RESEARCH HIGHLIGHTS

Groundwater and Crop Choice in the Short and Long Run

by Fiona Burlig, Louis Preonas, and Matt Woerman

How do farmers respond to higher groundwater costs?

Context

Ninety percent of global freshwater is consumed by agriculture. Irrigation enables high-value crop production and allows farmers to adapt to climate shocks such as droughts. Groundwater makes up about a third of the freshwater supply used for irrigation. But humans are using the earth's groundwater resources more quickly than they are naturally replenished, swiftly depleting our groundwater stocks—necessitating the need for long-run groundwater management.

California is one of the world's most valuable agricultural regions, producing three-quarters of the country's fruits and nuts and about half its vegetables. But the state has faced—and under climate change will no doubt continue to face—severe droughts and rapidly-declining groundwater aquifers. Historically, California farmers have been able to freely access the groundwater under their land, paying only the cost of the energy needed to pump the water out of the aquifer. Now, the state is in the process of implementing the Sustainable Groundwater Management Act (SGMA), which stands to be one of the world's most consequential groundwater regulations. The Act is designed to achieve statewide groundwater sustainability by 2042, which would require reducing groundwater pumping by 19 percent on average. Local implementing agencies have discretion and may achieve these reductions through taxes and fees, cap-and-trade mechanisms, pumping restrictions, and/or other conservation incentives. The effectiveness and economic consequences of any such regulation hinge on both the extent of farmers' responses and their means of adapting to higher irrigation costs over the long run.

Research Design

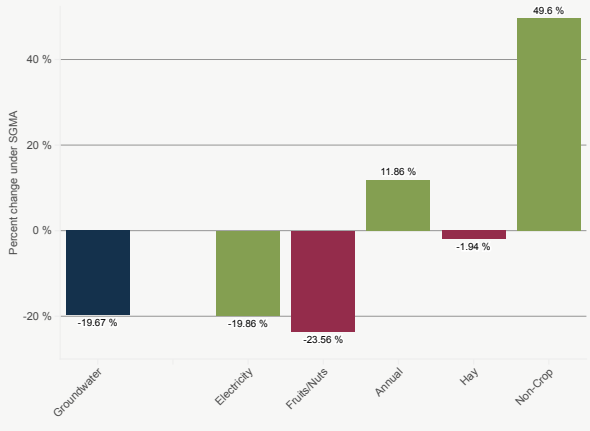
The researchers seek to discover how farmers respond both in the short- and long-term to changes in groundwater pumping costs. They specifically study whether farmers use less groundwater as costs increase, as well as whether farmers shift to growing different crops that would demand less water. Because electricity powers most groundwater pumps, and armed with information on electricity consumption, groundwater levels, and pump efficiency, the researchers can—for the first time—quantify both groundwater extraction and pumping costs at a large scale across the majority of California's Central Valley. They then use these data to model how farmers' crop choices and groundwater use respond to changing groundwater costs over different time horizons. They begin by modelling how farmers respond to year-over-year changes in groundwater costs to estimate the changes they are predicted to make over the short-run. After that, they model how farmers change their long-term growing habits.

Findings

When groundwater costs permanently increase, farmers switch to growing crops that require less water.

Over short time horizons, higher groundwater pumping costs lead farmers to change how they irrigate their crops but not what they grow. This is partly because most farmers plant perennials such as almonds, grapes and alfalfa. These high-profit, water-intensive crops also have high upfront planting costs and produce multiple years of harvests, so farmers would be less inclined to make changes in the short-run. In contrast, when faced with permanent increases in the cost of groundwater (as are to be expected under SGMA), farmers do switch to crops that use less water. Specifically, they plant fewer fruit/nut perennial crops and switch to either

Figure 1 · Change in land use under California policy



annual crops or no crops at all. In the long run, for every 10% increase in groundwater pumping costs, farmers reduce fruit/nut perennial cropping by 1.4% and increase fallowing by 0.72%, translating into an overall reduction in groundwater pumping of 3.6%. How much farmers change their behaviors and they ways in which they change them differ greatly in the short- and long-term, underscoring the importance of studying long-term effects when designing policy solutions.

California can meet its groundwater targets, but doing so will cut fruit and nut production by a quarter and leave 50 percent more cropland unused.

The researchers next measure how stringent SGMA will have to be to meet its sustainability goals and the consequences of such regulations. Using data from the California Department of Water Resources, the researchers estimate that SGMA requires regulated groundwater basins to reduce pumping by 19 percent on average. To meet these goals using a price mechanism—as is currently being proposed by more than half of SGMA's implementing agencies—would require a groundwater pumping tax of approximately 60%, or nearly $30/acre-foot of water on average. However, such a stringent tax would cause nearly 9 percent of cropland to be switched to crops that require less water—driving a 24 percent decline in fruit and nut perennials and a 50 percent increase in land not used for growing.

"Water does have value, and we learn that lesson when there is less of it to go around—but it shouldn't get to the point where some are starved for water. That's why policies that put a price on groundwater are so important. Our study shows that they lead farmers to treat water as a commodity that should be conserved, changing how or what farmers grow in a way that is more suitable to the land conditions and natural resources that we all have to share—rather than using up natural resources for free to make the greatest profit."

FIONA BURLIG
ASSISTANT PROFESSOR, HARRIS SCHOOL OF PUBLIC POLICY

CLOSING TAKE-AWAY

California's Sustainable Groundwater Management Act will alter the landscape of crop production across California by incentivizing large shifts away from fruit and nut perennials and towards an exit from agriculture. This could have downstream impacts on food prices. But at a broader level, it illustrates the challenges countries will face in balancing the conservation of depleting water resources and food supplies under climate change.

The Energy Policy Institute at the University of Chicago (EPIC) is confronting the global energy challenge by working to ensure that energy markets provide access to reliable, affordable energy, while limiting environmental and social damages. We do this using a unique interdisciplinary approach that translates robust, data-driven research into realworld impacts through strategic outreach and training for the next generation of global energy leaders.