Agricultural groundwater management in California: Possible perverse consequences?

Louis Sears
David Lim
C.-Y. Cynthia Lin Lawell

Abstract

The sustainable management of groundwater resources for use in agriculture is a critical issue in California and globally. Increasing competition for water from cities and environmental needs, as well as concerns about future climate variability and more frequent droughts, have caused policy-makers to look for ways to decrease the consumptive use of water. When designing groundwater management policies, it is important to consider any possible perverse consequences from the policy.

The sustainable management of groundwater resources for use in agriculture is a critical issue in California and globally. Increasing competition for water from cities and environmental needs, as well as concerns about future climate variability and more frequent droughts, have caused policy-makers to look for ways to decrease the consumptive use of water.

California has been experiencing its third-worst drought in 106 years. From 1960 to the present, there has been significant deterioration in the groundwater level of the Central Valley of California, making current levels of groundwater use unsustainable. Figure 1 shows the decline in groundwater levels in California since 2011, by administrative basin.

Groundwater management is particularly important in California as the state produces almost 70 percent of the nation's top 25 fruit, nut, and vegetable crops. Most crops in California come from two areas: the Central Valley, including the Sacramento and San Joaquin valleys; and the coastal region, including the Salinas Valley, often known as America's "salad bowl". Farmers in both areas rely heavily on groundwater. Understanding the economics of sustainable agricultural groundwater management is particularly timely and important for California as legislation allowing regulation of groundwater is being implemented gradually in California over the next several years.

Possible perverse incentives from policy

Incentive-based water conservation programs are extremely popular policies for water management. Farmers can receive a subsidy for upgrading their irrigation systems; less groundwater is "wasted" through runoff, evaporation, or drift; marginal lands can be profitably retired; and farmers can choose whether to participate. However, such policies can have perverse consequences.

In many places, policy-makers have attempted to decrease rates of groundwater extraction through incentive-based water conservation programs. Between 1998 and 2005, the state of Kansas spent nearly $6 million on incentive programs, such as the Irrigation Water Conservation Fund and the Environmental Quality Incentives Program, to fund the adoption of more efficient irrigation systems. Such programs paid up to 75% of the cost of purchasing and installing new or upgraded irrigation technology, and much of the money was used for conversions to dropped nozzle systems. These policies were implemented under the auspices of groundwater conservation, in response to declining aquifer levels occurring in some portions of the state due to extensive groundwater pumping for irrigation.

In California, the State Water Efficiency and Enhancement Program (SWEEP) provides financial assistance in the form of grants to implement irrigation systems that reduce greenhouse gases and save water on California agricultural operations, including evapotranspiration-based irrigation scheduling to optimize water efficiency for crops; and micro-irrigation or drip systems. San Luis Canal Company in the San Joaquin Valley offers $250 per acre to encourage the transition to pressurized irrigation systems (Sears et al., 2016).

Similarly, though funding for this order was not passed, under the Water and Energy Saving Technologies Executive Order B-29-15, the California Energy Commission, California Department of Water Resources, and California State Water Resources Control board were to provide funding for innovative technologies, including rebates for conversion from high pressure to low-pressure drip irrigation systems (Sears et al., 2016).

However, although they are extremely popular policies for water management, we find that policies that encourage the adoption of more efficient irrigation technology may not have the intended effect. Irrigation is said to be “productivity enhancing”; it allows the production of higher

value crops on previously marginal land. Thus, a policy of subsidizing more efficient irrigation technology can induce a shift away from dry-land crops to irrigated crops. They may also induce the planting of more water-intensive crops on already irrigated land, as by definition, more efficient irrigation increases the amount of water the crop receives per unit extracted.

Similarly, land and water conservation and retirement programs may not necessarily reduce groundwater extraction, although they are billed as such. An example of a land retirement program is the Conservation Reserve Program (CRP) created by the federal government in 1985 to provide technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. These programs include payments to landowners to retire, leave fallow, or plant non-irrigated crops on their land.

However, there is substantial evidence that farmers enroll their least productive, least intensively farmed lands in land retirement programs, while receiving payments higher than their opportunity costs, thus accruing rents. It is quite unlikely that an irrigated parcel, which requires considerable investment in a system of irrigation (which, in turn, enhances the productivity of the parcel), will be among a farmer's plots with the lowest opportunity cost and thus enrolled in the program. Instead, farmers may opt to enroll non-irrigated plots in the CRP program, which does not have any effect on the amount of irrigation water extracted.

In a previous study (Pfeiffer and Lin, 2014), which has been featured in such media outlets as the New York Times, the Washington Post, Bloomberg View, and AgMag Blog, as well as in a previous issue of ARE Update, our research team focused on incentive-based groundwater conservation policies in Kansas and found that measures taken by the state of Kansas to subsidize a shift toward more efficient irrigation systems had not been effective in reducing groundwater

extraction. The subsidized shift toward more efficient irrigation systems has in fact increased extraction through a shift in cropping patterns. Better irrigation systems allow more water-intensive crops to be produced at a higher marginal profit. The farmer has an incentive to both increase irrigated acreage and produce more water-intensive crops (Pfeiffer and Lin, 2014; Lin Lawell, 2016).

We find similar results in our analysis of the effects of land and water conservation and retirement programs on groundwater extraction in Kansas. Theoretically, we know that because the programs are offer-based, farmers will enroll their least productive land. Our empirical results support this conclusion; we find essentially no effect of land conservation programs on groundwater pumping, which occurs, by definition, on irrigated, and thus, very productive land (Pfeiffer and Lin, 2014; Lin Lawell, 2016).

Our result that increases in irrigation efficiency may increase water consumption is an example of a rebound effect, or "Jevons' Paradox", which arises when the invention of a technology that enhances the efficiency of using a natural resource does not necessarily lead to less consumption of that resource. Jevons found this to be true with the use of coal in a wide range of industries (Lin, 2013). In the case of agricultural groundwater, we find that irrigation technology that increases irrigation efficiency does not necessarily lead to less consumption of groundwater (Lin, 2013; Lin Lawell, 2016). In particular, if demand is elastic enough, the higher-efficiency technology operates at a lower marginal cost and increases revenue, in which case irrigation efficiency will increase applied water (Pfeiffer and Lin, 2014; Lin Lawell, 2016).

In California, SWEEP grant funds cannot be used to expand existing agricultural operations or to convert additional new acreage to farmland (California DWR and DFDA, 2016), which may limit how much a farmer can respond to the increased irrigation efficiency resulting from SWEEP

grant funds to increase irrigated acreage. However, by lowering the marginal cost of irrigation SWEEP grant funds may encourage farmers to continue irrigating more marginal lands (Sears et al., 2016). Furthermore, this increased efficiency may allow farmers to continue growing more water intensive crops, even as groundwater becomes scarcer. Thus, SWEEP funds could make farmers in water-stressed locations less sensitive to existing price signals as groundwater becomes scarce, and may slow their adjustment to depleting groundwater stocks over the long term.

The California Department of Agriculture and the California Department of Water have recently introduced a pilot program within SWEEP that incentivizes joint action by farmers and larger water suppliers to implement more efficient irrigation technology in return for an agreement to halt the use of groundwater for agricultural purposes. However, this program may be used most by farmers and water suppliers who rely relatively little on groundwater as a source. In this case, while irrigation may become more efficient, this may have little effect on groundwater use, the target of the policy. As a result, the costs of the program may unfortunately exceed its benefits.

While heavily irrigated, California's cropland still includes almost one million acres of dry land farming, or non-irrigated land used for planting crops. Dry land farming constitutes about 9 percent of total cropland and 3.5 percent of total farmland in California. Another half a million acres of cropland is currently left to pasture, but could be converted to cropland without improvements. In addition, farmland in California includes about 13 million acres of rangeland and pasture, only about half a million of which is irrigated. Thus, a possible perverse consequence of California's SWEEP grant funds is that farmers have may choose to convert more marginal land that is currently used for rangeland and dry land farming to more productive irrigated cropland as part of any efficiency gains from new irrigation technology purchased with state incentives, and this possible increase in irrigated acreage may lead to an increase in groundwater consumption.

Land retirement programs at the federal and state level have had limited effectiveness in California, and may also have perverse consequences. The largest federal land retirement program, the Conservation Reserve Program, provides rental payments to landowners who retire their land and follow conservation practices for a contracted period of time, usually 10 years. While this program has retired 35 million acres of land nationally, it had only enrolled about 138,000 acres in California as of 2007, well below its share in total farmed acres. This is due in large part to the relatively high value of agricultural land, particularly irrigated farmland, in California.

The most important state-level land retirement program in California is the Central Valley Project Improvement Act Land Retirement Program, which purchases land and water rights from owners. Between 1992-2011, the program has retired about 9,000 acres as part of a planned 100,000 acre retirement.

The modest effect of land retirement programs on groundwater extraction in California is evidence of a design flaw of land retirement programs. In areas of high value agricultural production like California, farmers will demand much higher payments to voluntarily abandon crop production. Since California's most water-stressed regions coincide with areas of high value irrigated agricultural production, land retirement programs in these areas may be limited in their effectiveness, or very costly. In addition, the relatively low levels of Conservation Reserve Program spending in California suggest that the land that has been enrolled in the program is likely low-value land. Thus, just as in Kansas, land conservation programs may be ineffective in reducing groundwater extraction in California.

Conclusion

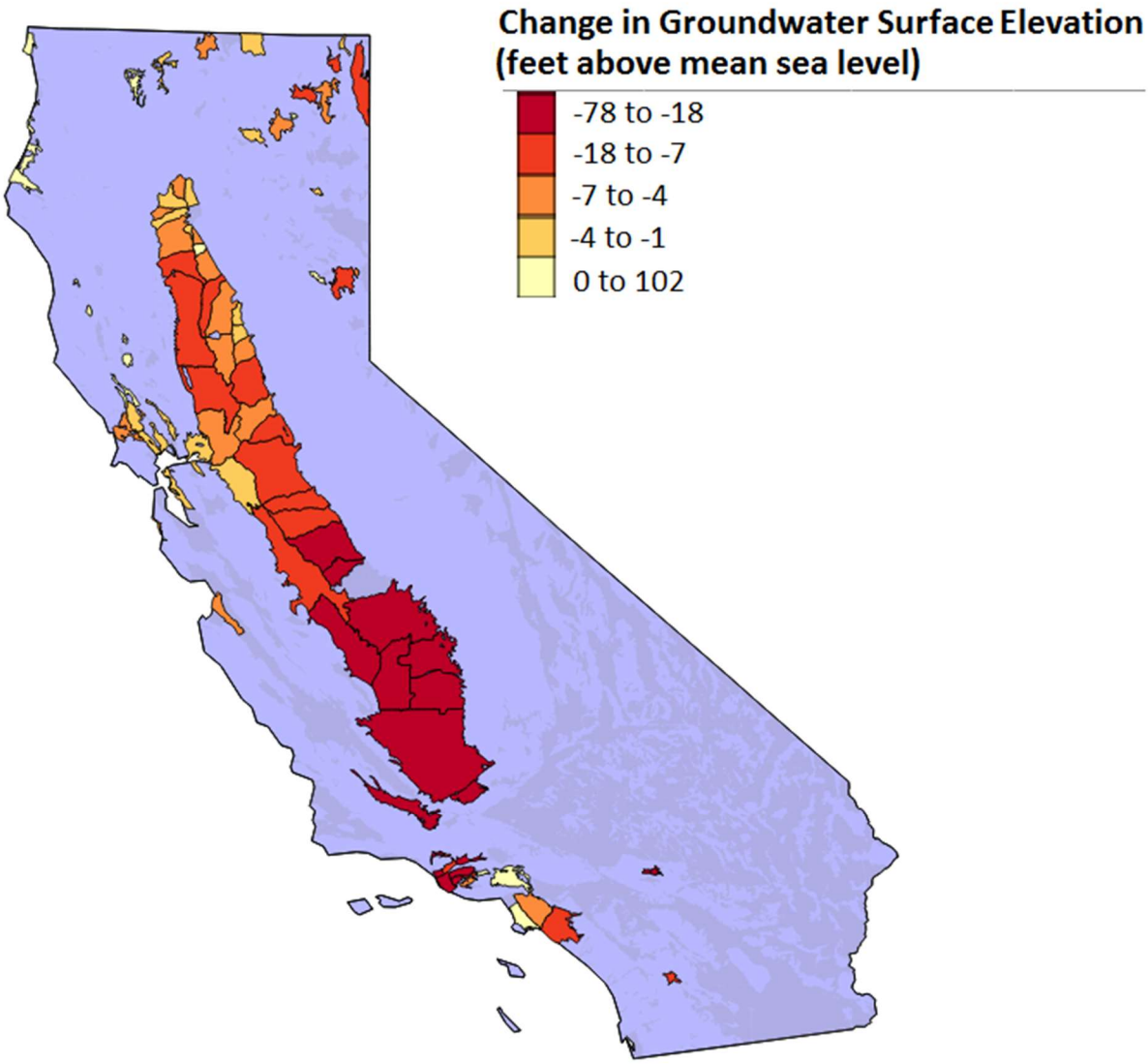
Incentive-based groundwater conservation programs are a prime example of a well-intentioned policy that may have perverse consequences, meaning that they may actually increase rather than decrease groundwater extraction. When designing policies and regulation, policy-makers need to be aware of the full range of implications of their policy, including any potential perverse consequences.

Authors' Bio

Louis Sears is a Ph.D. student in the ARE department, David Lim is a B.S. student in Environmental Science and Management, and C.-Y. Cynthia Lin Lawell is an Associate Professor in the ARE department, all at UC Davis. They can be contacted by email at sears@primal.ucdavis.edu, dahlim@ucdavis.edu, and cclin@primal.ucdavis.edu, respectively.

Figure 1.

Decline in Groundwater Levels in California Since 2011, By Administrative Basin



Data source: California Department of Water Resources

For additional information, the authors recommend:

Ferraro, Paul J. (2016). "When conservation efforts end up using more water". Bloomberg View. 2 August 2016. URL: http://www.bloomberg.com/view/articles/2016-08-02/when-conservation-efforts-end-up-using-more-water

Lin, C.-Y. Cynthia. (2013). Paradox on the Plains: As water efficiency increases, so can water use. California WaterBlog. URL: http://californiawaterblog.com/2013/08/13/paradox-on-the-plains-as-water-efficiency-increases-so-can-water-use/

Lin Lawell, C.-Y. Cynthia. (2016). The management of groundwater: Irrigation efficiency, policy, institutions, and externalities. Annual Review of Resource Economics, 8, 247-259. URL: http://www.des.ucdavis.edu/faculty/Lin/Annual_Review_Res_Econ_groundwater.pdf

Pfeiffer, Lisa, and C.-Y. Cynthia Lin. (2009). Incentive-based groundwater conservation programs: Perverse consequences? Agricultural and Resource Economics Update, 12 (6), 1-4. URL: http://s.giannini.ucop.edu/uploads/giannini_public/20/dd/20dded8e-e2cf-4e04-917a-9bfddc3a7837/v12n6_1.pdf

Pfeiffer, Lisa, and C.-Y. Cynthia Lin. (2014). Does efficient irrigation technology lead to reduced groundwater extraction?: Empirical evidence. Journal of Environmental Economics and Management, 67 (2), 189-208. URL: http://www.des.ucdavis.edu/faculty/Lin/PfeifferLin_irrigationtechnology_paper.pdf

Sears, Louis, Ernst Bertone Oehninger, David Lim, and C.-Y. Cynthia Lin Lawell. (2016). The economics of sustainable agricultural groundwater management: Recent findings. Working paper, University of California at Davis. URL: http://www.des.ucdavis.edu/faculty/Lin/CalAg_groundwater_paper.pdf

Wines, M. (2013). Wells dry, fertile plains turn to dust. New York Times, 19 May 2013. URL: http://www.nytimes.com/2013/05/20/us/high-plains-aquifer-dwindles-hurting-farmers.html?pagewanted=all