Energy Efficiency in Groundwater Extraction for Agriculture in Bangladesh

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Sector(s): Agriculture, Environment, Energy, and Climate Change

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Location: Mymensingh and Kishoreganj districts, Bangladesh

Sample: 360 villages

AEA RCT registration number: AEARCTR-0007012

Research Papers: Targeted Subsidies for Water Conservation in Smallholder Agriculture

Partner organization(s): AVA Development Society, International Rice Research Institute (IRRI), Oxford Policy Management

Groundwater pumping is an affordable and popular method for irrigation as well as a source of rapidly increasing electricity consumption in low- and middle-income countries. Researchers conducted a randomized evaluation to test the impact of providing subsidies for a soil monitoring technology on the electricity used to pump groundwater to agricultural fields in rural Bangladesh. They found that the technology reduced the amount of electricity used for irrigation, but only when subsidies were directed to the groundwater providers, giving them an incentive to save on energy costs without affecting farmers' crop yields.

Policy issue

Water is essential for agriculture, and groundwater pumping can be an efficient method for irrigating multiple agricultural plots in rural areas. At the same time, challenges such as increased groundwater depletion, severe water stress due to climate change, and the fact that groundwater pumping emits carbon dioxide and contributes to climate change raise the question of optimal groundwater use in agriculture. As land under cultivation expands, water consumption and electricity use for pumping can strain natural resources, contribute to climate change, and increase costs of food production.

One roadblock to efficient water pumping is the lack of information regarding the optimal timing of irrigation. However, while policies that promote the adoption of simple technologies may be a promising step to address water use and electricity consumption, they often fail to achieve their projected impact due to low take up by farmers. The issue may instead be incompatible incentives for farmers and water sellers to adopt new practices. For example, in low-income countries, where a village consists of hundreds of tiny farming plots, local market dynamics and negotiation between farmers and water sellers can affect water allocation. Few prior studies on technology adoption have considered this—targeting incentives to actors other than the farmer. Can changing whom incentives are targeted to reduce electricity use for groundwater pumping in agriculture?

Context of the evaluation

Bangladesh has a highly agrarian economy, with about half its population employed in agriculture and 70 percent of land dedicated to farming[1], . Almost 90 percent of rural households rely on agriculture for at least part of their incomes as well as household consumption and food security[2]. Rice is the dominant crop. Groundwater supplies much of the water for rice farming in rural Bangladesh, and it is usually sourced through individual water pumps that serve several plots. The standard practice for rice crops in this context is to irrigate by flooding the field and waiting a few days to irrigate again when there is no more standing water. Unlike other inputs where individual farmers select the quantity and frequency for application on their plots of land, farmers do not control their use or access to water. Instead, water sellers, who operate tube wells for groundwater pumping, jointly decide with multiple farmers how much water to distribute at a given time, often irrigating several small plots at once. Therefore, villages, that normally have hundreds of small plots (less than 0.71 acres on average cultivated per plot during the dry season), share water access that is controlled by a limited number of providers (2.6 pumps per village on average).

Alternate Wetting and Drying (AWD) is a simple technology that gives farmers a more accurate picture of water needs for their plots by measuring soil moisture below ground level with a perforated plastic pipe; when soil moisture drops below a certain level, farmers know the crop needs water. This is a common method used around the world and has been shown to reduce groundwater use without compromising crop yields.

Details of the intervention

Researchers conducted a randomized evaluation to test the impact of providing subsidies for a soil monitoring technology (AWD) on the electricity used to pump groundwater to agricultural fields in rural Bangladesh. Specifically, researchers offered subsidized AWD pipes in January 2019, during the rice planting season. To begin, they selected one pump in each of the 360 villages across nine subdistricts, or upazilas. Using the subdistricts to help standardize geographical differences across villages, the researchers randomly assigned farmers and sellers from selected villages to one of four different groups:

1. *Farmer subsidy*: In 105 villages, subsidies and information to adopt the AWD technology were offered directly to farmers, as done under the status quo government policy.
2. *Tube well owner subsidy*: In another 105 villages, the same subsidies and information were offered to tube well owners to test whether the technology would be used more effectively by water sellers as opposed to farmers.
3. *Joint decisions*: In the third set of 105 villages, farmers and tube well owners were invited to organized village meetings to make collective decisions on irrigation practices and frequency.
4. *Comparison*: The 45 villages assigned to this group did not receive any subsidy or invitations to the meetings.

In order to better understand the effect of the price of the technology on the outcomes measured, researchers offered two levels of subsidies covering the cost of 77 or 55 percent of the AWD pipes. About half of the villages received the high subsidy and another half received the low subsidy across the two subsidy groups described above.

In December 2018, researchers conducted surveys to collect data on electricity meter readings, location coordinates of the pump and irrigation area, and water prices from the previous season. The process was repeated in March and April 2019 in order to capture the end of season electricity use. They also collected information about agricultural production in previous seasons, copies of electricity bills to fill in missing data due to broken meters, and information on farmer and tube well owner relations, including on decision making processes for irrigation. Researchers repeated the data collection on electricity usage during a second season from December 2019 to April 2020.

Results and policy lessons

Researchers found that electricity use for pumping decreased when subsidies targeted tube well owners instead of farmers. This reduction in pumping, however, did not lead to a detectable change in farmer yields, indicating an improvement in water-use efficiency.

Adoption of AWD pipes: Uptake of AWD pipes was similar across the three intervention groups, meaning that farmers and tube well owners were similarly likely to purchase the pipes. Since the technology provides information on soil moisture, that information could be used across multiple adjacent plots and did not necessitate installation on each plot serviced by a water seller.

Resource use and efficiency: Targeting AWD subsidies to tube well owners reduced electricity consumption by 38 percent over two years, without compromising agricultural productivity. Similarly, electricity consumption decreased by 30 percent when subsidies were provided through village meetings. Overall, these results indicate an increase in efficiency as rice yields effectively did not change even with lower water use. Researchers suggest that this is because, in contrast to traditional flooding methods, gradual irrigation using information from AWD pipes allowed for more precise irrigation.

Yields and price pass through: Water sellers decreased the need for water pumping as a result AWD pipe adoption, which increased electricity savings. However, they did not lower the cost of water sold to farmers nor did they provide other benefits to farmers, such as increased flexibility for payments. Researchers suggest that this may be a result of water selling being a monopoly with the ability to set prices and ration quantities without competition, making it feasible for sellers to avoid adjusting to market changes to maintain customers in these villages.

Cost-effectiveness: At US$25.60 per ton of avoided CO2, researchers suggest that this was a highly cost-effective way of reducing emissions[3]. On average, sellers saved 2400 kwh in electricity use, and it is estimated that water sellers avoided US$115 in costs through farmers' use of AWD.

More broadly, this study points to the importance of targeting the right agents in order to reap benefits of technological change in agriculture. Many interventions for new ideas tend to go directly to the farmers for implementation. Instead of targeting end users, policymakers should consider incentives at different levels of the market, especially in contexts where farming is done on fragmented plots such as in the case of Bangladesh.

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3. Kenneth Gillingham and James H Stock, "The cost of reducing greenhouse gas emissions." Journal of Economic Perspectives 32, n. 4 (2018): 53–72, DOI: 10.1257/jep.32.4.53