International Water Management Institute

Water Issue Brief - 23

Putting research knowledge into action

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

Scaling best-fit irrigation bundles in Mali: A pathway for improved development outcomes

The context

Access to irrigation is increasingly recognized as a means to promote agriculture-led economic growth and as an adaptation strategy for climate-related shocks and stressors (Smith et al. 2019). Inclusive agriculture, specifically, provides opportunities for the participation of groups such as women and youth. In Mali, women produce 80% of the country's agricultural products and comprise 65% of the agricultural labor force (ONE 2017). In addition, they grow a significant percentage of vegetable crops, several of which are considered high value. However, women are more likely than men to engage in informal, lower-paid work. Improving inclusion in irrigated vegetable value chains can not only increase the production of nutrient-rich, profitable vegetable crops but also create sustainable job opportunities for currently disadvantaged groups.

Key messages

- Production of high-value irrigated vegetables has significant potential to raise incomes, particularly for women farmers.
- A pathway was identified to scale 'best-fit' bundles of irrigation technologies, practices and services.
- The proposed bundles are adaptable and scalable to other regions, increasing their potential to reach larger numbers of farmers and achieve better and more inclusive development outcomes.

Key issues

In 1999, the Government of Mali adopted the Stratégie Nationale de Développement de l'Irrigation (SNDI) (National Strategy for Irrigation Development) (GoM 1999), the main framework for implementing irrigation programs and actions. The SNDI considers irrigation as one of the most effective means of boosting food and nutrition security, reducing imports, increasing rural incomes and limiting out-migration from rural areas.

Although rice under large-scale, state-funded irrigation schemes remains the main irrigated crop, small-scale farmer-led irrigation, including of vegetable crops, is gaining importance in agricultural policy. In 2017, the government passed a law requiring 15% of irrigated land to be allocated to women and youth (GoM 2017). This is significant because women have historically had limited access to and control over the resources needed to benefit from agriculture-led economic growth (IWMI 2023a).

Despite government initiatives to expand land under irrigation, only a small share of Mali's irrigation potential has been tapped (Malabo Montpellier Panel 2018). Similarly, while irrigated vegetable production is increasing, it is still largely characterized by rudimentary irrigation practices based on wells and manual watering using buckets and cans. Technologies such as diesel, petrol and solar-powered irrigation pumps are gaining ground, but the initial costs are too high for the average farmer to afford.

Farmers at a field demonstration of solar-powered irrigation equipment in Sikasso, Mali (*photo:* Thai Thi Minh/IWMI).

Recognizing that technology introduction and scaling is not a linear process – and indeed that such linear processes have in the past resulted in technologies being abandoned – the International Water Management Institute (IWMI) took a systemic, adaptive approach. Focusing on Koutiala, a city and administrative district in Mali's southern Sikasso region, IWMI investigated 'best-fit' bundles of irrigation technologies, practices and services and an exposure-based pathway for scaling these bundles along the irrigated vegetable value chain (IVVC) (Sidibé and Minh Forthcoming). As the name suggests, the pathway aims to create the conditions to expose irrigators to alternative and innovative irrigation solutions beyond those currently offered in the region. Although specific to Koutiala, the best-fit irrigation bundles are adaptable and scalable to other regions in Mali, increasing their potential to reach larger numbers of farmers and achieve better and more inclusive development outcomes.

Action research method

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 method. This 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.

Data were collected from individual farmers, farmer groups and other actors in the IVVC in Koutiala city and the surrounding villages of N'Golonianasso, Nampossela, Sirakele, Zanzoni and M'Pessoba. Data analysis identified four farmer segments: resource-rich farmers, resource-limited farmers, resource-poor farmers, and farmer cooperatives and groups. These segments, each of which has slightly different financial capacities and irrigation needs, are covered in more detail in Table 1. The following sections provide an overview of the analysis, the best-fit irrigation bundles co-identified for the farmer segments and the pathway co-developed to scale the bundles.

Constraints to innovation adoption

Agricultural production in Koutiala is dominated by cereal crops such as millet, sorghum, rice and maize as well as groundnut and beans. These are produced largely during the rainy season from June to October. Among cereal crops, only rice is irrigated. Irrigated vegetable production starts in the dry season, which extends from November to May. Irrigation using (shallow) groundwater is applied to high-value crops such as tomato, onion, potato, chili pepper, cabbage, African eggplant and okra.

Vegetable farmers include women and men of different social categories. Labor-intensive manual irrigation is the dominant irrigation practice by resource-poor farmers. Water is drawn from traditional or improved wells and applied to vegetable crops using buckets and watering cans. Motorized pumps are used by farmers who can afford them. Isolated solar-based irrigation systems are scattered throughout the study area. Water scarcity and a decrease in water use efficiency are common across all practices and systems. Irrigation-related organization is relatively limited.

Vegetables are produced for both home consumption and to sell on local and nearby urban markets. Different ***marketing channels*** are used to link the supply and demand of irrigated vegetable products. Direct selling typically occurs at local and urban markets, but some products are sold directly to consumers and brokers on farmers' fields. This is generally the case for farmers organized in groups and cultivating adjacent fields or the same vegetable garden equipped by donors. Products are taken to the market by motorbike, tricycle or donkey cart or carried on women's heads, depending on the distance and volume of products to be sold.

An emerging trend is the use of cell phones by farmers and retailers to exchange information about product availability and agree on prices in advance. This is helping to mitigate some of the challenges related to vegetable transportation and perishability, notably product dumping at markets if farmers are unable to negotiate a profitable price.

Irrigation equipment supply

Irrigation equipment suppliers in Koutiala are private businesses. They are mostly medium-sized enterprises that engage with major importers and wholesalers in the capital Bamako to supply various pumps, panels, plastic pipes and accessories to irrigators at the local level.

Motorized pumps imported from China, Dubai and Japan are available from numerous traders. The price varies from USD 100-200 for Chinese pumps to USD 300-400 for Japanese pumps. Pumps from Dubai fall somewhere between those two price ranges. Fuel costs are high and access to spare parts is limited.

The best-known and highest-quality ***solar-powered irrigation pumps*** on the market are manufactured by Grundfos (Denmark) and Lorenz (Germany). They are also the most expensive, costing USD 2,000-3,000 in 2022, depending on the pumping capacity. Cheaper brands from China cost USD 300-400. The smallest and cheapest pumps cost USD 70-100. The short life span of the cheapest pumps combined with the limited number of technicians with the skills to repair them are the main challenges facing irrigators using or considering these pumps.

Input supply

Farmers can access inputs such as seeds, pesticides and fertilizers through two main channels. The first is ***private input shops***. These shops will supply farmer cooperatives

on credit, if the cooperatives get a guarantee from a financial organization. However, this is often a slow process due to credit backlogs. The second channel is ***extension services or support*** from nongovernmental organizations (NGOs) and research institutions, who often provide (quality) inputs at discounted or subsided prices.

Service provision

Financial services are an important factor in farmers' decision to invest in irrigation. Various financial institutions provide formal credit to farmers. They include the Banque Nationale de Développement Agricole (BNDA) (National Bank for Agriculture Development), the microfinance organization Soroyiriwaso, and an inter-municipal body Miniankala Kafo, which encompasses the 29 municipalities in Koutiala. Three percent of the local taxes per municipality are allocated to the body to help fund its activities. Miniankala Kafo provides various services, such as support for vegetable production, construction of rural roads and access to a 'backup' fund that farmers can use to secure additional funding from financial institutions. However, it does not specifically target irrigation products or services.

Isolated initiatives to support ***market access*** are provided by the NGOs Association Malienne pour la Sécurité et la Souveraineté Alimentaires (AMASSA) (Malian Association for Food Security and Sovereignty) and Afrique Verte (Green Africa), which train women processers.

Best-fit irrigation bundles

The IVVC in Koutiala has strong support from research and donor-funded projects targeting women farmers. While this is supposed to boost vegetable production and contribute to gender-sensitive poverty reduction, it tends to disincentivize private risk taking and investment by farmers. Other issues such as stolen solar panels in M'Pessoba, abandoned project-funded pumps in Nampossela and unresolved water shortages in all the villages underline the project bias.

Non-exposure to alternative options and a lack of information in the study area (Koutiala) may explain the limited local solutions. Therefore, creating the conditions to expose irrigators to affordable solutions beyond those offered by projects is key to scaling irrigation bundles while gradually deconstructing the project and external funding mindset. In this context, irrigation bundles – combining affordable solutions and services with more expensive equipment covered by external support – could be the best fit in Koutiala and comprise the elements shown in Figure 1.

Water-lifting technologies. As most resource-limited and resource-poor farmers cannot afford motorized pumps, and only a limited number of resource-rich farmers can, this makes the pumps difficult to scale. In addition, fuel costs and maintenance issues suggest that these pumps are likely to

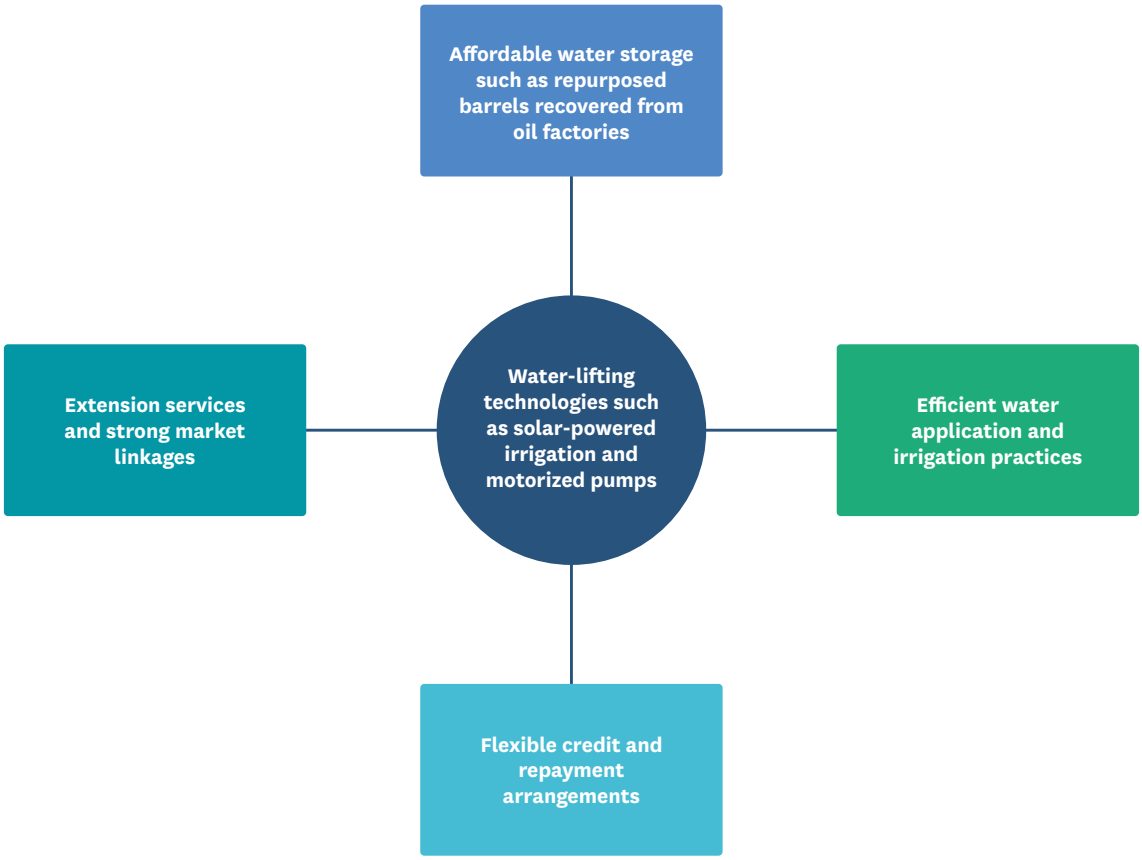

Figure 1. Elements of the best-fit irrigation bundle.

Tlamadou Bengaly (left) owns a shop selling solar panels in the city of Sikasso, Mali (*photo:* Thai Thi Minh/IWMI).

have limited reach. For this reason, the introduction of solar-powered irrigation technologies suitable for all farmers could be a promising alternative, if bundled effectively.

Several small solar-powered irrigation pumps exist that are portable and designed to irrigate plots of up to one hectare. This makes them particularly suitable for groups of women farmers supported by NGOs and development partners. The pumps could be bundled with affordable motorized pumps that can be used when there is less sunlight. In addition, having the option to use a solar-powered irrigation pump when there is ample sunlight would help to reduce the fuel and maintenance costs of a motorized pump. This bundle could thus harness the potential of each technology while offsetting the pitfalls.

Enabling farmers to invest in solar-based irrigation may require credit services. For instance, financial and government organizations, NGOs, equipment suppliers and farmers could jointly establish win-win credit services such as pay-as-you-go (IWMI 2023b) while learning from previous experiences of credit backlogs or failures.

Water storage. Among resource-rich farmers, agricultural water is generally stored in locally constructed metal water tanks supported by a metal frame. The cost of these tanks, including transportation and installation, ranges from USD 600 to USD 1,000. This is too expensive for most resource-limited and resource-poor farmers. As an alternative, secondhand 200-liter barrels recovered from oil factories could be repurposed and scaled to provide farmers with affordable water storage.

Water application and irrigation practices. In many cases, farmers fetch water directly from water tanks in watering cans. This can involve several trips between the tank and farmers' plots. To reduce labor and increase efficiency, farmers could use flexible pipes to convey the water to their plots. Combined with recovered oil barrels for water storage, this practice is both affordable and scalable.

Extension services, financial services and market linkages. Extension services provide advice, technical guidance and training on the best practices for vegetable production. Besides these tasks, extension agents could additionally broker farmers' access to affordable irrigation technologies, practices and services at scale. This brokerage role can take various forms. For instance, extension offices and other government organizations could act as guarantors for farmers seeking credit from financial organizations to buy irrigation bundles. The willingness of farmers to invest their own resources to buy secondhand water storage barrels for their land could be the key eligibility criteria for such credit.

Stakeholders could discuss the appropriate mechanisms that would guarantee their interests while making sure that any credit is repaid. These mechanisms should be self-sustaining to prevent project bias. One way of ensuring repayment is by helping farmers market their irrigated vegetables more effectively.

Farmer segments for irrigation bundles

The data analysis identified four farmer segments. Each segment is slightly different in terms of the amount of water needed, land access, pump preferences and capacity to invest in the irrigation bundles (Table 1).

Table 1. Farmer segments and their main characteristics.

Characteristics	Resource-rich farmers	Resource-limited farmers	Resource-poor farmers	Farmer cooperatives and groups
Access to land and water resources	• Own large plots of land • High capacity to control water resources	• Own irrigated land • Partial control over water resources	• Own inherited portions of cultivated land • Access limited mainly to groundwater using cans and buckets	• Own collective vegetable gardens equipped by support organizations along with individual cultivated land • Access to groundwater
Current irrigation practices and investment	• Improved irrigation system managed by individual farmers • Irrigated crops (tomato, onion, potato, chili pepper, cabbage, African eggplant and okra)	• Individual irrigation management • Combination of flexible pipes and watering cans • Irrigated crops	• Individual/group management • Use of watering cans and buckets for irrigation • Irrigated crops	• Individual and/or collective irrigation management • Irrigated crops
Access to different services	• Easy access to extension services, inputs and markets • Self-sufficient, so no need to resort to financial services	• Patchy access to extension services and inputs • Access to financial services but reluctant to take out individual credit	• Difficult to access extension services, inputs and marketing services • Do not use financial services	• Easy access to extension services • Rely on NGO support • Difficult to access inputs and marketing services
Financial capacity	• High financial potential to invest in irrigation technology bundles as individuals	• Medium financial potential to invest in the bundles as individuals	• Very limited financial capital, especially women farmers • Low potential to invest in the bundles	• Limited financial capacity to invest individually in the bundles • Potential to invest collectively in the bundles
Preferences for technology bundles	• High-capacity irrigation bundles • Investment without credit services	• Low- to medium-capacity technology bundles • Need credit services adapted to their conditions • Need marketing support	• Low-capacity bundles • Require credit services and inputs that fit their needs • Need marketing support	• Medium- to high-capacity bundles. • Need support for collective financial management and mobilization

Exposure-based scaling pathway

Figure 2 shows the existing pathway and the exposure-based pathway co-identified to scale the best-fit irrigation bundles. Building on the existing pathway to support vegetable farmers' access to irrigation technologies, presented at the bottom of Figure 2, the exposure-based pathway aims to scale the best-fit bundles. The exposure-based pathway has three components, which are described below.

Exposing farmers to new and affordable irrigation solutions focuses on introducing farmers to alternative irrigation solutions in real-life situations, thereby boosting farmers' willingness to invest on their own and gradually move away from the project bias that dominates the existing pathway. This component can be operationalized by organizing demand-supply linkage events. During these events, demonstrations are held at existing irrigation sites to show farmers the relevance of the solutions for their conditions.

Establishing multi-stakeholder dialogues between users and service providers around the solutions (Minh et al. 2020). This includes discussing the conditions under which farmers would be willing to invest in irrigation. This component involves engaging (micro) finance organizations and determining viable financial modalities such as pay-as-you-go that minimize risk and maximize the rewards of investing in irrigation for all stakeholders.

Establishing one-stop shops for information exchange and partnership among different stakeholders could help to sustain demand-supply linkages along the IVVC in the long term. One-stop shops involve different providers, such as private irrigation and input supply companies, working together to promote and sell a range of products, with microfinance organizations facilitating access to affordable credit services.

Extension agents from research organizations and NGOs could come together to reflect on and facilitate the exposure-based scaling pathway. The role of research organizations would be to create dialogue among different stakeholders and document the whole process, while the role of NGOs would be to connect farmers with local communities and support the process. Additionally, extension offices would collect data on the crops grown and help with assessment and scaling.

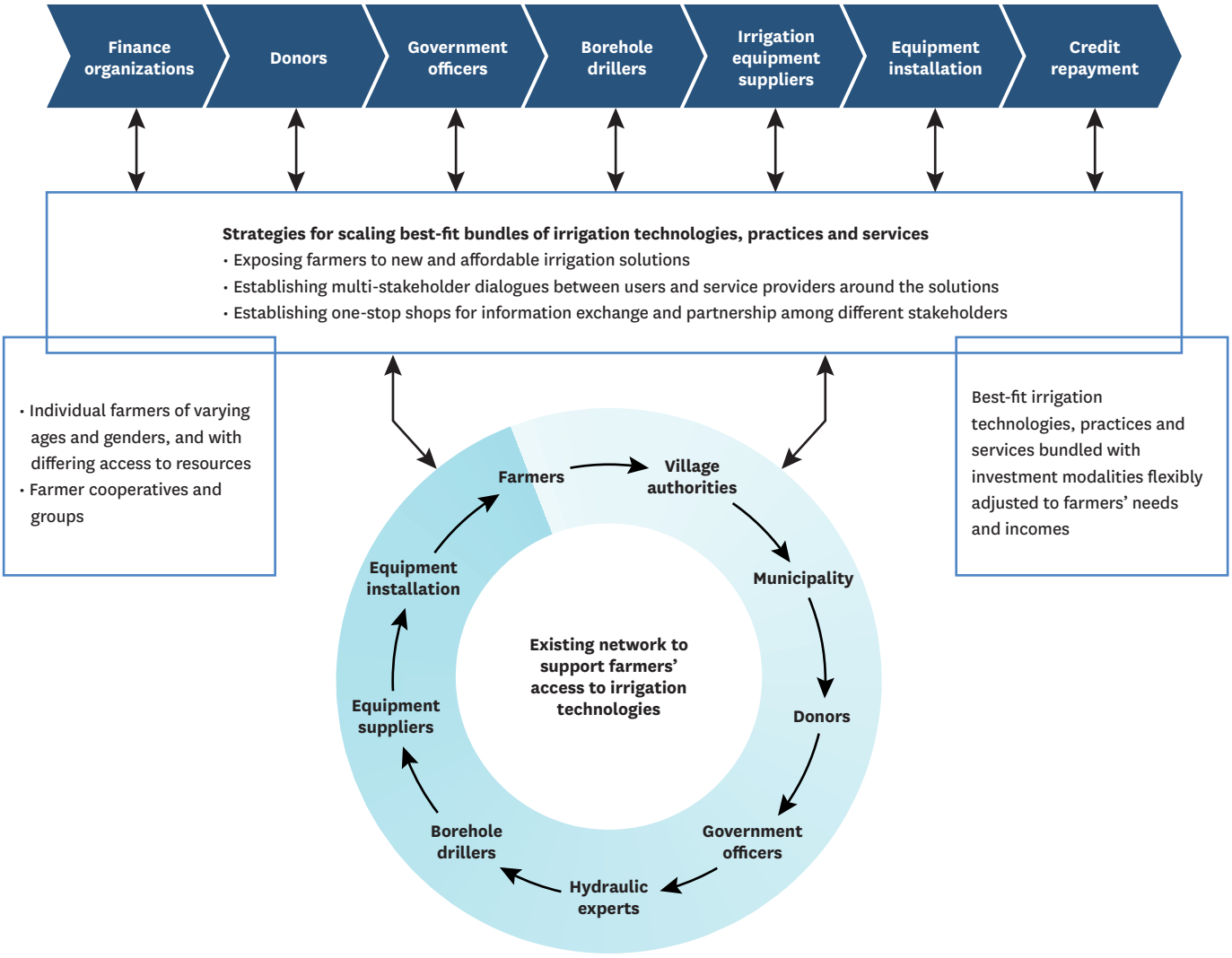

Figure 2. An exposure-based pathway to introduce and scale best-fit bundles of irrigation technologies, practices and services. The existing network is shown at the bottom of the diagram.

Factors influencing the pathway

Several factors hinder and enable implementation of the exposure-based scaling pathway.

Hindering factors

A potential hindering factor is that the scaling pathway itself may add to the already ***high initial costs*** of irrigation equipment by moving farmers away from project funding towards private investment. These costs particularly deter resource-poor farmers from exploring innovative practices. The barrier presented by high costs is exacerbated by the lack of information on cheaper alternatives or the lack of options tailored to users' purchasing power. The dearth of information on cheaper alternatives reinforces the overreliance of resource-poor farmers on project-funded solutions.

The ***insufficient geographical coverage of hydraulic workers*** (there is one hydraulic worker for the whole of Koutiala) combined with the security situation in Mali add to communities' limited access to information. Furthermore, many farmers ignore the advice given by hydraulic experts, either because of a lack of knowledge or because hiring a borehole driller without first consulting a hydraulic expert is faster. At the same time, borehole drillers describe the geological situation in Koutiala as challenging. This commonly results in slower drilling speeds than donors expect or budget for. In some instances, donors have refused to pay drillers for their services.

High donor requirements regarding who is eligible for support also make it difficult to mobilize funding for new irrigation technologies. For groups or communities who successfully acquire funding, implementation delays present a further challenge. For example, the government approved a borehole drilling project in Zanzoni some time ago, but the project has yet to be implemented. These delays are one of the reasons why wealthier farmers tend to make their own investments.

The ***sustainability of interventions*** is another key issue. Spare parts may not be accessible in the area or are too expensive for local communities to afford without external support. In addition, the cost of maintaining irrigation equipment is frequently overlooked in project planning. As a result of this oversight and farmers' strong reliance on external support, several technologies and practices have been abandoned, despite important initial investments.

Such a fragmented playing field encourages ***competing claims, conflicts of interest and finger pointing*** among stakeholders. This is especially the case between private businesses and government offices, with government offices stating that water resources belong to the state and any water initiative should be recorded in the government database. Meanwhile, private businesses accuse the government of unfair competition.

Finally, finding the ***right organization*** to broker information and partnerships and sustain them over time is a major hindering factor. Resolving this issue would likely require an initial investment in a mechanism such as a one-stop shop to play this role and then high operational costs to maintain it and make it efficient.

Enabling factors

A key enabling factor is the ***growing interest*** in irrigation solutions from all stakeholders in the IVVC. Linked to this are ***existing irrigation investments*** that could be redirected – in part or full – toward the introduction of new solutions. The ***presence of project-funded collective gardens*** that are currently challenged by flawed irrigation systems or abandoned technologies provide a high-potential testing ground for these new solutions. Moreover, the range of products available on the market and the number of actors able to adapt them to suit different farmer segments present a strong opportunity for the scaling pathway, if robust market linkages can be established along the IVVC.

The way forward

Scaling best-fit irrigation bundles in a sustainable way requires gradually reversing the overreliance in Koutiala on donor support and creating the conditions for vegetable farmers to invest their own resources in low-risk, high-potential irrigation technologies, practices and services. To achieve this, we recommend the following:

- **Combining available and affordable secondhand solutions with more expensive technologies** provided with external support. This will not only reduce the often-prohibitive initial costs for both farmers and support organizations, but it could also encourage farmers to invest in irrigation technologies in the long term. This applies particularly to resource-limited and resource-poor farmers who have the most to gain from improved irrigation.

- **Tailoring best-fit irrigation bundles** to farmers' differing needs and capacities, and operationalizing the scaling pathway to extend the bundles' reach.

- **Finding consensus among stakeholders.** Achieving this will require bringing all stakeholders together to engage in and discuss the scaling pathway while securing the interests of all actors. A broker organization that serves as a one-stop shop for information, products and services as well as a guide for farmers at every stage of the technology financing, purchasing and repayment process could help to catalyze change in the current project mindset.

- **Creating a business network** of IVVC stakeholders and actors to facilitate farmers' access to agricultural markets, thereby securing farmers' return on investment.

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