Price Incentives for Groundwater Conservation in India

Researchers:

Nick Hagerty

Ariel Zucker

Sector(s): Environment & Energy

Fieldwork: Aga Khan Rural Support Programme–India (AKRSP-I), Abdul Latif Jameel Water and Food Systems Lab (J-WAFS)

Sample: 1,111 farmers

Initiative(s): Agricultural Technology Adoption Initiative (ATAI), King Climate Action Initiative (K-CAI)

Target group: Farmers Rural population

Outcome of interest: Climate change Conservation Energy conservation

Intervention type: Incentives

AEA RCT registration number: AEARCTR-0009337

Research Papers: Conservation Payments: Experimental Evidence from Groundwater Irrigation

Partner organization(s): Weiss Family Program Fund for Research in Development Economics

Groundwater is becoming an increasingly vital input to agriculture due to erratic rainfall, but a widespread lack of regulation or pricing often leads to overconsumption and depletion. Researchers conducted a randomized evaluation to test the provision of financial incentives on small-scale farmers' voluntary groundwater conservation in Gujarat, India. They found that small conservation payments reduced irrigation hours and associated electricity use, suggesting that conservation payments may be an effective and cost-effective solution.

Policy issue

Groundwater is a critical natural resource for agricultural irrigation, but unregulated extraction has led to widespread depletion of water resources. As water becomes scarce, this can exacerbate conflict over available resources. Electricity pricing further complicates the problem: in many regions, power for pumping groundwater is free, flat-rated, or highly subsidized, which can accelerate groundwater use while straining public utilities and degrading electricity services. Despite these challenges, energy subsidies remain politically popular, but a potential alternative approach that sidesteps these challenges is voluntary conservation payments, in which governments or other actors provide compensation to individuals who lower their water extraction. Relying on rewards instead of penalties (like higher costs or taxes), conservation incentives can ease political and policy constraints to alter the existing practice. Can financial incentives for groundwater conservation encourage farmers to practice water-conserving behaviors and reduce electricity consumption without sacrificing their productivity?

Context of the evaluation

Groundwater is an important source for India's rural and urban domestic water supplies.[1], Effective groundwater management in India is thus crucial to building resilience to shocks in temperatures and rainfall patterns. The Saurashtra region of the state of Gujarat is a semi-arid [2], area facing declining groundwater levels due to droughts and rising demand for water,[3], partially because farmers tend to pump groundwater for irrigation from wells on their land or share with neighbors to better manage erratic weather.[4]

Groundwater pumping in Gujarat relies on electricity needed to power the equipment for water extraction, and the government subsidizes this electricity. Farmers in the region primarily grow cotton and, to a lesser degree, sorghum, millet, groundnut, and pulses. Cotton requires large amounts of water and energy to cultivate. Eligible farmers planted and irrigated crops in the previous season primarily using groundwater, had a maximum of two wells in use on their farm, did not have more than one pump starter in use on a well, and were not part of a network of more than four farmers sharing irrigation sources. Additionally, most farmers were literate, had finished primary and secondary school.

Gujarat, India. Flood irrigation used by smallholder farmers.

Photo: Nick Hagerty | Montana State University

Details of the intervention

Researchers conducted a randomized evaluation to test the impact of offering financial incentives for voluntary groundwater conservation to small-scale farmers on their use of irrigation and water pumping behavior.

Farmers were offered to either receive payment incentives to conserve water during three months of the main irrigation season or not to receive any incentives. Using hours-of-use meters installed on the pump starter of each participant's main irrigation source, researchers collected meter data each month from December 2022 to March 2023. After the first month of measurement, participants were informed if they had been selected for the program, and farmers in intervention groups received information about their benchmark—the number of hours farmers were expected to pump water per month based on the number of pumping hours during the first month of study. Researchers randomly assigned 1111[5] farmers to one of the following five groups:

1. *High benchmark + high price (141 farmers)*: Farmers were offered a payment of INR 100 (US$1.20) per hour of water pumping conserved up to a monthly pumping limit [6] of 115 percent of their benchmark quantity.

2. *High Benchmark + low price (131 farmers)*: Farmers were offered a payment of INR 50 (US$0.60) per hour of water pumping conserved up to a monthly pumping limit of 115 percent of their benchmark quantity.

3. *Low Benchmark + high price (145 farmers)*: Farmers were offered a payment of INR 100 (US$1.20) per hour of water pumping conserved up to a monthly pumping limit of 85 percent of their benchmark quantity.

4. *Low Benchmark + low price (145 farmers)*: Farmers were offered a payment of INR 50 (US$0.60) per hour of water pumping conserved up to a monthly pumping limit of 85 percent of their benchmark quantity.

5. *Comparison group (549 farmers)*: Farmers were informed that they were not selected for the new payment program. They were offered a reward of 100 INR for keeping their meters installed for the duration of the study.

Researchers collected data in the summer of 2022, prior to the randomization on land size, household size, types of crops, crop management, irrigation decisions in the previous year, the power of the primary pump, water conservation strategies and attitudes, the precise location and depth-to-water of each well, and whom they shared pumps and pumped water Leveraging satellite data and hydrogeology data from digitalized groundwater prospects maps, researchers also created proxies of farmers' agricultural yields.

Results and policy lessons

Conservation payments cut groundwater pumping and electricity use, without reducing yields. Effects seemed to strengthen over time as farmers gained trust in the program, with stricter benchmarks and modest payments proving most effective.

Hours of groundwater irrigation: Farmers who were offered conservation payments pumped for 10.4 fewer hours per month, on average, for the duration of the program relative to the comparison group. Moreover, farmers receiving conservation payments decreased their hours of use by 22 percent in relation to farmers in the comparison group.

Energy consumption: Farmers who were offered conservation payments decreased their electricity consumption by 140 kilowatt-hours (kWh) per month (a 23 percent decline) compared to farmers in the comparison group's average of 611 kWh per month.

Impacts of being offered conservation payments on hours of irrigation and energy consumption increased during the three-month intervention. Two factors may explain this pattern: farmers' growing trust in the program after receiving payments, and a greater response to conversation payments later in the season when water was less critical for crop growth. Additionally, researchers found that offering an INR 50 per hour of pumping price incentive, compared to no incentive, yielded a stronger effect than increasing the incentive from INR 50 to INR 100. For energy consumption the pattern reversed; raising the price from low to high produced a stronger effect than introducing the program at the low price. Since energy use was a measure of irrigation hours that varied by pump power, this suggests that farmers with more powerful pumps were more responsive to higher prices. Researchers posit that for these farmers, the value of an hour spent pumping might have been higher, so a stronger price incentive was needed to encourage conservation.

Agricultural yields: Despite farmers reducing irrigation hours, being offered a payment to reduce water use did not lead to any change in yields, indicating that reducing irrigation did not have a negative economic outcome for farmers.

Cost analysis: Researchers estimated that the conservation payment program reduced electricity use at a cost of INR 6.10 (approximately US$0.07) per kWh conserved, which is slightly larger than the average cost of electricity procurement, which was INR 5.40. For future analysis, researchers also highlight the importance of considering the broader social costs of groundwater depletion and air pollution from electricity generation, even modest estimates of these costs would strengthen the case for subsidizing conservation payments, likely making them socially preferable to expanding electricity supply.

Furthermore, stricter benchmarks can further improve the cost-effectiveness of the program. They do so by reducing rewards for electricity that would not have been used and by causing farmers to conserve more in response to the lower benchmarks. In this study, the low-benchmark group achieved both greater conservation and lower costs, with average cost of conservation less than half that of the high-benchmark group.

Taken together, the results suggest that moderate incentives for groundwater conservation can lead farmers to decrease groundwater use for irrigation over time, indicating that responses to incentives can be sustained.

---

1. https://www.worldbank.org/en/news/press-release/2020/02/17/improving-groundwater-management-india
2. Jariwala, Kaustubh A., and Prashant G. Agnihotri. 2024. "Time Series Modeling of Drought in a Semi-Arid Region of South Gujarat, India." *Journal of Earth System Science* 133: 154. doi: https://doi.org/10.1007/s12040-024-02357-5.
3. Bandyopadhyay, Nairwita. 2023. "*Impact of Climate Change on Water Crisis in Gujarat (India)*". In Ecological Footprints of Climate Change, edited by Upal Chatterjee, A.O. Akanwa, Suraj Kumar, Suraj Kumar Sign, and A. Dutta Roy. Cham: Springer Climate, Springer. doi: https://doi.org/10.1007/978-3-031-15501-7_8.
4. Hoogesteger, Jamie. 2022. "Regulating agricultural groundwater use in arid and semi-arid regions of the Global South: Challenges and socio-environmental impacts." *Current Opinion in Environmental Science & Health*, no.27 *(June). doi: https://doi.org/10.1016/j.coesh.2022.100241.*
5. *Randomization was conducted in Stata on a sampling frame of 1347 farmers at the level of 1328 "pools" of farmers who shared water. However, 236 farmers attrited before their randomly selected treatment was revealed to them, leaving 1111.*
6. *Farmers exceeding the monthly pumping threshold retained water access but were no longer eligible to receive incentive payments.*