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Solar Irrigation for Agricultural Resilience

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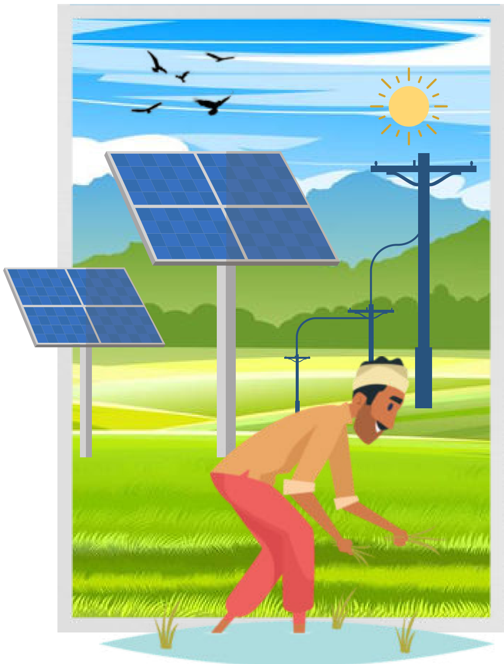

Pumping behavior of solar irrigation farmers for assessing the sustainability of groundwater in Bangladesh and India

The increasing use of Solar Irrigation Pumps (SIPs) has raised concerns about the overexploitation of groundwater. So, this study aims to evaluate the impact of SIPs on pumping behaviour of farmers and its subsequent effect on overall groundwater resources in Bangladesh and India. In Bangladesh, the study is being carried out in the intensively irrigated North-West region, where the government is promoting the fee-for-service model for solar irrigation. This model creates a solar irrigation command area by setting up centralized sponsored SIPs. In India, the study is being conducted in the state of Gujarat, where the grid-connected solar irrigation pump model has been implemented under the Suryashakti Kisan Yojana (SKY) scheme.

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Introduction

Groundwater pumping has encouraged unsustainable abstraction rates in regions of Bangladesh and India. Consequently, the anticipated rise in the use of Solar Irrigation Pumps (SIPs) leads to concerns of groundwater overexploitation. This, in turn leads to decreasing well yields and falling water tables. It is assumed that in the event of free electricity (solar) and no financial incentive to limit pumping, farmers will likely increase the volume of groundwater withdrawn. This may happen through overirrigation, expansion of the area under irrigation (for personal use or sale), or an increase in the area of high water-intensive crops (Hartung and Pluschke 2017).

However, changes in farmers' irrigation behavior depend on a range of factors, such as the type of solar irrigation model used (on or off-grid solar irrigation pumps), existing crop patterns, developed value chain markets, and biophysical factors such as water availability (which depends on the climate, aquifer type and groundwater tables). Therefore, understanding how farmers' pumping behavior changes with the introduction of solar irrigation is critical to determining the expected impact on groundwater sustainability.

This study evaluates the impact of SIPs on farmers' groundwater abstraction practices in Bangladesh and India as part of the Solar Irrigation for Agricultural Resilience in South Asia (SoLAR-SA) project.

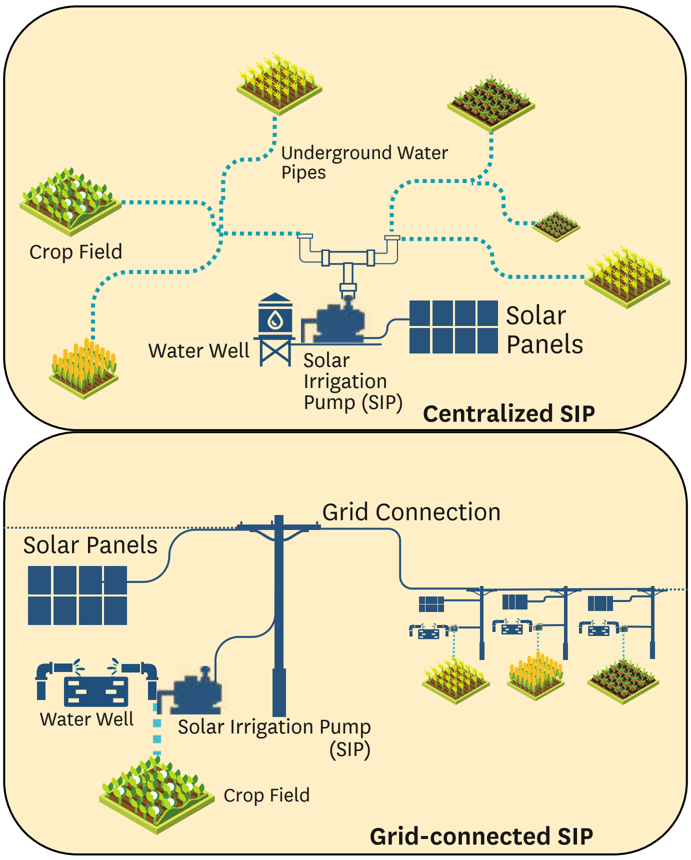

Figure 1. Schematic of a centralized SIP (top) versus a schematic of a grid-connected SIP (bottom).
Source: Illustration by Aariz Raza, IWMI.

Solar irrigation and groundwater in Bangladesh

In Bangladesh, the Infrastructure Development Company Limited (IDCOL) has taken the initiative to implement the fee-for-service model for solar irrigation. This model involves centralized sponsored SIPs with power ranging from 5 kW to 20 kW (Figure 1). These SIPs are centrally managed by a company that sells water to farmers in the designated command area through buried pipelines, replacing existing diesel pumps. There are plans to connect these SIPs to the grid in the future, and the operating company will have the option to evacuate excess energy based on a feed-in tariff.

However, there is concern that the relatively lower cost and ease of using SIPs, compared to diesel pumps, may increase groundwater abstraction. Currently, around 1.6 million pumps are used for groundwater irrigation in Bangladesh, with 80% being diesel pumps that irrigate approximately 80% of the total irrigated area. This is higher in the northcentral and northwest regions, which is at 94%. Most of this irrigation is used for water-intensive *boro* paddy cultivation, and the sustainability of groundwater irrigation in these regions is already under threat. The groundwater tables are still shallow in most wells but are declining, with about 65.7% of monitoring wells in the northwestern region showing a significant falling trend (Mojid et al. 2019). Additionally, increasing groundwater tables are breaching the suction- limit of approximately 6 meters, rendering shallow tube wells (which account for about 86% of total wells) technically inoperable for the whole year.

Against this backdrop, this study aims to evaluate the impact of SIPs on farmers' irrigation behavior and the subsequent effects on overall groundwater levels and resources. The study is being carried out in the most groundwater-stressed region of Bangladesh, namely the northwest (Rangpur and Rajshahi divisions) (as shown in Figure 2). In the dry season, *boro* paddy is the region's dominant and main water-consuming crop, primarily fed by groundwater.

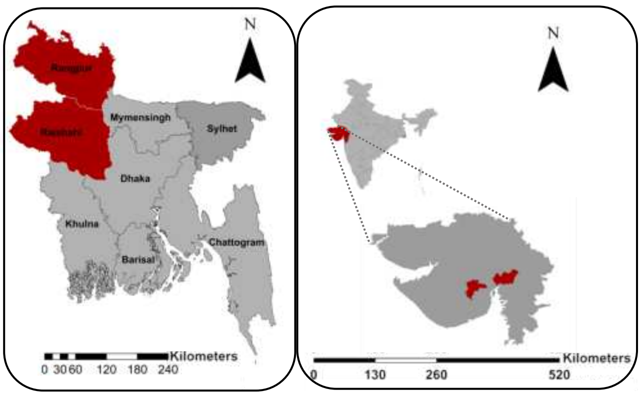

Figure 2. Study locations in Bangladesh (left) and India (right).
Source: IWMI India

Solar irrigation and groundwater in India

The Indian government is actively promoting solar irrigation through policies and programs. The flagship Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) scheme seeks to solarize 3.5 million irrigation pumps in total - 2 million through standalone solar pumps and 1.5 million by grid-connecting existing agriculture pumps. In the latter case, a solar photovoltaic (PV) module of appropriate size is installed in the farmer's field. The existing pump/connection is metered in net terms, measuring the difference between energy drawn from the grid for pumping and the excess energy generated that is sent back to the grid. As a result, the solar PV system generates and evacuates solar energy throughout the day but the pump only consumes electricity when it is operating. Any excess energy generated is sold back to the grid, thus incentivizing farmers to use energy (and water) more carefully and efficiently to maximize their income from selling energy.

It is critical to assess whether this grid-connected model of solar irrigation will ease or exacerbate the existing groundwater situation. Approximately 14 million electric pumps, mostly running on subsidized electricity, have played a vital role in the expansion of groundwater irrigation in India but have also led to uncontrolled groundwater overexploitation in many parts of the country. Groundwater in northwest and southern peninsular India, where most of these electric pumps are located, has seen widespread depletion. An assessment carried out by the Central Groundwater Board (CGWB) in 2022 revealed that 22% of assessed blocks, primarily in northwest and southern peninsular India, are categorized as either overexploited or critical (CGWB 2022). Continued unsustainable use of groundwater can reduce India's cultivated area by up to 20% and up to 68% in groundwater-depleted regions (Jain et al. 2021).

Given this context, this study evaluates the impact of grid-connected solar pumps on farmers' pumping behavior and its subsequent effect on overall groundwater resources. The study is being conducted in the state of Gujarat, where the grid-connected SIP model has been implemented under the Suryashakti Kisan Yojana (SKY) scheme. More than 90 feeders have been solarized, with over 75% of farmers' irrigation pumps now being powered by solar energy.

Solar panels in a village in Gujarat, India
photo: Keyur Rathod IWMI.

Measuring and comparing farmers' groundwater abstraction

The study is taking a slightly different approach in India and Bangladesh to account for the different solar irrigation models. The common denominator is comparing the abstraction behavior of solar farmers with that of non-solar farmers.

In Bangladesh, the water application of diesel and solar farmers for *boro* paddy, the main post-monsoon irrigated crop, is being monitored for 100 farmer plots (each for solar and diesel farmers) in six SIPs and nearby villages. These SIPs and diesel farmers were selected after initial surveys, during which detailed data on crops, land, soil and pump characteristics were collected. The water application is being monitored by combining instrumentation (flow meters in SIPs) and regular flow tests with farmer irrigation logbooks. SIP operators and diesel farmers were trained before the monitoring began.

A diesel pump in Birganj, Dinajpur village in Bangladesh
photo: NGO Forum for Public Health.

In India, the study uses an energy-based approach to monitor farmer groundwater use in India, utilizing state-of-the-art energy monitoring data from the SKY scheme. This approach relies on converting data on energy used for pumps (by farmers) to data on groundwater abstraction based on a set of defined relationships (Wang et al. 2020). The energy-water conversion factor (power consumed/volumetric discharge) is derived by testing a representative set of pumps at different times of the year. The monitoring of approximately 160 farmers is being carried out, including comprehensive data collection on their pumps, crops, pump flow rates and energy use. This data is being used to derive current and past groundwater abstraction for a larger set of solar and non-solar farmers.

Now, data for two years (2021-22 and 22-23 cropping season) has been completed and analysis is under way.

This analysis will involve comparing the groundwater abstraction behavior of solar and non-solar farmers in India and Bangladesh. These results will be of great interest to policymakers, researchers and practitioners working in the field of sustainable agriculture and water management, as they will provide valuable insights into the potential of solar irrigation to address the groundwater depletion challenge in India and Bangladesh.

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Project

The Solar Irrigation for Agricultural Resilience in South Asia (SoLAR-SA) project aims to sustainably manage the water-energy and climate interlinkages in South Asia through the promotion of SIPs. The main goal of the project is to contribute to climate-resilient, gender-equitable, and socially inclusive agrarian livelihoods in Bangladesh, India, Nepal and Pakistan by supporting government efforts to promote solar irrigation. This project responds to government commitments to transition to clean energy pathways in agriculture. All countries in this project have NDC commitments to reduce GHG emissions and SIPs can play a significant role in reducing emissions in agriculture. https://solar.iwmi.org/

About SDC

The SoLAR -SA project is supported by the Swiss Agency for Development and Cooperation (SDC). SDC is the agency for international cooperation of the Federal Department of Foreign Affairs (FDFA). Swiss Agency for Development and Cooperation, which is an integral part of the Federal Council's foreign policy, aims to contribute to a world without poverty and in peace, for sustainable development. SDC, through its Global Programme Climate Change and Environment (GPCCE), helps find solutions to global challenges linked to climate change. It engages in global political dialogue and manages specific projects in the fields of energy, climate change adaptation, sustainable development of mountainous regions and prevention of natural hazards that are likely to influence regional and international policy.

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The International Water Management Institute (IWMI) is an international, research-for-development organization that works with governments, civil society and the private sector to solve water problems in developing countries and scale up solutions. Through partnership, IWMI combines research on the sustainable use of water and land resources, knowledge services and products with capacity strengthening, dialogue and policy analysis to support implementation of water management solutions for agriculture, ecosystems, climate change and inclusive economic growth. Headquartered in Colombo, Sri Lanka, IWMI is a CGIAR Research Center with offices in 14 countries and a global network of scientists operating in more than 30 countries.

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