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International Water Management Institute

Water Issue Brief - 28
Putting research knowledge into action

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

Market segmentation to facilitate scaling of solar-based irrigation bundles in Ethiopia

The context

Despite the high potential of and strong demand for wider adoption of agricultural innovations in Ethiopia, scaling efforts have often been ineffective, and innovation adoption remains limited (Minh et al. 2021). Successful and sustainable innovation scaling requires co-identifying and co-developing best-fit solutions for farmers and other actors in the value chain (Seifu et al. 2020). Bundling these solutions, such as solar-powered irrigation pumps, with pay-as-you-go financing has improved the enabling environment for adoption (IWMI 2021). Identifying the farmer segments interested in investing in such bundles and strengthening linkages along the irrigation value chains are essential for matching demand and supply and creating the conditions to reach scale.

Key messages

- Bundles of solar technologies and services have been identified that address many current barriers to smallholder solar-based irrigation, such as high initial investment costs, limited market access, and women and youth exclusion.
- Innovative approaches, such as demand-supply linkage and partnership, to linking private and other value-chain actors and services are needed to create opportunities for the private sector to invest in scaling solar irrigation.
- To ensure success of scaling, market segmentation is a precondition to develop best-fit bundles for different farmer groups and efficiently match demand and supply.

Key issues

Scaling agricultural innovations is critical for alleviating poverty, increasing food and nutrition security, and helping farmers adapt to climate change (Gebreyes et al. 2021). Although there are different pathways for scaling agricultural innovations and a range of available innovations that can be scaled, private sector actors play a crucial role in farmers' decisions to invest in and adopt the innovations. Using an action research approach, the International Water Management Institute (IWMI) co-identified a private sector-led scaling pathway for solar-based irrigation bundles (SBIBs) in Ethiopia (IWMI 2023).

This pathway builds on earlier IWMI research, which showed that innovation scaling is successful when one or more core innovations (e.g., solar-powered irrigation pumps) are bundled with complementary innovations (e.g., pay-as-you-go financing and pre- and after-sales services) that improve the enabling environment for adoption (IWMI 2021). Facilitating demand and supply linkages between users and providers of technologies and services is part of implementing this pathway. Therefore, identifying and segmenting the different user groups, their resources, preferences, and potential are essential to successfully match demand and supply and create the conditions necessary for effective scaling.

A farmer with his solar-powered irrigation pump in Lemo, Ethiopia (*photo:* Thai Thi Minh).

Market segmentation

Under the Africa Research in Sustainable Intensification for the Next Generation (Africa RISING) and Feed the Future Innovation Lab for Small-Scale Irrigation (ILSSI) projects, IWMI analyzed the irrigated vegetable value chain in Ziway (in Oromia region) and Wereta (Amhara region) in Ethiopia to identify and characterize the market segments for solar-based irrigation innovation bundles (Figure 1). Market segmentation is the process of dividing a market into smaller, more defined categories. Each segment or group shares similar characteristics such as demographics, interests, needs, location or preferences. Market segmentation helps businesses and other market actors to target user groups more precisely, develop tailored products and services, and make more informed investment decisions. Data for the analysis were collected through interviews, focus group discussions and stakeholder consultation workshops involving producers, private sector entities, and governmental and non-governmental development actors. The analytical framework of the analysis included the behavioral, demographic and psychographic dimensions to examine farmers' financial management, investment behavior and investment preferences.

Structure of the irrigated vegetable value chain

Garlic, onion, tomato, cabbage and pepper are among the main irrigated vegetable crops in Wereta during the dry season. The same crops are grown in Ziway along with lettuce, Swiss chard, kale, bean and maize. Surface water is the main irrigation source, although groundwater is sometimes used. Irrigators in Ziway depend on Lake Ziway and other rivers in the watershed, while those in Wereta use the Tana, Gumara and other smaller rivers. Hand-dug shallow wells are used for backyard irrigation, household consumption and livestock.

Farmers in both regions can access local and regional markets for their irrigated crops. Brokers may link them to wholesalers and retailers, and prices are negotiated at the farm gate. Brokers and traders sell produce at local markets in Wereta, Ziway and Bahir Dar or the capital Addis Ababa. Higher-grade crops are sometimes exported.

Poor availability of inputs and high cost of production are the most reported challenges in irrigated agriculture, i.e., the rising costs of vegetable seeds, agrochemicals, fertilizer and fuel. Diesel and petrol prices have more than doubled in the last two years, with local markets often facing shortages. This has led to irrigators having to buy from the black market, incurring an additional cost of about 50% of the official price.

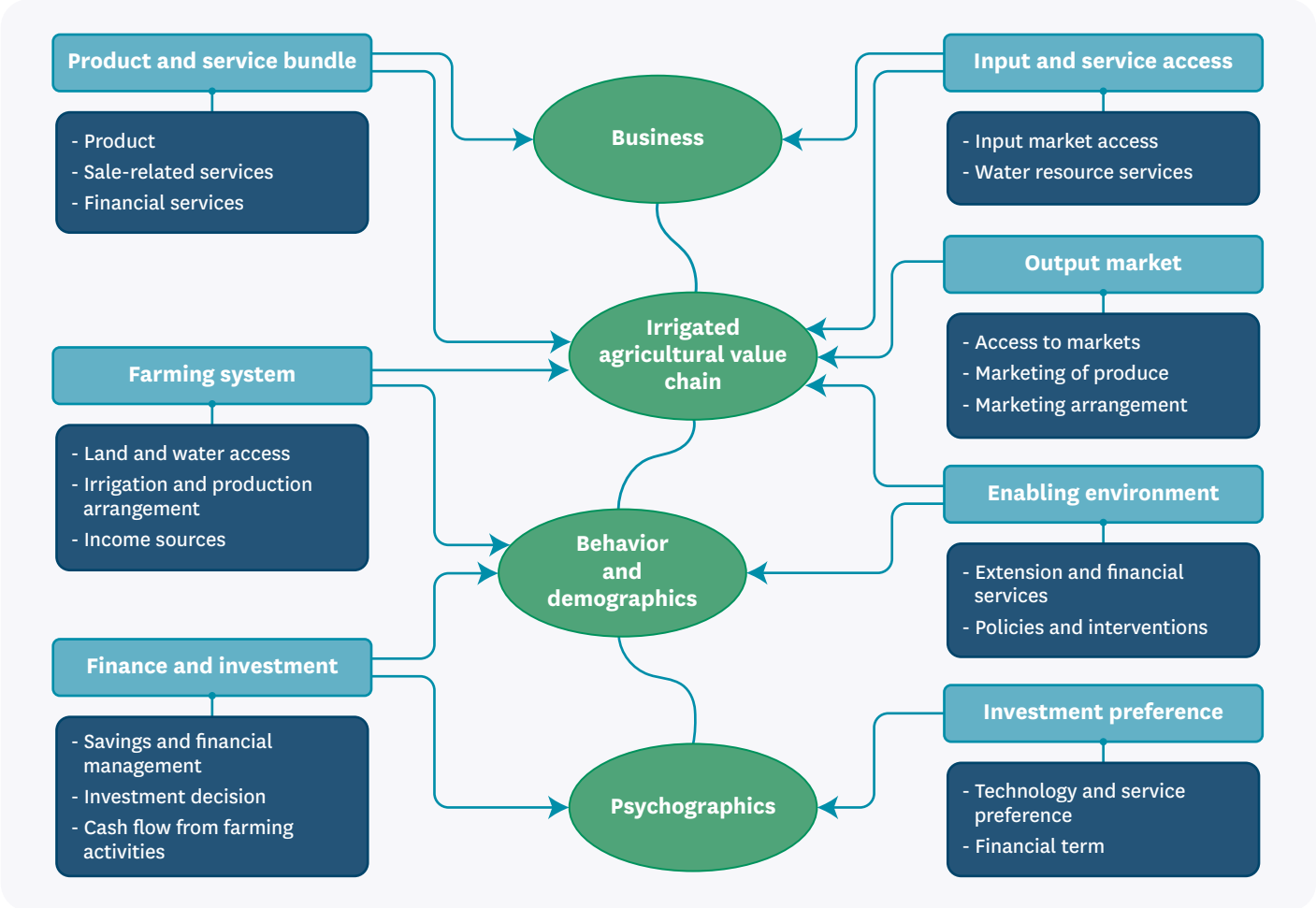

Figure 1. An analytical framework for segmenting the market for solar-based irrigation.

Water-lifting technologies

The supply chain for water-lifting technologies and services is generally very similar to that of Wereta and Ziway. This is outlined below, along with any key differences.

Fuel-powered motor pumps are the most commonly used irrigation technology for lifting water, followed by manual pumps. The motor pumps are imported, mainly from China. Private distributors and retailers dominate the supply of pumps. Most of the suppliers also sell accessories and spare parts. However, they do not provide operation and maintenance (O&M) services, which are outsourced to local technicians. Local agriculture and irrigation offices are actively involved in the motor pump supply chain. They evaluate technical specifications, process purchases and distribution, and provide O&M services through technicians.

The major challenge regarding motor pumps has been the rapid price increase. Suppliers in Ziway mentioned that the average price of diesel pumps rose from roughly Ethiopian birr (ETB) 13,000 (USD 246) to ETB 24,000 (USD 454) in just over a year. Distributors and retailers said they are struggling to procure motor pumps because importers in Addis Ababa are facing a shortage of the foreign exchange needed for imports.

Solar-powered irrigation pumps (SPIPs) are not readily available in the local markets of Wereta and Ziway. This is because they are capital-intensive to stock, and sales are relatively slow. Rensys is one of the official SPIP suppliers in Bahir Dar, the regional capital of the Amhara region. There are no pump suppliers in Ziway; two sales agents for Rensys place orders on behalf of farmers when there is demand. In addition, some nongovernmental organizations (NGOs) working in irrigated agriculture are increasingly supplying SPIPs in targeted locations. For instance, Farm Africa in Ziway promotes SPIPs through a cost-sharing scheme whereby farmers pay 45% of the pump cost and Farm Africa provides the remaining 55%.

Other factors affecting the uptake of SPIPs are farmers' limited access to information about the availability and performance of these technologies in their localities and the pre- and after-sales services available. The lack of local availability and reliability of O&M services for SPIPs also makes farmers hesitant to invest in these technologies.

Water resource development services

Groundwater is used for irrigation, livestock and household consumption in both locations. Shallow well development is mostly undertaken by traditional hand diggers using hand tools and manual tube drilling systems, and in a few instances, with mechanical rigs in Wereta. Conventional wells are usually shallow, about 10 meters (m) deep. Manual tube drilling service providers develop wells up to 30 m deep.

Borehole drilling services are offered mainly by private sector businesses to farmers, projects and institutional clients. Their rigs can drill wells up to 180 m deep. These rig drillers face several challenges, including a lack of working capital, the rising cost of equipment and maintenance, poor access to higher-capacity machinery, and limited availability of spare parts. On the farmer's side, access to information about drilling services for SPIPs could be much higher.

Rensys company demonstrating solar-powered irrigation pumps for farmers in Lemo, Ethiopia (*photo:* Thai Thi Minh).

Financial services

Despite the high number of financial institutions operating in Ethiopia, access to financial services is, for several reasons, still an obstacle for many farmers. First, there is little financial literacy, often because of low education levels. Second, poor record-keeping limits farmers' ability to show proof of operations and income when applying for credit. Third, unfavorable attitudes and fears about the perceived complexity of credit systems prevent farmers from making inquiries about credit relevant to their activities. Fourth, smallholder farmers in Ziway often have fragmented operations in several locations with an average farm size of 0.25–2 ha. Therefore, the cost of managing credit to smallholders is high and unattractive to mainstream financial service providers. Fifth, demand for financial services outmatches supply. Grants from development partners such as the World Bank have been crucial in addressing some of this capital gap. Finally, smallholder agriculture is perceived to be high risk, primarily due to unpredictable input prices and low output, the latter also being exacerbated by climate change. Moreover, farmers have little control over market access and output prices. Market prices are often decided by one or more brokers who serve as their link to retailers and wholesalers in the main towns. Political unrest in parts of the country also limits the willingness of financial institutions to lend to smallholder farmers.

Government and NGO interventions

The *woreda* (district) offices of agriculture and irrigation lead the provision and facilitation of key and supporting services, notably technical and advisory services, financial services, capacity building and organizing irrigation pump users. These offices organize farmers and youth groups (water user associations and producer cooperatives) near water sources and facilitate access to high-capacity motor pumps through government schemes. They also partner with the private sector, including input and technology suppliers, and link microfinance institutions with producers.

Additional support from NGOs and governmental actors was observed in Wereta and Ziway. These included interventions from Spanish Aid, World Vision, Korea International Cooperation Agency (KOICA), Wetlands International, and Farm Africa.

Solar-based irrigation bundles

In partnership with Rensys, IWMI determined the best-fit solar-based irrigation bundles (SBIBs) and a pathway to support scaling (Figure 2).

Pay-As-You-Own (PAY-OWN) is a credit finance scheme that allows farmers to use irrigation equipment while making small, regular payments until the total cost is paid up. This modality allows farmers to overcome the initial capital barrier to acquire solar-powered technology.

Pre-sales services include credit- and product-client fit assessment to determine a client's creditworthiness and the most appropriate pump. The creditworthiness assessment tool, co-developed through the ILSSI partnership with the Bahir Dar Institute of Technology, assesses various socioeconomic criteria and determines the eligibility of potential clients. It is beneficial for minimizing the risk to Rensys in financing pumps for and with farmers. After-sales services cover various activities such as pump installation, and training on pump operation and maintenance.

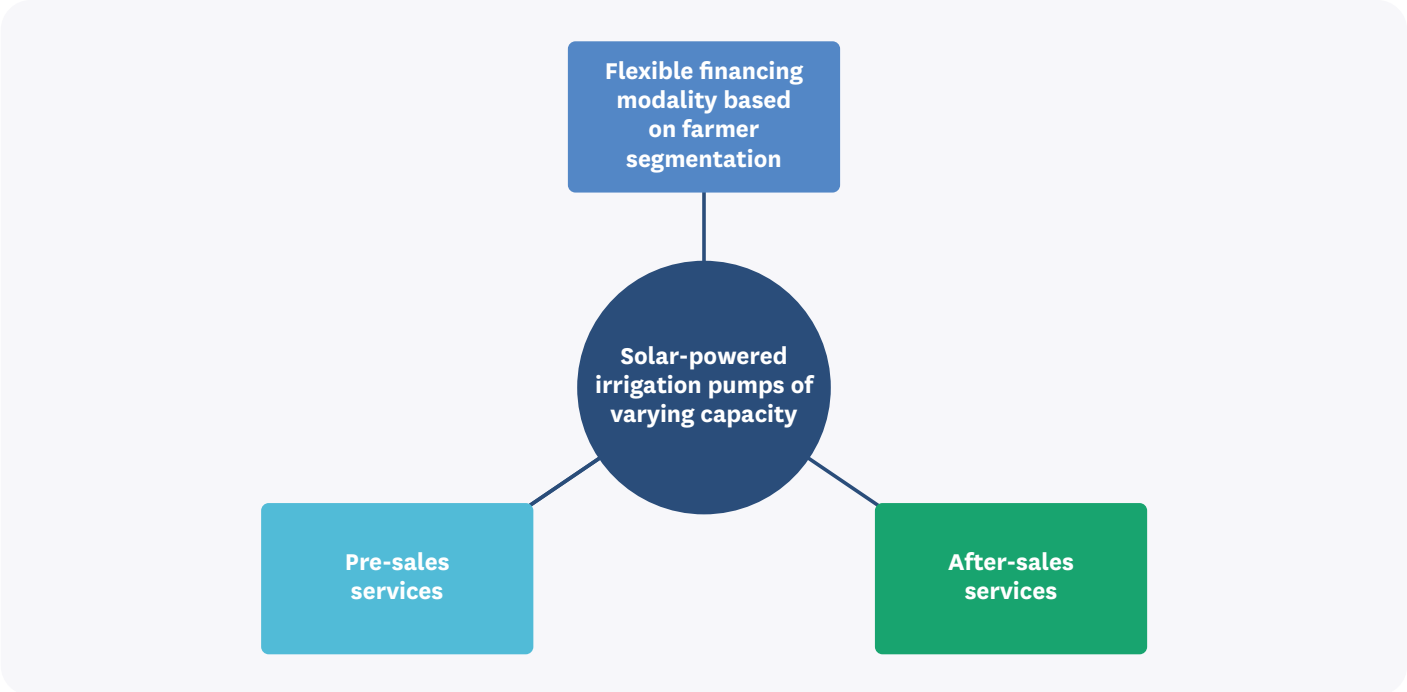

Figure 2. Elements of solar-based irrigation bundles.

Farmer segments for solar-based irrigation bundles

The IWMI analysis identified four farmer segments that stand to benefit from the SBIBs: Resource-rich farmers, resource-limited farmers, project pilot beneficiaries and organized irrigators (Table 1).

Table 1. Farmer segments and their characteristics.

Characteristics	Resource-rich farmers	Resource-limited farmers	Project pilot beneficiaries	Organized irrigators
Land and water access	- Have access to own land - Have additional cultivable land for farmer groups - Have access to multiple water sources, mostly 30-70 m boreholes and/ or hand-dug wells about 10 m deep	- Rent land for farming - Have access mainly to surface water (e.g., lakes Ziway and Meki, rivers Nile and Gelda, and spring Mismo)	- Have access to own land - Have access to groundwater through tube wells or hand-dug wells from project pilots	- Own or rent land close to farms of other group members - Have access mainly to surface water (e.g., lakes Ziway and Meki, rivers Nile and Gelda, and spring Mismo)
Irrigation and production arrangements	- Make individual decisions on crops to grow each season - Individual irrigation for home plots - Collective irrigation for group-based plots - Water lifting mainly by motor pumps; application by flooding - Individual cultivation and sale of produce	- Make individual decisions on crops to grow each season - Irrigation done individually or in groups - Water lifting done manually or using motor pumps; application by watering cans or flooding	- Take individual decisions on irrigation application and crops to grow each season - Water lifting by solar or motor pumps; application by flooding and/or drip	- Take individual decisions on crops to grow each season and production with collective support during planting, weeding, chemical application or harvest - Group-based irrigation 2-3 times on a rotational basis and supplemental irrigation individually - Use motor pumps and flooding - Individual or collective product marketing
Irrigated vegetable value chain	- Grow high-value crops, including tomato, cabbage and pepper	- Grow high-value crops, including tomato, cabbage and pepper - Have limited incomes because of the small size of farms	- Grow high-value crops, including tomato, cabbage and pepper - Have limited income because of the inability to irrigate the entire land area and home consumption of most of the output	- Cropping 2-3 times/year offers significant returns to farmers as a group - Cultivate different vegetable crops - Members have better access to input and output markets and technical and advisory support
Marketing	- Sell produce at the farm gate to brokers for the export market - Sell produce to wholesalers at the farm gate for local markets	- Sell produce in local markets to retailers or directly to consumers	- Sell produce in local markets to retailers or directly to consumers	- Produce sold individually to brokers at the farm gate or retailers and wholesalers in local markets - Produce sold collectively to brokers for the export market in Djibouti and other neighboring countries

Continued ...

Characteristics	Resource-rich farmers	Resource-limited farmers	Project pilot beneficiaries	Organized irrigators
Financial capital and potential	- Harvesting vegetables and fruits 2-3 times a year offers significant returns	- Limited financial capital due to the cultivation of 0.5 ha or less, partly for home consumption - Lack of information and the fear of a formal credit system limiting access to bank loans	- Low to medium financial capital due to limited access to improved technologies and financial services - High potential to expand production to increase income	- High financial capital as a group - Better access to credit benefits members
Technology and service preferences	- Low-capacity solar pumps for home gardens - Higher-capacity pumps for larger farms - Group investment (with adjacent farms) on deep water wells and/or higher-capacity solar pumps possible - Pumps bought outright or through a payment plan	- Low-capacity pumps for home gardens - High-capacity pumps shared with neighboring farmers - Payment through a subsidy scheme or down payment and subsequent payment plan (quarterly or biannual payment over 1-2 years)	- Require low- to medium-capacity pumps to complement existing solar pumps from projects - Payment through a down payment and subsequent payment plan	- Require high-capacity solar pumps for group use - Low- to medium-capacity pumps to supplement group irrigation - Outright/down/subsequent installment payments depending on the collective financial capacity - Require SPIPs bundled with water application equipment

Source: Melaku et al. 2023.

Factors influencing investment in solar-based irrigation

Several factors influence farmers' investment in solar-based irrigation. The **limiting factors** relate, among others, to farmers' difficulties in accessing finance, inappropriate irrigation practices and poor bargaining power. In addition, available solar packages are often unsuitable for farmers' needs. At the same time, a large-scale government subsidy for motor pumps distorts the market and acts as a disincentive for SPIP adoption.

Enabling factors exist for the farmer segments, technology suppliers and development actors. For farmers, SPIPs remove the issue of (rising) fuel costs and have a significantly lower maintenance requirement. Organized irrigators can better access technical and advisory services on irrigated agriculture and technologies, including higher-capacity SPIPs via loan and credit services. They also receive technical and financial support from the local government to develop their groundwater resources.

Another possibility explored by the study was group loans and investments by farmers owning adjacent plots. Resource-rich farmers who require medium- to high-capacity SPIPs and can develop deep wells would benefit from investing as a group and sharing the use of the pumps and water resources. Resource-limited farmers in a similar context can also benefit from such opportunities using a group loan or subsidy arrangement to facilitate the purchase of pumps and well development.

For technology suppliers and other actors, a better understanding of the potential, natural resources and preferences of different farmer segments can lead to business development opportunities. Solar-based technology and service providers can use such information to develop tailored products and services based on the needs and contexts of different user groups. This has the potential to improve sales and customer retention. Governmental and nongovernmental actors can use this information to inform and guide their planning and efforts to promote and supply solar-based irrigation bundles.

Moreover, events and platforms such as multistakeholder dialogues to strengthen linkages along the SPIP value chains can bring various stakeholders together and promote knowledge exchange, networking and new business opportunities (Minh et al. 2020). Finally, the increasing support from NGOs and government policies and strategies for irrigation and climate-smart agricultural development in Ethiopia also presents opportunities. Even though efforts are not always bundled and are primarily at the piloting and demonstration stages, they are vital for introducing solar-based technologies, creating awareness, and facilitating social learning and experience sharing among farmers and extension agents.

The way forward

The potential of solar-based irrigation to increase agricultural productivity, reduce poverty and enhance climate resilience is substantial. Solar-based irrigation enables farmers to bypass the infrastructure and energy constraints to adapt to a changing climate and boost their own climate resilience. To maximize this potential, the following activities are recommended to strengthen linkages in irrigation value chains and match demand and supply regarding solar-based irrigation bundles for the farmer segments outlined in this brief.

- **Adequate consideration** of the biophysical context, value-chain dynamics, technology options, and local availability of pre- and after-sales services is necessary to scale SBIBs. Insights provided by market segmentation should guide the development of services and best-fit bundles for different farmer groups.

- **Existing and emerging opportunities** to enable and facilitate investment in and scaling SBIBs should be exploited. These include capacity building, particularly for *woreda* extension agents, through experience-sharing and training on solar irrigation, O&M of solar pumps and the different technology options. Feasible water storage technologies and appropriate application methods should be demonstrated to farmers. This approach will address the misperception that SPIPs have insufficient water discharge and can only irrigate during high light-intensity hours.

- **Organizing irrigators** is an efficient way to leverage the opportunities and benefits of being part of a group, including better access to financial services and storage facilities for produce and greater bargaining power. Linking water development services with users is a key requirement for ensuring water access for irrigation, encouraging different groups to invest in SBIBs. Connecting rig drillers with organized irrigators and resource-rich and resource-limited farmers interested in investing in deep wells as a group is also recommended. In addition, individuals, small and medium enterprises, and private companies engaged in groundwater development need support via training on the latest technologies and O&M of technologies that can operate across various landscapes and soil types.

- **Innovative solutions** are needed to address financing challenges and the unsustainable business environment for SBIBs arising from the large-scale government subsidy for motor pumps. One such solution could be to include SBIBs in future government subsidy schemes. If applicable, climate financing mechanisms may be used at the federal level. For organized irrigators, finding ways to facilitate partnerships with technology suppliers and financing institutions will enhance the uptake of SBIBs.

- **Enhancing the capacity and visibility** of local suppliers and sales/service agents is urgently needed. Networking at local levels is weak, hindering the knowledge and information flow among development actors, suppliers and users, and perpetuating negative perceptions about SPIPs among farmers.

- **Establishing an active sales and service network** at local levels is essential for the private sector to lead the solar-based irrigation market. Linking sales agents or distributors with local irrigation extension agents is also necessary to connect technology supply chains and farmer segments more efficiently. Financing mechanisms should be integrated whenever possible, and the possibility of formal arrangements with microfinance institutions should be explored. Feasible and tested mechanisms, approaches and tools are necessary if the private sector is to finance pumps. Suppliers should diversify their solar technology options, keeping pump mobility, capacity, battery for storing power, and technologies for multiple uses in mind. The unfolding energy price crisis could be a turning point for scaling SBIBs if the relevant actors demonstrate the comparative cost-benefits of SPIPs over motor pumps.

Danghesta village, Dangila district, Amhara region, Ethiopia, runs on gravity where water from a tank flows into the irrigation tubes. The tank is filled using a small pump powered by a solar panel. This home garden is part of a conservation agriculture trial that is being run in partnership with IWMI, Bahir Dar University, and the Innovation Lab for Small-Scale Irrigation (ILSSI) project (*photo:* Mulugeta Ayene/WLE).

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