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California’s San Joaquin Valley is home to more than four million people, half of the state agricultural output, and most of its critically overdrafted groundwater basins. The Sustainable Groundwater Management Act of 2014 (SGMA) requires to bring groundwater basins into balance by 2040. To achieve sustainability more than half million acres of farmland (~10% of current acreage in the valley) might need to be permanently retired of production.

Given the magnitude of the problem, local agencies are especially sensitive to developing plans that minimize the potential economic losses and risks of the transition to sustainable groundwater use. On the other side, groundwater depletion cause many impacts: puts at risk thousands of drinking water wells, results in significant economic impacts on infrastructure given the associated subsidence, and increases energy use and greenhouse gas emissions, among others.

However, planning for groundwater sustainability is challenging. The plans have to deal with some inherent uncertainties associated to modelling estimates of groundwater flows, hydrologic variability, and the impacts of a changing climate in the human-natural system.

To help inform stakeholders and policy-makers, we develop a support tool to improve decision-making under uncertainty that analyzes the trade-offs between groundwater operation rules, agricultural production, drinking water wells at risk, energy use, and sustainable groundwater levels. To do that we propose a framework that links a hydrologic model, a groundwater model, and an agricultural production model based on a positive mathematical programming approach, and two ancillary models that obtain wells at risk and energy use based on resulting groundwater levels. We then simulate different groundwater operation rules, and for each rule, we perform a Monte Carlo analysis with synthetic future scenarios, obtaining the performance of the simulated rules under uncertainty. We apply this framework in each of California’s San Joaquin Valley regions.

The results of the support tool show clearly the trade-offs between agricultural economic output, wells at risk and energy use. More specifically, dynamic rules that adapt groundwater use to climatic conditions and aquifer levels perform better in most of the assessed objectives than rigid rules. This support tool show great promise to better inform decision-making when multiple objectives and trade-offs are under consideration, as it is in California’s San Joaquin Valley, but also
might be useful in many other regions facing groundwater depletion.