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Solar Irrigation for Agricultural Resilience

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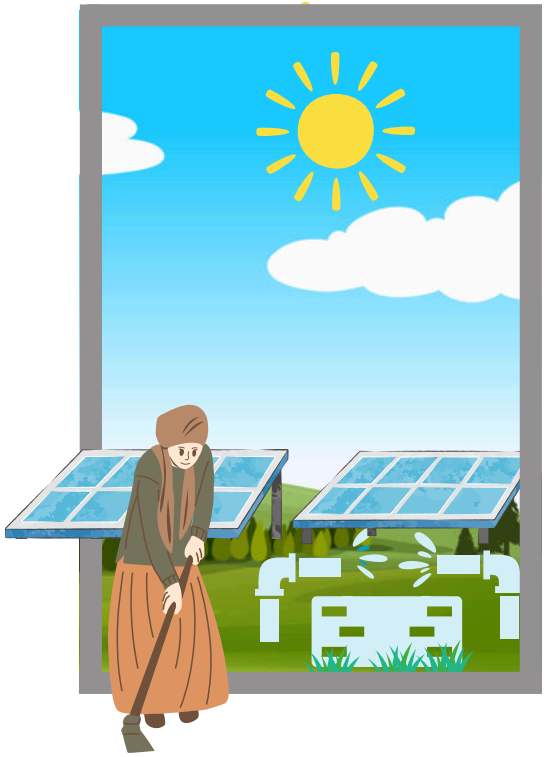

Promoting sustainable agriculture through feed-in tariff policy in Pakistan: Solar irrigation pumping for enhanced crop diversification

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This project brief highlights sustainable irrigation methods along with the potential benefits of promoting solar-powered irrigation systems in Punjab, Pakistan. To promote the broad adoption of ecologically sustainable farming methods, the brief stresses the need to create a legislative framework that gives suitable incentives to farmers to improve their living conditions and increase the variety of crops they grow. In this regard, a feed-in tariff (FIT) policy that supports solar irrigation pumps (SIPs) might reduce financial costs and the dependency on nonrenewable fossil fuels, thereby incentivizing farmers to save groundwater resources and sell power back to the grid by implementing a feed-in tariff rate of Rs. 20/kWh for SIPs in Pakistan.

The agriculture sector has garnered widespread recognition for stimulating the water, energy and food nexus, and it has become an essential constituent of sustainable development initiatives (Hartung and Pluschke 2018). Irrigation accessibility is indispensable in facilitating sustainable agricultural expansion and ensuring food security while promoting climate-resilient livelihoods. Globally, advancements have been made to technological innovations in irrigation to enhance agricultural productivity and address the escalating energy requirements linked to machinery and irrigation systems. These advancements influenced augmented farming commodities and mitigated energy demands in the agriculture sector. However, such technological advancements necessitate the establishment of sustainable irrigation-energy frameworks and emphasize the integration of renewable energy, specifically solar technology, into the agriculture sector (UNECE 2020).

Groundbreaking technological innovation and climate-resilient solutions led to a notable decline in carbon footprints. This substantially mitigates escalating fuel expenditures, while supporting livelihood diversification and addressing the dynamic requirements of a shifting climatic landscape. Given the extensive assimilation of renewable energy resources, it is important to incorporate sustainability objectives and multifaceted agendas into the decision-making process. To facilitate the widespread adoption of environmentally sustainable agricultural practices and to promote the cultivation of diverse crops, it is important to devise a regulatory framework that offers suitable incentives to farmers. Thus, executing such initiatives can yield improvements across various facets of agricultural operations, encompassing cultivation procedures, processing infrastructure for farming commodities, utilizing state-of-the-art machinery and adopting renewable energy systems (Goel et al. 2021). This policy brief analyses the prospective benefits that can be achieved by executing incentive-based solar irrigation practices.

'73% of the land area in Pakistan is irrigated using groundwater which stands at 60 billion m . This has resulted in overexploitation of groundwater resources due to the lack of a comprehensive national policy on the utilization of groundwater pumping in Pakistan (Shah and Akbar 2021)'

In a developing country such as Pakistan, small-scale landholding farmers have difficulties meeting crop water requirements through critical periods of a cropping cycle. This is due to escalating energy costs, specifically diesel and electricity, and frequent disruptions in energy supply. This has increased the demand for solar irrigation pumps (SIPs), characterized by an absence of fuel expenses while conserving grid electricity and removing the inflated demand for diesel in geographically isolated regions. Pakistan observed a widespread implementation of solar-powered irrigation, where farmers employed solar irrigation pumps (SIPs) leading to a notable improvement in water management. However, it is important to sustainably expedite the adoption rate of SIPs to enhance agricultural productivity throughsustainable solutions (Raza et al. 2022). There is sufficient evidence to show that farmers who implement environmentally conscious methodologies exhibit a positive correlation with the acquisition of financial aid from governmental and nongovernmental entities. This correlation is attributed to the mitigation of economic constraints experienced by farmers, hence facilitating an increased inclination towards cultivating a wider variety of crops (Di Bene et al. 2022; Serebrennikov et al. 2020; Kassie et al. 2015).

The utilization of SIPs, through a feed-in tariff (FIT) policy, has been identified as a viable means to facilitate and advance agricultural growth as this will provide the farmers with an extra stream of income, and help them recover their investments in solar systems quickly. SIPs can harness energy from sustainable and renewable resources, decreasing farmers' dependency on nonrenewable fossil fuels. Moreover, a larger percentage of arable land can be utilized to cultivate diversified crops given the critical nature of mono-cropping, and its susceptibility to pesticide attacks and market fluctuations (Akram and Asif 2020).

A female farmer using a solar irrigation pump in Saroba village, Pakistan (*photo*: IWMI Pakistan).

Ramsha Bano, a farmer in Saroba village, Chakri District, Pakistan, tends to her kitchengarden using a SIP and grows various seasonal and off-season vegetables and fruits. By using a SIP, she generates a higher income since she saves the cost of fossil fuel to run a diesel pump and sells the produce in the local market. She could further increase her income if she had access to selling the electricity produced by the installed SIP when it is not in use. Her water requirements for producing vegetables are minimal and most of the time she has access to free electricity which can be used to generate extra income.

Among the 1.2 million installed tube wells in Pakistan, farmers exhibit a preference for diesel-powered tube wells, owing to lower installation expenses in contrast to electric tube wells for groundwater extraction.

A solar irrigation pump site at National Agricultural Research Centre (NARC) Chak Shahzad Islamabad, Pakistan (*photo*: IWMI Pakistan).

This brief determines the FIT rate threshold for the sale of electricity that would dissuade farmers from engaging in the overextraction of groundwater resources. Research conducted by International Water Management Institute (IWMI) on remunerative crops in Rahim Yar Khan, Jhang and Chakwal districts in Pakistan evaluated the behavioral preferences of farmers that refrain from water pumping and engaging in selling electricity to the grid instead, utilizing a FIT rate as a determining factor specifically during the *kharif* season. The research found that to optimize the efficacy of on-farm energy utilization, implementing a FIT rate of Rs. 20/kWh or higher was attractive enough to encourage farmers to sell electricity rather than pump more water. Farmers seem not to refrain from pumping at rates lower than 20/kWh. The approach demonstrated the likelihood of implementing environmentally sustainable farming techniques effectively, encouraging widespread adoption of renewable energy resources and helping the cause for better groundwater governance.

To establish a comprehensive FIT policy in Pakistan that aligns with the requirements of SIPs including (but not limited to) size, efficiency and cost-effectiveness, the government authorities must analyze the objectives and qualifications and consider a FIT rate of Rs. 20/kWh or higher. This rate was determined after conducting choice experiments with different tariff structures to identify farmers' preferences. Putting a FIT policy in place requires connecting SIPs to the grid which can only be achieved through government support and a proper policy in place. Also, an examination of the financial allocation to acquire excess electrical energy from agricultural producers, considering energy subsidies and fiscal disbursement, needs to be conducted (Sunny et al. 2023). Knowledge propagation and cultivating comprehension through synergistic linkages among relevant stakeholders through awareness campaigns, and capacity enhancement endeavors concerning the importance of preserving water resources, and the benefits linked to the implementation of SIPs are equally important. To efficiently manage the surplus solar energy from the agriculture sector, it is vital to create and maintain a resilient grid infrastructure (Padole et al. 2022).

Implementing a consistent source of income will be a driving force for investing funds into solar-powered agricultural systems in Pakistan. Pakistan can balance agricultural development and the conservation of water resources by adopting a FIT policy rate of Rs. 20/kWh or higher, promoting water use efficiency and prioritizing integrated water resource management. The adoption of an alternative energy source is anticipated to yield favorable outcomes in terms of greenhouse gas (GHG) emission reduction, thereby playing a vital role in the amelioration of climate change consequences. This initiative will enhance the accessibility of SIP systems to a diverse group of farmers across demographic categories, creating opportunities for agricultural improvement.

A farmer using the Solar tube well at Rahim Yar Khan, Punjab Province (*photo*: Amjad Jamal/IWMI).

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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 15 countries and a global network of scientists operating in more than 55 countries.

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