Price Incentives for Conservation: Experimental Evidence from Groundwater Irrigation

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Motivation

- Groundwater is a critical source of irrigation globally (40%) and especially in India (60% of supply)
- Pumping is unregulated almost everywhere
  - No marginal price for groundwater
  - In many cases (e.g. India), no marginal price for the electricity used to pump it
- Water levels are falling in many regions
  - Can increase poverty & conflict (Sekhri, 2018) and reduce farm production (Blakeslee et al., 2020)
  - Expected to reduce cropping intensity (Dang et al., 2019) and scope for climate adaptation (Fishman, 2018)

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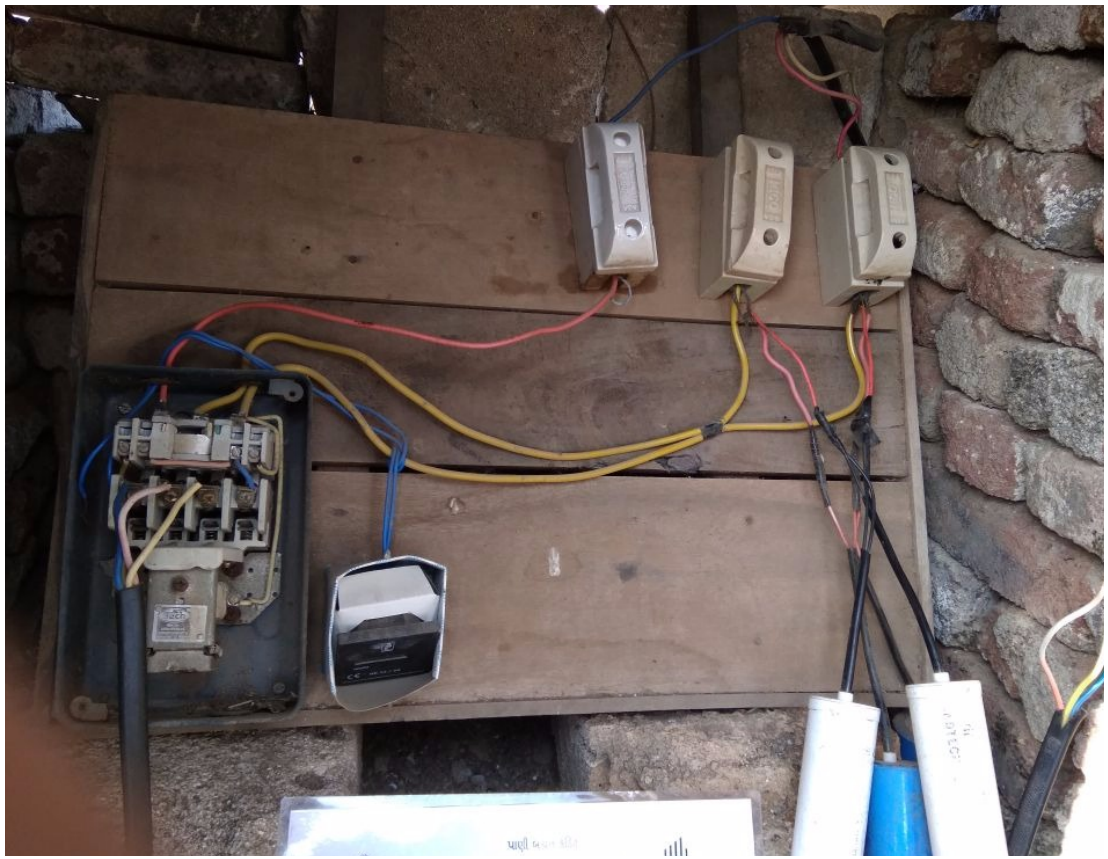
Conservation credits: A PES approach to groundwater conservation

- Our intervention: Program that pays farmers to use less water, called "conservation credits"
- Implements a price incentive without requiring the power of taxation

Conservation Credits: Structure

- Install hours-of-use meters on farmers' groundwater pumps
- Offer payments for reduced pumping relative to a benchmark quantity



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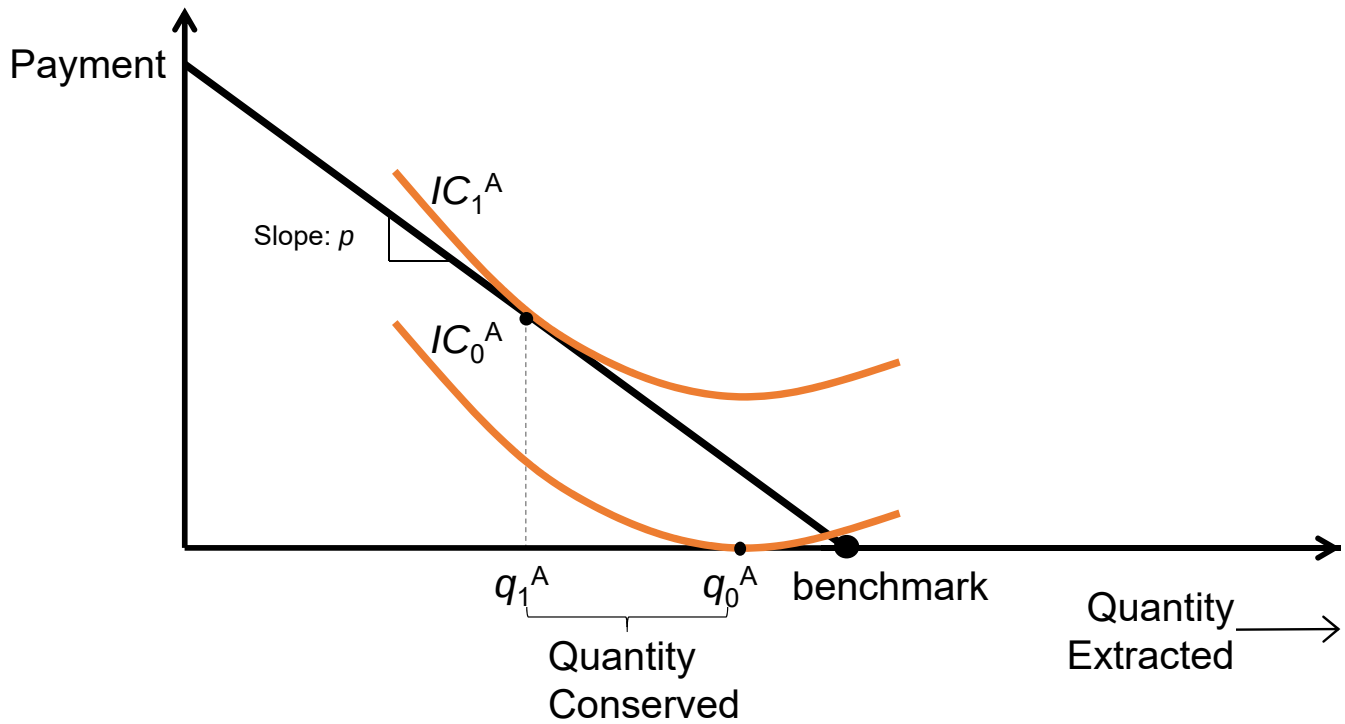


Program may be a promising policy tool

- Conservation payments may be able to overcome constraints to regulation
- Political constraints
  - Electricity subsidies in agriculture are entrenched means of redistribution (PES increases redistribution)
  - Groundwater access considered a property right (PES pays farmers for not exercising this right)
- Enforcement/observational capacity
  - Metering *hours-of-pump-use* is cheaper and less easily circumvented than metering *water*

Research objectives

1. Evaluate conservation credits: PES is a promising policy tool under political constraints

2. Test whether conservation credits reduce subsidized energy consumption enough for a Pareto improvement between farmers and electric utilities

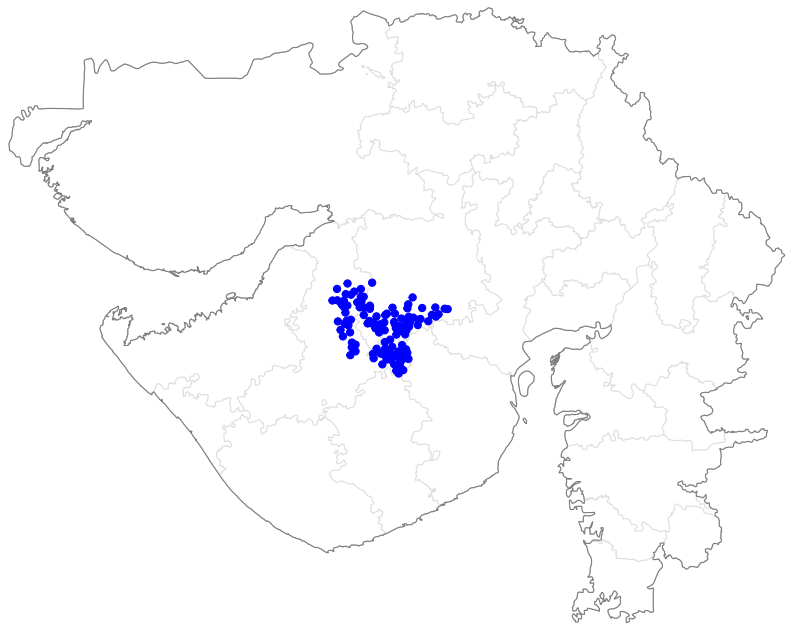
3. Estimate the demand for groundwater in irrigated agriculture using experimental price variation

Agenda

- Introduction
- Experimental Design
- Results
- Conclusion

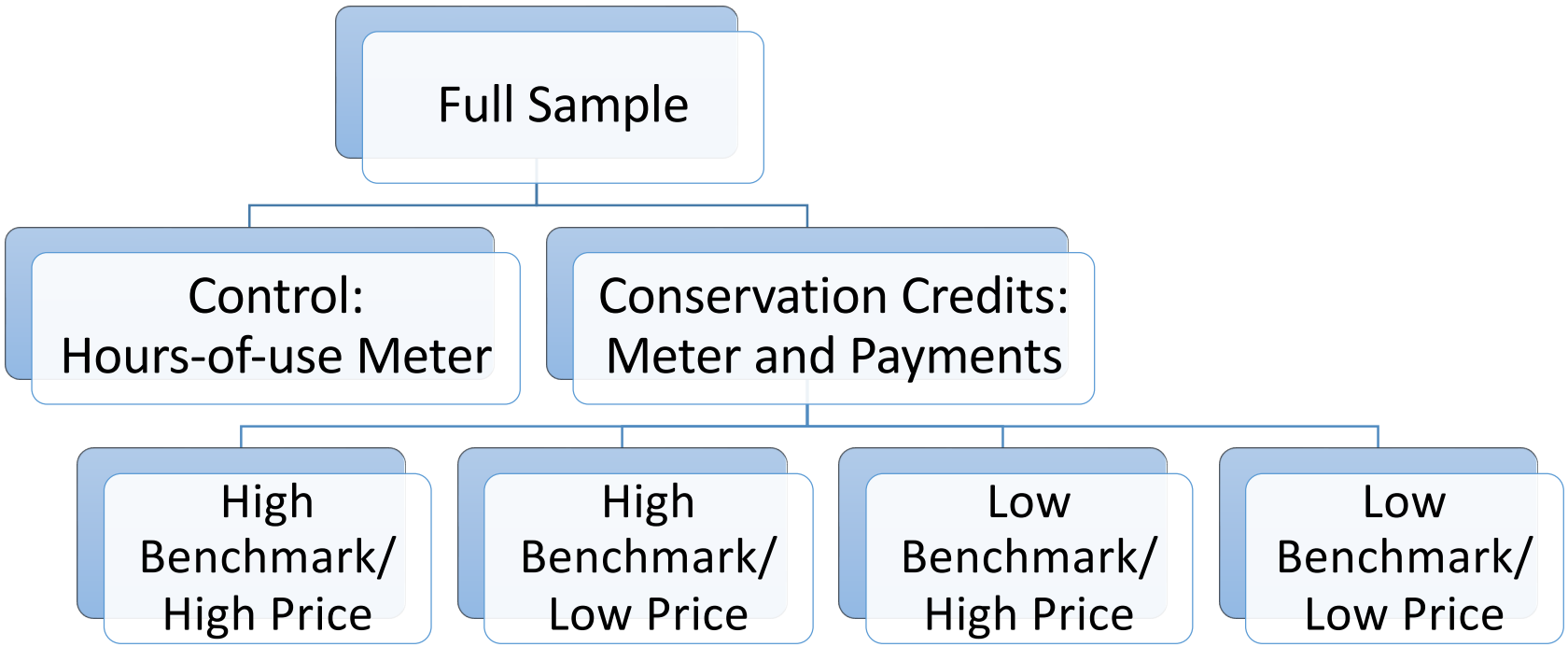
Setting

- Inland Saurashtra, Gujarat (where our partner organization was working)



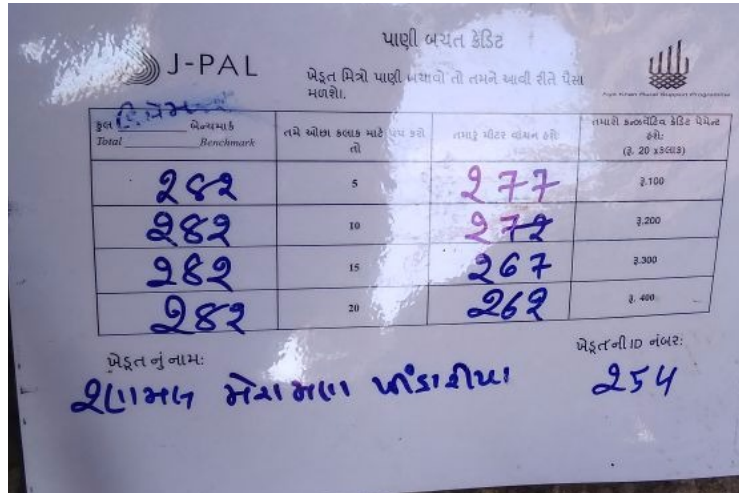
Experimental Design

- Randomly assign half the sample to Conservation Credits
  - Stratify pairwise on forecasted hours of irrigation.
- Four CC sub-treatments vary contract parameters



Conservation Credits: The intervention

- An hours-of-use meter is installed on the farmer's main pump.
  - Monthly hours benchmark based on single month of pre-randomization irrigation
  - Verbally communicated and posted on a laminated sheet near the meter



- Meters are read monthly for three months
- Farmers receive a check if they pump less than the benchmark.
- Receive 100 INR per meter for keeping meters installed (Control too)

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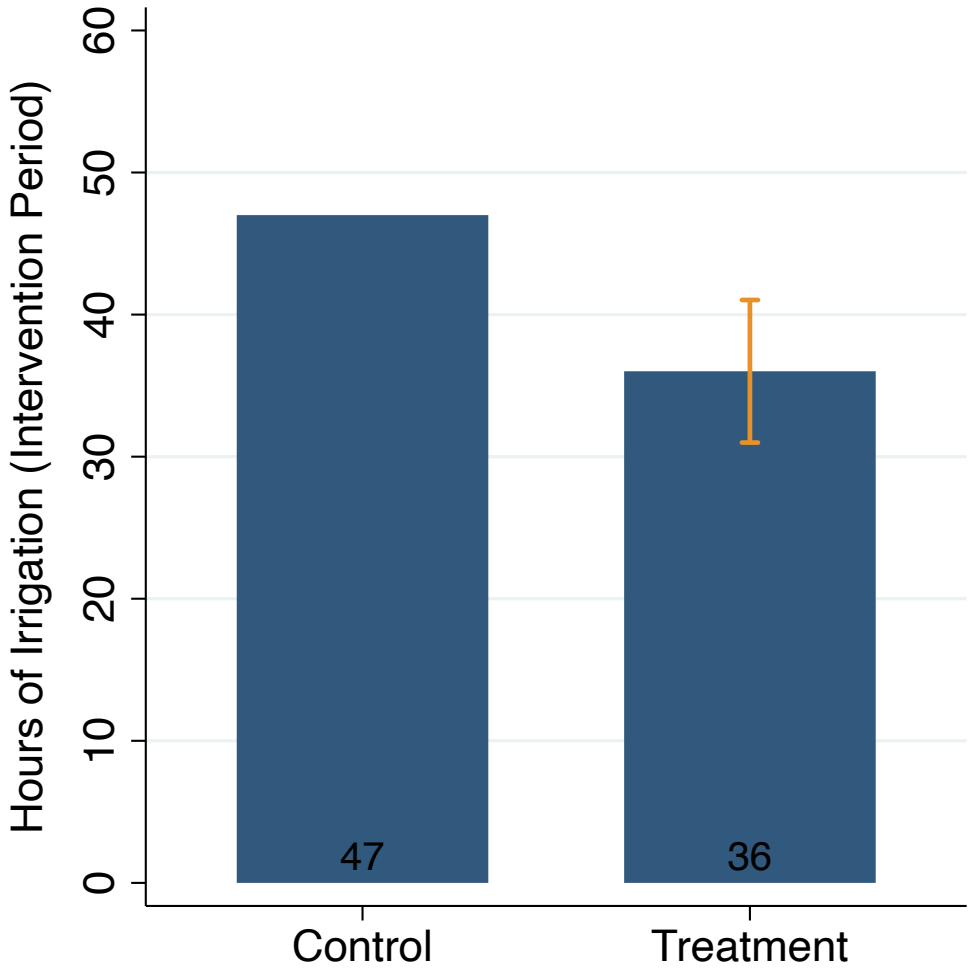
Characteristics are balanced by treatment

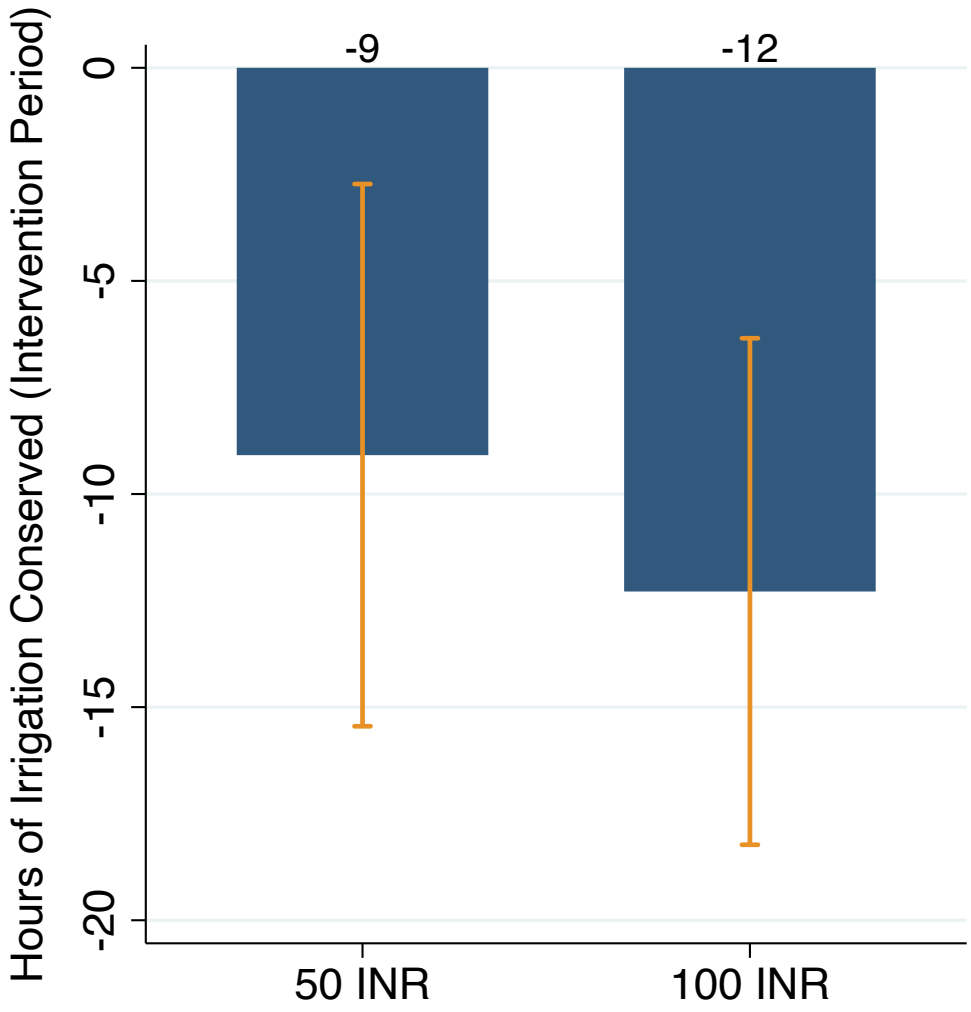
	Full Sample		Control	Treatment
	(1) Mean	(2) SD	(3) Mean	(4) Mean
A. Demographics				
Household size	6.34	2.85	6.46	6.22
Literacy (household head)	0.82	0.38	0.83	0.81
B. Farm statistics				
Plot hectares	1.95	1.35	1.97	1.92
Number of crops cultivated	1.96	1.08	2.01	1.91
Fraction of farmed area planted with cotton	0.53	0.41	0.54	0.53
C. Well Statistics				
Total number of active wells	1.19	0.39	1.19	1.19
Deepest well: depth (meters)	58.62	85.17	53.66	63.12
Deepest well: max water level (meters)	16.07	36.60	14.68	17.33
D. Irrigation Statistics				
Pre-intervention monthly irrigation hours	71.71	71.09	69.81	73.43
Purchased water for irrigation	0.01	0.11	0.01	0.01
Test for joint orthogonality of covariates				
F-statistic			1.03	
P-value			0.41	
Sample size				
Number of individuals	989		471	518
Percent of sample	100.0		47.6	52.4

Conservation credits reduce irrigation time by 24%



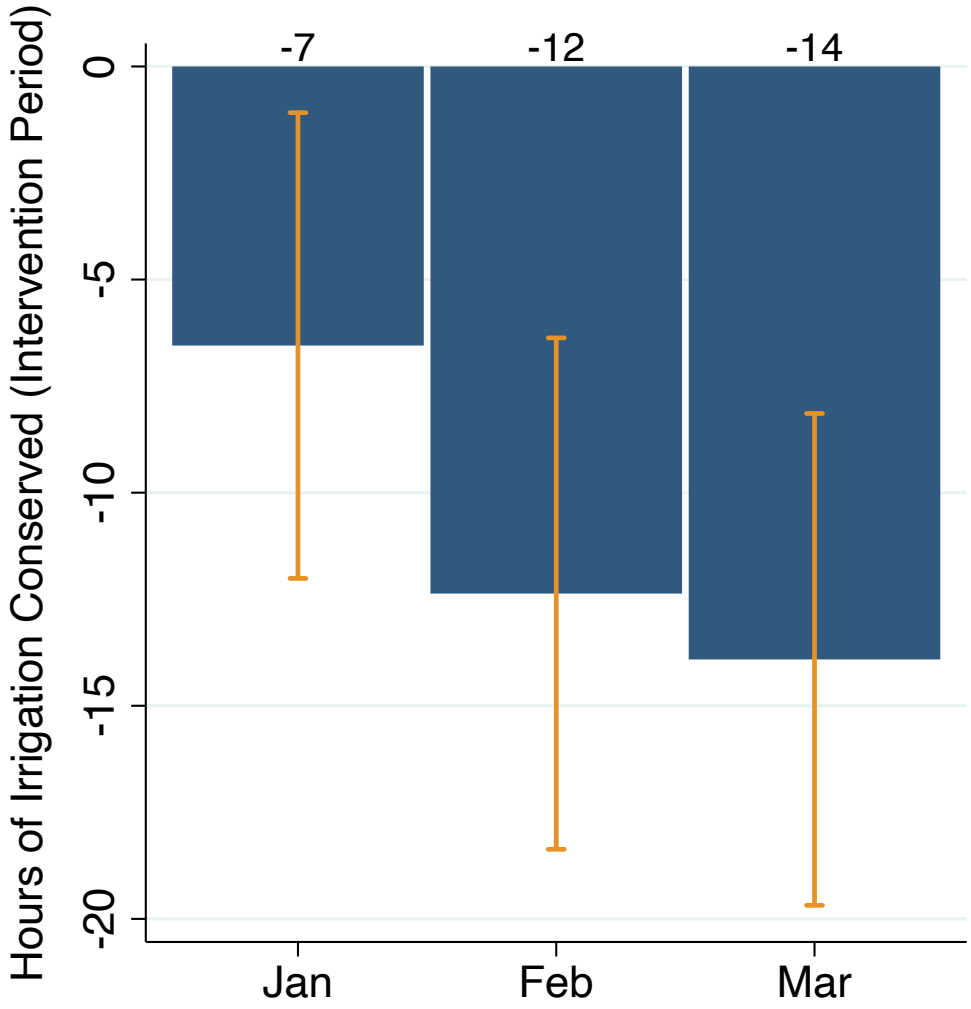
Converting hours to energy use, ATE is -151 kWh per month

Higher prices have small additional effect



- Reduction in irrigation with 50 INR/hour price: 9 hours
- Additional reduction with 100 INR/hour price: 3 hours

Treatment effects increase over time



- Treatment effect increased from 7 to 14 hours over time
- Explanations: increasing trust, increasing price sensitivity, limited initial excitement effects

Intervention shows potential for cost-effectiveness

Parameter	Value	Unit	Source
Comparing cost-effectiveness			
Cost of reducing electricity use through this program	6.1	INR/kWh	Authors' calculation
Average cost of electricity procurement per unit sold, Gujarat	5.4	INR/kWh	Paschim Gujarat Vij Company Ltd. (2021)
Cost of electricity procurement, Punjab	7.9	INR/kWh	Mitra, Balasubramanya, & Brouwer (2023)

- Incentive expenditure per kWh conserved is similar to the marginal cost of procurement for local utilities (excluding social costs)

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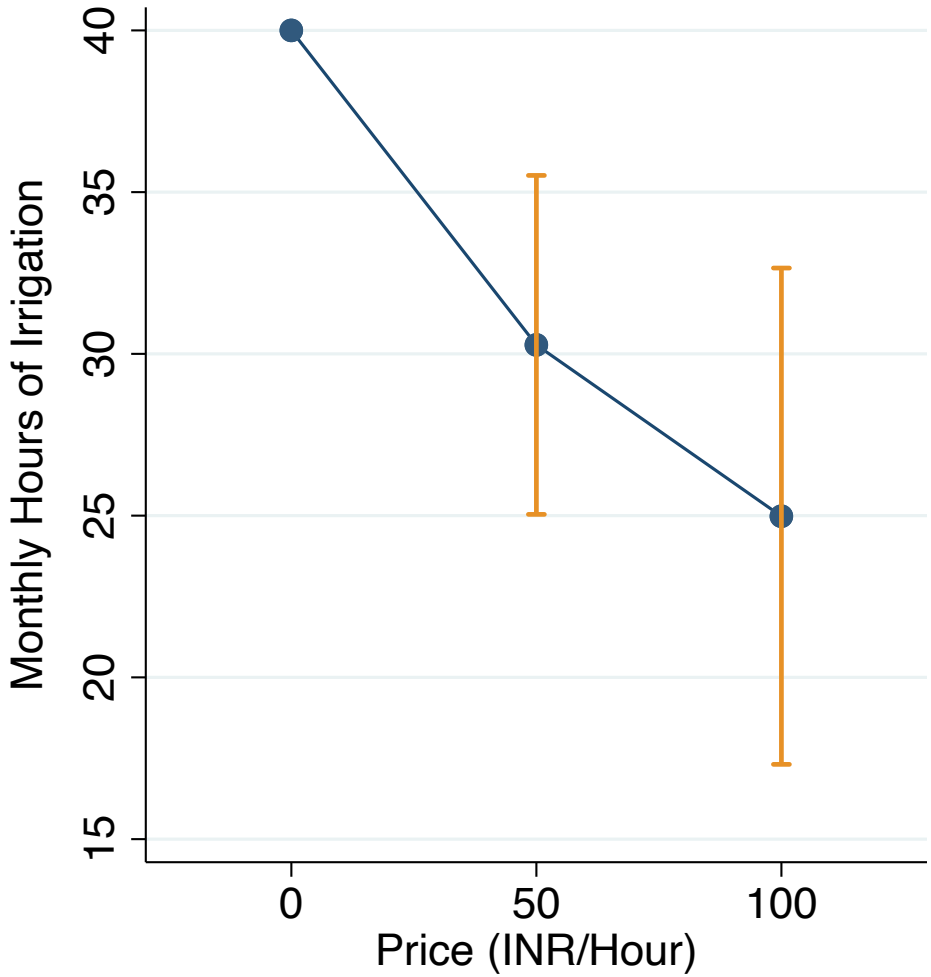
We estimate a price elasticity of -0.2



- Use subtreatments, interacted with controls, as instruments for marginal price
- Critical (unrealistic?) assumption: farmers do not respond to the conservation credits treatment *unless* the conserve enough to get paid

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Conclusion

- Our randomized evaluaiton of a PES approach to groundwater conservation shows price incentives are a promising approach to irrigation efficiency
- Irrigation and associated energy use declines by 24%
- Relatively low subsidy costs per kWh conserved suggest potential for Pareto improvements from such a program delivered at scale
- Implied elasticity of groundwater demand of -0.2 is comparable to estimates from many US states