IWMI
International Water Management Institute

Photo: Prashanth Vishwanathan/IWMI

Solar-powered irrigation:
Adding value through a business model approach

The solar revolution in a new context

Solar power is poised to revolutionize water use in agriculture, providing an attractive means for farmers to irrigate their crops. The International Water Management Institute (IWMI) has demonstrated the potential to add value through a variety of applications, drawing on its multidisciplinary expertise and wealth of experience in research for development.

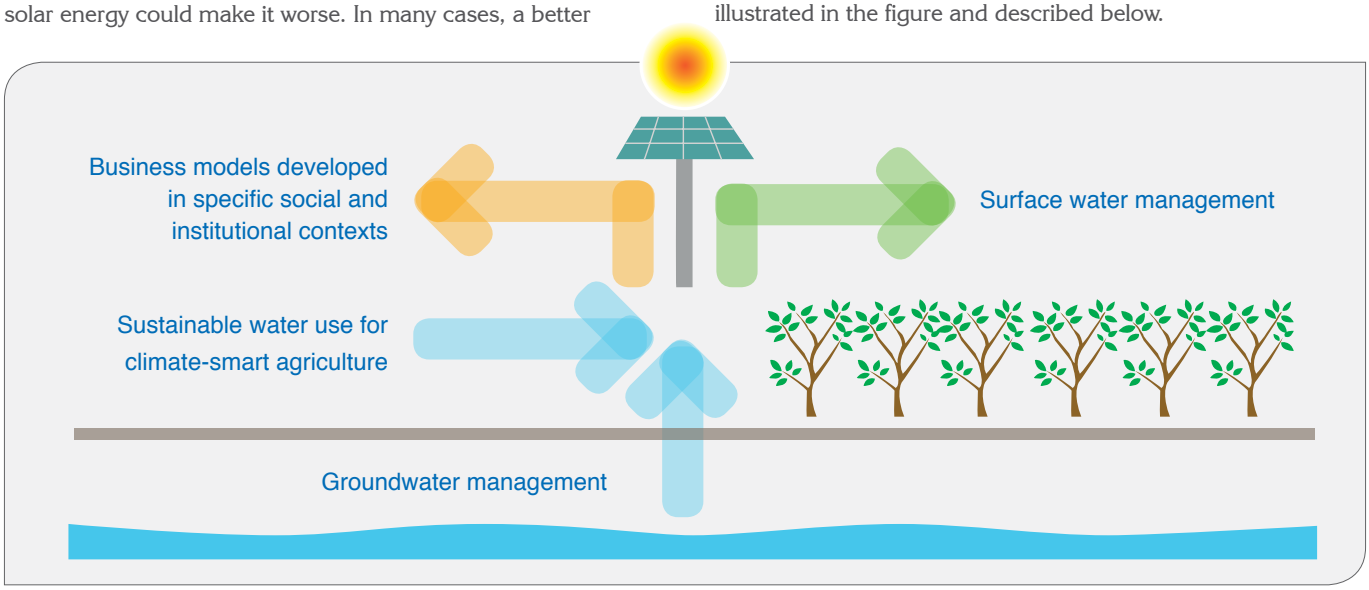
Given the highly variable cost of fossil fuels, solar panels today offer farmers a cheap and renewable source of power for pumping water, whether from ground or surface water bodies. While larger pumps make it possible for service providers to deliver irrigation to others, smaller units create the potential for smallholders in rainfed agriculture to provide supplementary irrigation, thus boosting productivity and enhancing resilience.

Solar-powered irrigation may seem like an easy win, particularly with governments under pressure to reduce carbon emissions and feed growing populations. However, over-abstraction of groundwater is already a problem in many parts of the world, and uncontrolled pumping with "free" solar energy could make it worse. In many cases, a better understanding of the groundwater resource would help avoid wasted investments.

As farmers adopt solar pumping on a large scale, governments need to create new institutional and regulatory frameworks, and use "smart" incentives to safeguard water resources and capitalize on the long-term potential of solar technology. A further requirement is business models for solar irrigation, which offer opportunities for farmers to look beyond conventional sources of incomes. Each case is context specific and needs to capitalize on local potential, while avoiding adverse environmental and social impacts. Innovative financing mechanisms and comprehensive planning can add significant value, helping to achieve sustainability and equity objectives in the use of surface and groundwater resources.

A unique mix of expertise

IWMI has more than three decades of experience in managing and implementing multidisciplinary research-for-development projects on agricultural water use. To support decisions on investment in solar-powered irrigation, we provide objective analysis and advice across five interrelated aspects, as illustrated in the figure and described below.



IWMI's integrated approach to solar-powered pumping for irrigation.

Business model development

In order for solar power to succeed in providing green energy, ensuring sustainability and improving farmers' livelihoods, new systems must not only be attractive to farmers financially but also encourage sustainable management practices. IWMI develops novel business models to guide decisions on investments in solar-powered irrigation. Governments, financing organizations, farmers and private-sector suppliers all have a role to play in implementing business models that provide solutions.

Social and institutional context

IWMI's many years of experience have given our staff a deep understanding of the local institutional and social contexts in which business models must operate. We deploy a variety of tools and extensive knowledge to the task of analyzing and resolving social and behavioral factors (such as power relations, land and water governance, and gender perspectives) that affect the success of agricultural innovations.

Sustainable water use for climate-smart agriculture

Strong expertise in sustainable water management enables IWMI to assess a wide range of options – from water abstraction and storage to optimizing water use in irrigation – for helping smallholders use water productively. Such practices are critical for making agriculture climate smart, with steadily increasing productivity, greater resilience to climate change, lowered energy use, and reduced greenhouse gas emissions.

Groundwater management

IWMI's research for development encompasses all aspects of groundwater use:

- Mapping resources, understanding aquifer hydrology, and modeling groundwater response to changes in irrigation
- Advising on context-appropriate technologies for pumping
- Assessing linkages across the water-energy-food nexus
- Development of managed aquifer recharge mechanisms to store water
- Designing financing mechanisms to minimize negative environmental impacts and promote sustainable water use

Surface water management

IWMI research provides an in-depth understanding of natural (wetlands, floodplains and watersheds) and built (levees, dams and irrigation channels) surface water infrastructure at all scales. In the context of solar-powered irrigation, our research provides insights on:

- What happens to water once it is extracted, how water is used and why it is misused
- How water can be used most effectively and equitably for agriculture, and what techniques farmers can use to store and conserve it
- The water quality implications of return flows from irrigated agriculture

Putting our capacity to work

IWMI's work is giving rise to a growing set of business models for different situations. The main distinction between them is that some are applicable for "off-grid" situations (i.e., areas without electricity or with poor levels of service) and some for "on-grid" situations (i.e., where the electricity utility offers opportunities for buy-back of surplus power from the solar irrigation installation). We are developing other models as well, including a decentralized-grid model, which combines features of the on-grid and off-grid models with the potential to supply energy for small-scale domestic enterprises.

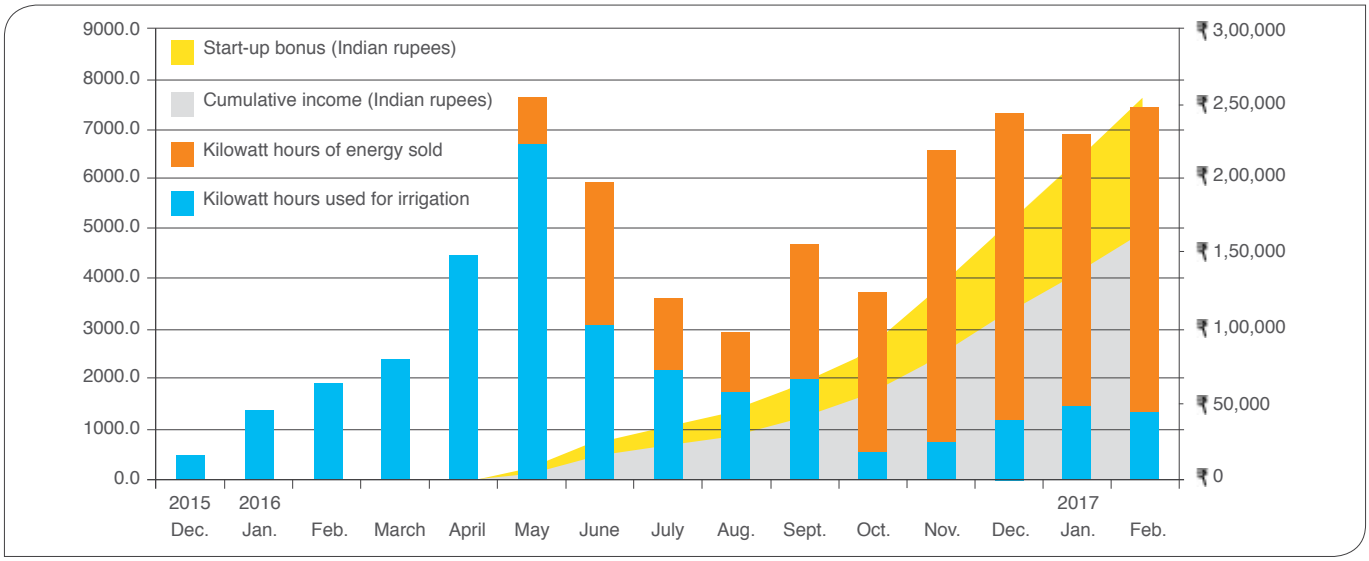
On-grid model – A cooperative that irrigates crops and sells surplus power

In Gujarat, India, the IWMI-Tata Water Policy Research Program (a longstanding collaboration between the Institute and the Tata Trusts) has developed an on-grid business model suited to a groundwater-scarce region where farmers currently get free or highly subsidized electricity for pumping.

Since experience with subsidized electricity shows that many farmers take more irrigation water than they need, our concern was that unrestrained solar pumping would soon worsen the depletion of groundwater resources. In response, we proposed to farmers the option of selling surplus electricity generated by solar panels to the electricity utility, thus creating an incentive to use water more efficiently.

In collaboration with local partners, we established a pilot project in Kheda district with six farmers, each growing wheat, paddy and vegetable crops on plots of about 0.4 hectares. The solar pumps were connected to a micro-grid, which in turn was linked to the national grid at a single metered point. Each farmer contributed 10% of the capital cost of the equipment, which the government subsidized as part of a carbon mitigation program.

The farmers formed the Solar Pump Irrigators Cooperative Enterprise (SPICE), which is selling back surplus solar power under a 25-year agreement with the local power company. The farmers no longer need to use their diesel pumps and are responding favorably to the new approach, as evidenced by the shift in energy use for agriculture (blue bars in the figure) and energy sales to the utility (orange bars).



Response to new incentives for efficient irrigation in Gujarat, India.

Off-grid model: Solar service providers help expand crop production

In Bihar, India, the IWMI-Tata Program developed a business model tailored to the needs of farmers in an area where groundwater is plentiful but electricity is not available to farmers and the high cost of diesel contributes to low agricultural productivity. Under this off-grid system, solar-Irrigation Service Providers (sISPs) in Chakhaji village were supplied with a large solar pump and a network of buried pipelines, which they are paying for in installments. The sISPs work in competition with each other in the village to help keep water prices low and encourage farmers to expand agricultural production.

With significant cumulative revenues and savings of cash that otherwise would have been spent on diesel for irrigation, the sISPs are enthusiastic about the model. Several diesel pumps in the vicinity have gone out of operation. IWMI forecasts that water market turnover will grow three to fourfold. Once a few farmers decide to expand production, others will likely follow suit. At this point, it will be viable for the sISPs to invest in more pipeline, so they can expand the service area of their businesses.

Off-grid individual pump model – Solar-powered irrigation in Ethiopia

In sub-Saharan Africa, solar power represents a promising option for irrigation in remote areas, but much work is needed to determine suitable technology packages for specific locations and opportunities for implementation. IWMI undertook a comprehensive study on the feasibility of solar irrigation in Ethiopia, taking into account biophysical factors, water availability and infrastructure to construct a solar irrigation suitability map.

For areas with potential for solar-powered irrigation, researchers evaluated environmental and economic sustainability; finance mechanisms; the institutional, policy and regulatory context; and the technology supply chain. The study tested eight solar pump installations for smallholder irrigation in selected regions.

From these studies, IWMI developed three business models for Ethiopia:

1. ***Individual farmers*** buying solar pumps for their own use, with micro-financing and the possible sale of surplus water (alternatively, with cost-sharing by farmer groups)
2. An ***out-grower or insurance scheme*** model, using commercial loans or micro-finance (applicable to agro-companies, particularly out-grower schemes with contracted farmers, that may be interested in investing in solar irrigation pumps)
3. A ***supplier model*** with micro-financing or commercial loans (viewed mainly from the perspective of solar irrigation pump suppliers)

While all the models for Ethiopia show promise, the current institutional, regulatory and financial landscape poses constraints for widespread adoption. Aspects of the current institutional framework will be addressed with the government, including adjustments to facilitate better access to solar irrigation for women.

Farmer Raman Parmar operating the switch that supplies energy generated by solar panels to the main grid at Thamna village, Anand district, in the Indian state of Gujarat.
Photo: Prashanth Vishwanathan/IWMI

Portable solar-powered pump for irrigation at Jawe community (kebele) in Lemo district (woreda) of Ethiopia's Southern Nations, Nationalities, and Peoples' Region.
Photo: Apollo Habtamu/International Livestock Research Institute (ILRI)

The way forward

Solar irrigation is expanding, with governments, donors, non-government organizations, other implementing agencies, technology manufacturers and suppliers, and farmers expressing keen interest. At IWMI, we believe the business model approach offers new insights and adds value to more traditional development models, which too often focus on technology alone. Environmentally and economically sustainable development of solar-powered irrigation has much potential to increase agricultural productivity, enhance livelihoods, and foster economic growth, while addressing resource constraints.

Having developed business models for solar irrigation in India and Africa, we are now expanding this work in collaboration with public and private sector partners. As an independent broker working across sectors to stimulate action, we welcome new interest in partnerships.

Our team

- Zenebe Adimassu – Agricultural water management (Ghana)
- Alvar Closas – Groundwater governance (Egypt)
- Nicole Lefore – Capacity building and business models (South Africa)
- Ian Makin – Irrigation (Sri Lanka)
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RESEARCH PROGRAM ON Water, Land and Ecosystems

CGIAR Research Program on Climate Change, Agriculture and Food Security — CCAFS

IWMI is a CGIAR center focused on research for development. CGIAR is a global research partnership for a food-secure future. Its work is carried out by 15 research centers in collaboration with hundreds of partners across the globe. www.cgiar.org

IWMI research on solar-powered irrigation forms part of two CGIAR Research Programs – Water, Land and Ecosystems (WLE), which IWMI leads, and Climate Change, Agriculture and Food Security (CCAFS), supported by the CGIAR Fund. Our work in India also receives financial support from the Tata Trusts.

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