastructure systems, incorporating strategies like Flood-MAR can be more cost-effective, sustainable and adaptative.

▶ **Integrated water management strategies can mitigate flood risk while also conserving floodwater from wet periods to utilize during future drought.** Strategies that mitigate each hazard in isolation tend to be less effective than integrated ones. In California, the geographic mismatch between north and south in terms of water availability, as well as the changing timing and magnitude of floodwaters, creates a challenge in moving flows from where they are available to where they are needed. Making the most of high-magnitude-flows for recharge could provide balance and bring a large portion of depleted groundwater aquifers into balance in areas such as the San Joaquin Valley.

▶ **Climate-informed hydrological modeling combined with basin-specific infrastructure assessments can inform management options.** This can also help prioritize the development or enhancement of diversion infrastructure despite significant uncertainties. It is critical to understand how water available for recharge is likely to vary depending on different policy and infrastructure assumptions and the extent to which these assumptions are subject to climate and other hydrologic uncertainties. In addition, socio-technological, financial and environmental feasibility may play equally or more important roles in investment decisions.

transfer floodwater across regions and store it locally. Compared to conventional surface storage options, using floodwater for MAR – known as Flood-MAR – can be more cost-effective, sustainable and adaptive while also offering benefits such as flood risk reduction and ecosystem services enhancement.

Despite increases in future projected water availability, differences between existing infrastructure capacity and policy uncertainties constrain how much water can be captured. To tap anticipated recharge potential through infrastructure expansion while dealing with increasing uncertainties, a Stanford-led research team developed a climate-informed and policy-relevant framework to quantify floodwater availability in California. The researchers additionally devised a basin classification system that considers existing constraints on deployment together with hydrologic potential under uncertain climate futures to identify priority areas of infrastructure investment needs.

Adapting to heightened climate-related risk will require transformational changes to existing water management practices to successfully manage droughts, floods and restore depleted groundwater aquifers simultaneously. Employing a modeling framework based on water available for recharge can inform effective investment decisions by policy makers and water resource managers. It also allows for adaptation to future climate-fueled drought and flood risk over depleted aquifers in California, as well as in similar hydrologic regions across the U.S.

An aerial of the East Branch California Aqueduct in northern Los Angeles County.

Credit: California Department of Water Resources

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## FOR MORE INFORMATION


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