Policy Brief

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Nick Hagerty and Ariel Zucker

Energy efficiency in smallholder agriculture

Do micro-irrigation systems deliver?

In brief:

- Promoting energy efficiency is a global priority, as it has promise to slow carbon emissions, aid in expanding energy access, and spur economic growth. However, investments in energy efficiency do not always deliver the expected benefits.
- Micro-irrigation systems are a widely promoted efficient technology with the potential to improve both water and energy efficiency in irrigated agriculture.
- A novel dataset linking irrigation hours, pump power, cultivation, and farm and household characteristics for 400 smallholder farmers in 44 villages in Gujarat, India shows that farmers using micro-irrigation systems (MIS) not only use more total energy, but also use more energy per area planted.
- Results from regression and matching methods suggest the increase in energy consumption is not explained by higher MIS adoption among high water-users. Alternative explanations include the failure to adjust pump power downwards for reduced irrigation needs or the poor maintenance of MIS pipes.
- Policymakers may benefit from dedicating resources to the efficient operation of MIS systems.

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Energy efficiency and micro-irrigation systems

Energy efficiency is a global priority, with the potential to slow carbon emissions and help expand energy access. In India, demand for energy is growing much more quickly than supply, and policies promoting energy efficiency are a key component of government strategies to maintain a robust energy ecosystem.

Micro-irrigation systems (MIS) are a technology with substantial potential to reduce energy consumption in India. MIS, referring to both drip and sprinkler irrigation, is thought to reduce the energy consumption required for irrigation by as much as 70 percent by efficiently delivering water in small doses directly to crop root zones, thereby reducing groundwater pumping.

However, investments in energy efficiency do not always deliver the expected benefits. One reason is that new technologies do not always deliver promised efficiency benefits under real-world conditions. Many technologies require complementary investments or behavioural changes to operate as designed, and users may not always dedicate the needed funds or efforts. Another reason may be the rebound effect, in which efficiency improvements from new technologies can encourage greater energy consumption, which offsets some of the gains. Evidence on the strength of both these effects in developing countries is slim.

Micro-irrigation may not deliver expected energy savings in India. MIS may be particularly susceptible to rebound effects in Gujarat. Farmers are often capacity constrained (by available groundwater or available electricity supply through agricultural feeders), and are likely to respond to efficiency gains by increasing consumption up to these constraints. In addition, farmers in Gujarat rarely face a marginal price for agricultural electricity. Without a financial incentive to conserve energy, they may be particularly unlikely to make complementary investments in maintenance, pump replacement, or gravity storage tanks that allow MIS to operate with less energy.

We evaluate whether MIS deliver energy savings in smallholder agriculture in India.

Overview of the research

The goal of the study is to study the energy efficiency gains from MIS. The research was a joint project of the Abdul Latif Jameel Poverty Action Lab (J-PAL) and the Aga Khan Rural Support Programme (AKRSP). We enrolled farmers in forty-four villages in Saurashtra, a water-scarce region in the western part of the state of Gujarat. In each village, we approached farmers who had previously interacted with AKRSP to participate in the study:

- Participating farmers received hours-of-use meters to measure their groundwater pumping.
- Meters readings were conducted by AKRSP field staff once per month for five months during the rabi irrigation season of 2018-19.
- J-PAL staff conducted a survey at the conclusion of the study to collect further information including micro-irrigation use, pump power, and farm size.

The ideal research design would involve an experimental comparison of farmers with and without MIS. In the absence of a controlled experiment, we use matching methods to try to create groups of MIS users and non-users who are observationally as similar as possible.

Research findings

1. **Energy consumption varies widely**. The modal farmer in our study group pumps around 20 hours per month, but many farmers pump more than 100 or fewer than 3 hours per month.

2. **MIS users consume more energy, and more energy per cropped area.** MIS users in our study group consume an average of 30 to 40 percent more energy per month than non-users of MIS. They also consume a similar amount more energy per area cropped.

3. **Increased energy consumption by MIS users is not explained by observed characteristics.** Our core finding does not change even after adjusting for a barrage of controls that describe the farm, household characteristics, and any unobserved factors that are common to a particular village.

Policy recommendations

- Expand monitoring of electricity and groundwater consumption. The first step to managing groundwater more sustainably is to understand how much, when, and where it is being consumed. Our study demonstrates that it is feasible to measure groundwater pumping for individual smallholder farmers for the cost of the meter (500-600 INR) and the meter reading visits.

- Consider increased training and extension for MIS users. The higher energy use per hectare among MIS users may indicate that the systems are being installed without appropriate complementary technologies or are maintained incorrectly. Providing greater access to ongoing education and maintenance services might improve the chances that the new technology leads to the hoped-for grid-scale reductions in energy consumption.