International Water Management Institute

Water Issue Brief - 22

Putting research knowledge into action

Adaptive Innovation Scaling - Pathways from Small-scale Irrigation to Sustainable Development

Scaling solar-based irrigation in Ghana's Upper East Region: A demand-supply linkage approach

The context

Numerous innovative solutions exist to increase agricultural productivity, enable irrigated farming and enhance water management under changing climatic conditions. However, most solutions are not available on a large scale to smallholder farmers and marginalized groups such as women and youth. Scaling these solutions, such as solar-based irrigation, requires co-identifying and co-developing 'best-fit' innovation bundles that are affordable, accessible and relevant to the local context. It also requires co-developing and operationalizing a scaling pathway based on strong demand-supply linkages along agricultural value chains.

Key messages

- A best-fit bundle of solar-based irrigation technologies and services was co-identified that addresses many of the current barriers to solar-based, farmer-led irrigation.
- A scaling pathway was then co-developed to link demand and supply for the bundle along the irrigated vegetable value chain.
- Although specific to the Upper East Region, the bundle is adaptable and scalable to other regions in Ghana.

Key issues

The potential of solar-based irrigation to increase agricultural productivity and reduce poverty has long been recognized in countries with insufficient and unreliable power grids, abundant sunshine, and scarce or unpredictable water resources. However, large-scale access to solar-based irrigation technologies by smallholder farmers and vulnerable groups such as women and youth is often complicated by weak supply chains, high upfront investment costs, a lack of access to suitable financing and a poor understanding of local market needs. Moreover, limited access to output markets for irrigated agricultural products discourages farmers from investing in solar-based irrigation.

In Ghana's Upper East Region, the International Water Management Institute (IWMI) worked with farmers, public and private sector actors, and other stakeholders in the irrigated vegetable value chain (IVVC) to co-identify a 'best-fit' bundle of solar-based irrigation technologies and services (Minh et al. Forthcoming). The bundle addresses many of the current barriers to solar-based, farmer-led irrigation. A scaling pathway was then co-developed and operationalized to link demand and supply along the IVVC and thereby extend the reach of the bundle throughout the Upper East Region and beyond.

Farmers attend a Pumptech field demonstration in Bawku, Ghana (*photo:* Thai Thi Minh/IWMI).

Constraints to innovation adoption

Irrigated vegetables are commonly grown in the dry season (November to March), although market demand is always strong. Depending on the income these crops generate, farmers regard them as high- or low-value vegetables. Low-value vegetables are mainly leafy greens such as amaranth, bitter leaf and hibiscus. Women see these vegetables as 'their crops', which they grow in small home gardens primarily for their own consumption. Any surplus is sold at local markets. High-value vegetables include pepper, eggplant, onion, tomato, watermelon, okra and cabbage, which are considered cash crops in the dry season. Men typically grow high-value vegetables, which require a significant investment throughout the cropping season in the form of inputs (such as fertilizers and pesticides), irrigation and labor.

Farmers use different water sources to cultivate irrigated vegetables, including dams, small reservoirs and wells or boreholes. They also use a variety of irrigation equipment such as buckets and watering cans, treadle pumps, petrol or diesel pumps, solar-powered pumps, open gravity systems and drip irrigation systems. Buckets, watering cans and treadle pumps are labor and time intensive and limit the area a farmer can irrigate. Petrol and diesel pumps help reduce the labor and time needed for irrigation but come with a myriad of challenges. They include noise and environmental pollution, high fuel costs, substantial maintenance and repair costs, and the need for replacements after three to five years of continuous use.

Another challenge for irrigated vegetable production is water availability. By February, dams and other surface water reservoirs have dried up. Although groundwater resources are abundant, the cost of drilling a borehole and buying a motorized pump is too high for many farmers. As a result, vegetable cultivation beyond February is rare. In addition, the high cost of inputs is a constraint to irrigated vegetable production. Farmers often use more chemical fertilizers, pesticides and insecticides in the dry season to enhance crop growth.

Action research approach to scaling

Under the Innovation Lab for Small-Scale Irrigation (ILSSI) and Africa Research in Sustainable Intensification for the Next Generation (Africa RISING) projects, and the CGIAR Research Program on Water, Land and Ecosystems (WLE), which ended in December 2021, IWMI used an action research approach to co-develop the best-fit innovation bundle and scaling pathway. The approach has four interrelated steps: analyze, co-develop, engage and reflect (Minh and Schmitter 2020). Together, the steps aim to provide a better understanding of the local context and engage stakeholders in co-developing solutions to the identified challenges. The engage and reflect steps are repeated throughout the process to ensure solutions are relevant and continually improved. The following sections provide an overview of the best-fit innovation bundle identified and the demand-supply linkage pathway co-developed to scale the bundle.

Scalable solar-based irrigation bundle

The analyze and co-develop steps of the action research approach determined the best-fit solar-based irrigation bundle for the IVVC (Figure 1). Although specific to the Upper East Region, the bundle is adaptable and scalable to other regions in Ghana. It comprises solar-powered irrigation pumps, a pay-as-you-own (PAY-OWN) flexible financing modality, and pre- and after-sales services.

Solar-powered irrigation pumps of varying capacity and price are imported from Germany and distributed in Ghana by Pumptech, a private irrigation equipment supplier. The pumps are designed specifically for off-grid water pumping and sold as

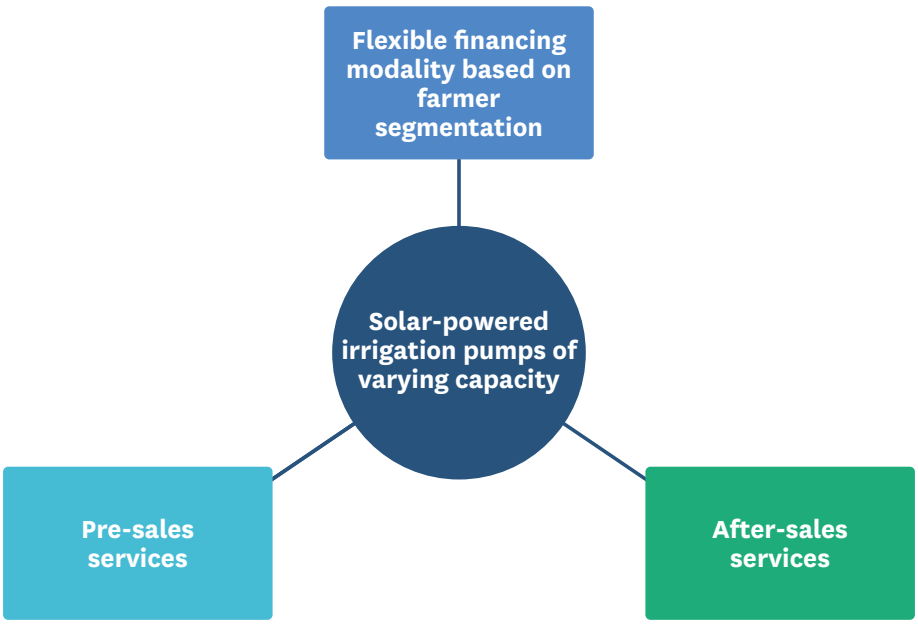

Figure 1. Elements of the solar-based irrigation bundle.

a package, which includes the pump, motor and solar panels. The pumps can be linked to an interactive app to collect data on pump use. This allows farmers to monitor water usage and reduce waste. In addition, the ability to operate the pumps remotely using a mobile device gives farmers flexibility and saves time for other activities.

The PAY-OWN ***flexible financing modality*** allows farmers to use the irrigation equipment while making small, regular payments until the total cost of the pump is paid off. The modality allows more farmers to overcome the initial capital barrier to acquire solar technology. All pumps can be sold under a PAY-OWN arrangement and connected to the interactive app, which also tracks payments.

Pre-sales services help customize the type of pump and accessories to fit a farmer's land size, water access and financial capital. These services for individual farmers or groups include a field investigation to identify the land size and irrigated crops, water source, existing irrigation investment and irrigation plan.

After-sales services cover various activities such as pump installation, training on pump operation and maintenance, and remote monitoring of pump performance.

Farmer segments for the irrigation bundle

The analyze and co-develop steps also identified four different farmer segments who stand to benefit from the solar-based irrigation bundle. The segments are resource-rich farmers, mobile farmers, resource-limited farmers and farmer groups (Table 1). Capturing farmer segments is critical for pump suppliers to diversify their supply models and to target specific segments with the most suitable pumps.

Table 1. Farmer segments and their characteristics.

Characteristics	Resource-rich farmers	Mobile farmers	Resource-limited farmers	Farmer groups
Land and water access	• Own a relatively large land area • Able to control water sources	• No ownership of irrigated land • Access mainly to surface water	• Permanent access to cultivated land • Access mainly to groundwater	• Individual ownership of cultivated land with possible access to common land for collective production • Access mainly to groundwater
Irrigation and production arrangement	• Advanced irrigation system managed by individual farmer	• Individual or informal group management	• Individual/group management • Potential to expand production	• Individual or collective management
Irrigated vegetable value chain	• Focus on high-value vegetables	• Flexible in terms of irrigation and irrigated crops	• Mainly cultivate leafy green vegetables	• Mainly cultivate leafy green vegetables for regular cash income
Marketing	• Diverse marketing and access to market information to manage price-related risk	• Direct sale at farm gate	• Direct sale at markets and farm gate	• Direct sale at markets and farm gate
Financial capital and potential	• High potential to invest in solar-powered irrigation as an individual	• Relatively high potential to invest in solar-powered irrigation pumps • Individual or group investment	• Very limited financial capital, especially women farmers • Limited potential to invest in solar-powered irrigation pumps	• Limited financial capacity to invest in solar-powered irrigation pumps • Potential to invest collectively in relatively high-capacity solar-powered irrigation pumps
Pump preferences	• High-capacity pump with payment schedule	• Low-capacity and movable pump • Pump with or without payment schedule	• Low-/medium-capacity pump and multiple uses	• Medium-/high-capacity pump • Multiple uses depending on collective financial management and mobilization

Source: Ofosu and Minh 2021.

Co-designing the scaling pathway

Based on the results of the co-develop step, IWMI partnered with Pumptech and the Regional Agricultural Department of the Ministry of Food and Agriculture (MoFA) to co-design a demand-supply linkage scaling pathway to scale the solar-based irrigation bundle (Figure 2) and operationalize the pathway with other partners.

As a private sector partner, Pumptech supplies PAY-OWN pumps to farmers and establishes sales and service networks to expand its market in the Upper East Region. As a public sector partner, the Regional Agricultural Department helps increase Pumptech's visibility by mobilizing other actors in the IVVC. As the research partner, IWMI provides knowledge, expertise, tools and services to de-risk investment for Pumptech, and develops inclusive business models for solar-based irrigation that target marginalized market segments and boost sustainable market development for solar-based irrigation. The demand-supply linkage scaling pathway consists of four components, as described below.

1. Establish sales and service networks

This is a core component of the scaling pathway and aims to upgrade the existing network of actors involved in supplying solar-powered irrigation pumps. In the current network, linkages between different actors are weak and fragmented. The ideal network involves the active participation of all actors such as pump distributors, borehole drillers, input dealers, innovative farmers and output offtake companies. In the ideal scenario, nongovernmental organizations and government-funded projects complement the activities of these actors.

IWMI co-organized demand-supply linkage workshops in the towns of Navrongo, Bawku and Bolgatanga to bring these actors together and establish stronger network linkages. In total, workshop participants suggested 144 individual farmers and 15 farmer groups as potential customers for Pumptech. Several participants also expressed an interest in becoming sales and service agents for the company. Three WhatsApp groups were set up to sustain and expand these networks. In addition, Pumptech introduced a commission scheme as an incentive to increase sales through both existing and newly established networks. Moreover, Pumptech and MoFA are collaborating to lead the future organization of district-level workshops.

2. Increase visibility and outreach

This component aims to promote solar-based irrigation products and services in the region as well as tailor pump supply models to specific market segments. To achieve this, Pumptech organized a series of field demonstrations and is building awareness of its pumps through farmer meetings, WhatsApp groups and extension delivery, among other channels. In collaboration with MoFA, Pumptech also opened a new regional branch office in September 2021. Overall, these efforts helped Pumptech to achieve an 80% increase in pump sales in 2021 compared to 2020 (WLE 2021).

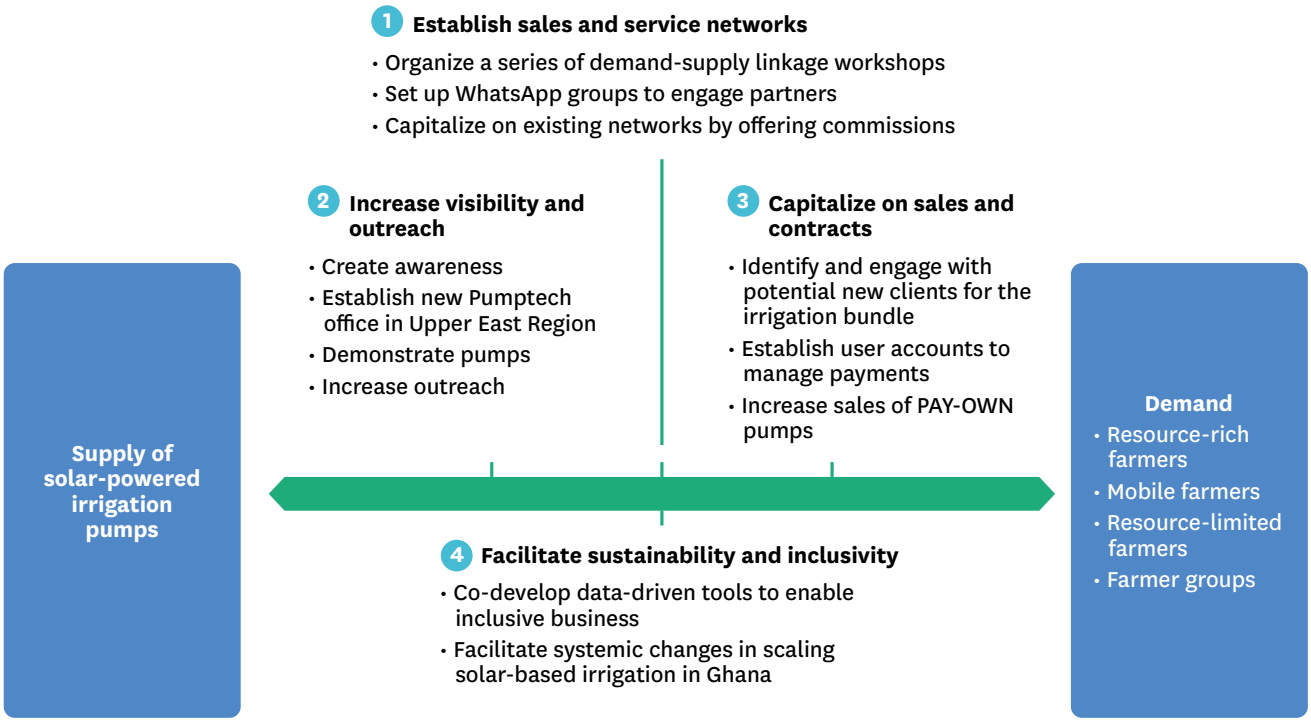

Figure 2. Demand-supply linkage scaling pathway for solar-based irrigation.

Participants in the demand-supply linkage workshop in Bolgatanga, Ghana (*photo:* Thai Thi Minh/IWMI).

3. Capitalize on sales and contracts

This component aims to increase pump sales in the Upper East Region and Ghana, in general. The opening of the new branch office allows further tailoring of the solar-based irrigation bundle to diverse farmer segments and closer engagement with high-potential individuals and groups identified during the demand-supply linkage workshops and elsewhere. In addition, Pumptech partnered with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) to de-risk its own investment in PAY-OWN pumps. Specifically, GIZ subsidizes 50-60% of the pumps sold under the PAY-OWN scheme to reduce Pumptech's risk in the event that a farmer defaults on payments.

4. Facilitate sustainability and inclusivity

This component aims to ensure the sustainable and inclusive scaling of solar-based irrigation. A key aspect of the component is the co-development of data-driven tools that enable private sector partners to target their products and services to the right people in the right way. These tools include client segmentation, digital marketing and data management, and customization of solar suitability mapping.

Targeting is particularly relevant when it comes to reaching women farmers, who are more likely to face difficulties accessing resources such as land, credit and information that would enable them to invest in irrigation. Furthermore, the PAY-OWN flexible financing modality is especially beneficial for resource-limited farmers, many of whom are women, who lack the collateral or credit history usually required to obtain a loan.

A ***digital marketing and data management system*** aims to improve business management and the efficiency of marketing efforts, especially those targeting the more challenging but promising small-scale irrigation market. The system also reduces errors in capturing customer information, improves information retrieval time and allows for comparative analysis across products, market segments and businesses.

Customization of solar suitability mapping. An interactive online solar suitability mapping tool, developed by IWMI, helps users identify suitable areas for solar-based irrigation depending on water sources and pump characteristics. The tool has been updated for Ghana to include distribution centers and enabling actors in the IVVC, with the aim of targeting marketing initiatives and interactions more effectively.

Facilitating systemic changes

At a broader level, IWMI undertook additional activities that focus on facilitating systemic changes in scaling solar-based irrigation.

Facilitating the local scaling ecosystem aims to enhance the demand-supply linkage scaling pathway by engaging actors within the ecosystem, such as community leaders, local

Multi-stakeholder dialogues aim to bring actors together and facilitate change (*photo:* Maxwell Twumasi/IWMI).

authorities and microfinance institutions, in co-developing and scaling bundles of solutions that strengthen the adoption of PAY-OWN pumps. Facilitation also includes scaling these bundles to other regions in Ghana.

Facilitating multi-stakeholder dialogues aims to create open organizational and institutional spaces that bring actors together and offer opportunities for learning, innovation, action and change while stimulating private sector investments and partnerships (Minh et al. 2020).

Institutional capacity building aims to build greater trust and enable knowledge sharing and collaboration between the private sector, public sector and research institutions, thereby contributing to an enabling environment for scaling solar-based irrigation in an economically and environmentally sustainable way.

Factors influencing the scaling pathway

Several factors potentially hinder or enable the demand-supply linkage scaling pathway. **Hindering factors** include solar panel maintenance and gender considerations along the IVVC. There is also the issue of limited financial and human capital.

Group dynamics such as leadership style, transparency, and social and cultural norms may also influence the effective management of group-acquired solar-based technology. Farmers' poor bargaining power may lead to low selling prices for irrigated vegetables and limited access to agricultural inputs and services.

In addition, government subsidies and uncoordinated interventions for value chain development have led to the duplication of efforts and a reduction in the benefits that farmers may have accrued. The introduction of solar-based technologies may fail to consider the social and economic dynamics of the target group as well as the lack of an established rural distribution network for these technologies. Moreover, government agencies and public service providers emphasize supply-side approaches while neglecting the demand side. As a result, the development of solar-based irrigation markets is limited to the wealthy market segments such as resource-rich farmers.

Among the **enabling factors** is the advantage that the solar-based irrigation bundle addresses both the high fuel costs of diesel and petrol pumps and the high initial investment that farmers often face in acquiring the solar-based irrigation technology. In addition, there is the significant degree of engagement of IVVC actors, especially irrigation equipment suppliers. Other key actors include extension agents, seed and fertilizer providers, microfinance groups, borehole drillers, and chiefs and traditional authorities.

The way forward

The potential of solar-based irrigation to increase agricultural productivity and reduce poverty is substantial. To maximize this potential, the following activities are recommended to further strengthen the solar irrigation scaling pathway described in this brief.

- **Investing capital** to sustain sales and service networks and enable private sector companies to expand in Ghana's Upper East Region and beyond. Attracting investment to de-risk the PAY-OWN flexible financing modality is essential for managing the risk of customers who are unable to fulfill their payment obligations as well as potential failures in technology supply chains. These measures will ensure that companies can tailor their business and financing models to their target market segments in the most effective way.

- **Strengthening farmers' collective action** is key to improving their access to and benefits from input and output markets as well as mobilizing financial capital for investments in solar-based irrigation. The government's focus on supply-side approaches to irrigation development has made the promotion of collective action in farmer groups a challenge.

- **Engaging actors along the IVVC** is crucial for the widespread adoption of solar-based irrigation by farmers. By engaging these actors, existing interventions supporting farmers' adoption of irrigation technologies and agronomic practices can be leveraged in the scaling pathway. Regional departments of MoFA can act as operational hubs connecting farmers with most services and resources required for irrigated agriculture as well as pump distributors' products and services.

- **Establishing multi-stakeholder dialogues and cooperation** on scaling solar-based irrigation can bring actors together to stimulate private sector investments and partnerships, inform public policies and programs, and trigger transformation at the system level.

A farmer with her irrigated vegetables in Ghana (*photo:* Nana Kofi Acquah).

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