Co-identification of value chain-based pathway for scaling of irrigation technologies and services: Cases in Basona Worana and Lemo woredas in Ethiopia

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The Africa Research In Sustainable Intensification for the Next Generation (Africa RISING) program comprises three research-in-development projects supported by the United States Agency for International Development (USAID) as part of the U.S. Government's Feed the Future initiative.

Through action research and development partnerships, Africa RISING is creating opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base.

The three regional projects are led by the International Institute of Tropical Agriculture (in West Africa and East and Southern Africa) and the International Livestock Research Institute (in the Ethiopian Highlands). The International Food Policy Research Institute leads the program's monitoring, evaluation and impact assessment.

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Contents

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Summary

A systemic approach to scaling of irrigation technologies and water management solutions to enhance value chain functionality requires addressing system barriers to irrigation development. Identifying scaling pathways through a lens of irrigated agricultural value chains requires analysis of the chain and its enabling environment to understand micro and macro environments of households and value chains as well as its influence on the scaling of irrigation technologies.

Throughout the action research process of co-identifying value chain-based scaling pathways various technology options and corresponding scaling pathways were identified in Basona Worana and Lemo woreda, Ethiopia. In Basona Worana, a demand-drive scaling pathway was identified for bundled water management and agricultural input services along the irrigated vegetable value chain. The pathway included farmer-led demonstration, setup of a seed bank, establishment of local innovation scaling partnerships, scaling across locations to reach more farmers, and the development of upstream value chain linkages. Input and service providers, trader, and Senselet potato factory are key actors influencing farmers' decision on irrigated vegetable production. The locally established scaling partnerships facilitate the collaboration among local stakeholders and partners to support farmers' investment into irrigation, thereby enabling the scaling of the bundled package to reach scale. In Lemo, a private-led pathway was identified for scaling of water lifting technologies and services. The pathway consists of establishment of local irrigation equipment supply chains, farmers as business partners, establishment of local innovation and scaling platforms, and scaling across locations. Irrigation technology and service providers are key actors influencing farmers' decision on irrigation adoption. Linking farmers with irrigation technology and service suppliers using local trader systems was identified as a key condition to reach scale.

Across these regions, the successful scaling of irrigation technologies and water solutions requires the bundling with other services that enable irrigated commercial vegetable and fruit value chains. These other services crucial in enabling scaling are new economic development reforms, dynamic food processing industry and high and stable market demand for vegetables and fruits. At the same time, the hindering factors include a lack of credit services, missing tradition of collective action to materialize a sustainable supply to market, dominance of supply-driven approaches and free-gift mentality, and limited collaboration and coordination among relevant actors and stakeholders.

These scaling pathways and influencing factors highlight that the successful scaling of bundled technologies and services requires bundling interventions that enable the irrigated commercial vegetable and fruit value chain. These interventions include, but are not limited to, extension and credit provision, input and output market linkages, and innovation brokerages. The local farmer entrepreneur groups, private irrigation service providers and technicians remain key value chain actors to enhance the reliability of the local irrigation supply segment and well-functioning of irrigated agricultural value chains in the two scaling pathways. Facilitating local innovation and scaling platforms is essential for the successful value chain-based scaling pathways. Hence, it is essential to identify the roles of different actors involving in the different components and facilitate the actors performing their roles in the scaling process. The actors and their performances, in turn, come together at the farm spontaneously to support farmers' adoption of and investment into irrigation.

Introduction

Access to water and improved soil moisture management is one of the key climate adaptation pathways for many smallholder agricultural farming systems (Global Commission on Adaptation report, 2019). Ethiopia's National Adaptation Plan (ETH-NAP) also targets small-scale farming communities to achieve the anticipated adaptation outcomes (FDRE, 2019). Under Africa Research in Sustainable Intensification for the Next Generation (Africa RISING) phase I, IWMI has evaluated the feasibility of various water lifting technologies which enabled smallholder farmers to overcome dry-spells or increase their land productivity outside of the rainfed season. Research findings in the first phase showed promise of using hand-and motorized pumps (solar, tractor driven, diesel pumps) to support off-season vegetable and irrigated fodder production (Okwany and Schmitter., 2016, Schmitter at al., 2016).

Furthermore, research has identified numerous constraints to expanding the use of irrigation technologies along the value chains. Barriers, which prevent smallholder farmers from entering into or advancing along the value chains are highly contextual and vary within and between countries. Some key identified challenges are insecurity of land tenure, lack of reliable markets (both in terms of the crop value chains and the technology supply chains), limited access to extension and credit services, inadequate or poorly maintained irrigation infrastructure, and lack of infrastructure (e.g. roads, access to electricity, well drilling) (Nigussie et al., 2017; Nakawuka et al., 2018; Otoo et al., 2018; Merrey and Lefore, 2018; Lefore et al., 2019). Often, farmer investment in irrigation depends on income from the sale of irrigated crops for re-investing in inputs (pumps, fertilizers, improved seeds, pesticides) and expending the irrigated areas to raise productivity (Adela et al., 2019; de Bont et al., 2019 and 2019a). Irrigation technology supply and services as well as access to well established and profitable output markets need to collide for farmers to see the value of investing in irrigation for their production system. Access to output market for agricultural products is a major factor determining farmers' adoption of irrigation technologies.

Hence, a systemic approach to the scaling of irrigation technology and water management solutions is needed to address these barriers and enhance value chain functionality. The systemic scaling approach helps to explore sustainable pathways to scaling so that irrigation technologies can better support sustainable intensification of household production systems, development of agricultural value chains, and resilience of food systems (Minh et al., in Prep.). The systemic scaling can be approached through the lens of irrigated agricultural value chains. This requires, first, an analysis of the chain to understand primary products and production-related factors to enhance sustainable production systems, market structure for agricultural products be produced and marketed in the chain, and the chain structure (Herman and T. Minh, 2020). The market analysis provides an understanding of market demands and requirements for products to be successfully produced and marketed in the chain. The chain structure analysis investigates the chain's functions, potential actors' roles and relevant knowledge and experience, value addition and distribution, and governance to determine how to organize the chain. Within the systemic scaling approach, irrigated value chain analysis can generate a better understanding of the level of entrepreneurship, gender, and social inclusion barriers to entrepreneurship and the mechanisms by which scaling of appropriate irrigation technology can be better integrated into the value chains (T. Minh et al., 2020).

Second, the identification of the value chain-based scaling pathway requires an analysis of the enabling environment to understand enablers and hinderers influencing farmers' adoption of the technologies, so that measures are put in place to ensure success. An enabling environment of irrigated agricultural value chains is a set of policies, informal institutions, support services and other conditions that create or improve gender and social inclusion and maintain a general operational environment, bringing together value chain actors in a co-operative manner (Herman and T. Minh, 2020). Understanding such micro and

macro environments of households and value chains as well as its influence on the scaling of irrigation technologies is important when catalyzing the appropriate enabling environment for integration and scaling of the irrigation technologies and water solutions in a sustainable manner (Lefore et al., 2019).

This report presents co-identification of value chain-based pathway for scaling of irrigation technology and water management solutions with local actors and stakeholders. Using an action research process, the co-identification was conducted in Basona Worana and Lemo woredas, Ethiopia from November 2019 to May 2020. The next sections elaborate the action research process used in the co-identification. The report is continued with presenting the results from the irrigated vegetable (and fruit) value chain analysis and enabling environment as well as the identification of the scaling pathways for bundled irrigation technologies and services in Basona Worana and Lemo woredas, respectively. The last section draws conclusions and recommendations for further action research on facilitating the demand-driven and private-led scaling pathways.

Methodology

Action research approach

In the 'Enhancing water productivity through piloting of agricultural water management technologies in the Ethiopian highlands' project (EWP project), an action research approach is used with four interrelated steps: analyse, co-design and test, reflect and act, and engage (Figure 1). The analyse step included a rapid assessment by an inter-disciplinary team from IWMI, involving researchers from various disciplines. This step was carried out in the Africa RISING project sites in Basona Worana and Lemo Woredas. The assessment aimed to:

- Investigate existing irrigation technologies and practices and farmers' interests and willingness to adopt,
- Understand the irrigated value chains structure and function,
- Investigate irrigation supply and output markets,
- Characterize the enabling environment at the woredas and zone level, and
- Identify technology opinions and scaling pathways.

Specific activities in the rapid assessment included:

- Consult local relevant stakeholders: Meetings with local relevant stakeholders were conducted to: 1) introduce the project's objectives and its linkages with the overall Africa RISING (AR) project/program, 2) consult the stakeholders with irrigation development in the woredas and potential sites for project activities, and 3) discuss future collaboration between the project and stakeholders' organization. In Basona Worana woredas, meetings were organized with: AR project's site coordinator, Office of Agriculture and Natural Resources (ANR office) of Basona Worana (deputy head of office, horticulture production team leader and small scale irrigation team leader), Collage of Agriculture and Natural Resources of Debre Birhan University, and Debre Birhan Research Center. A number of potential demonstration sites were identified, including Bakello, Keyit, Gudo Beret/Mush irrigation scheme, Abamote, Adisge, Dibut, Angolela, Dilila, Chiraro Debir and Kor Mamefia. The experts suggested Bakello, Adisge, and Dibut for the rapid assessment as these sites are representative to the different irrigation systems and value chains in the woreda. In Lemo woredas, meetings were organized with: the AR field coordinator and the Lemo woredas bureau of agriculture experts. Jawe, Shurmo and Dubancho kebeles (in Lemo woredas) and Kerekicho Kebele (in Angecha woredas) were recommended for the rapid assessment.

- Investigate existing irrigation system, irrigation practices and irrigated value chains*:* Site visits were conducted with experts from the office of agriculture. Various methods were used to collect data and information, including:
  - ✓ Focus groups discussion with farmers, Water User Association, cooperative and cooperative union, in a combination with field observation and transaction walks, to discuss the irrigation scheme, local irrigation system, practices, challenges and problems, local water governance, agricultural production, value chain structure, etc.
  - ✓ Semi-structure interviews with farmers were held to understand cropping system, access to inputs and services, marketing of products, irrigation scheme and its management, irrigation practices, irrigation problems and constraints, and their interest and willingness to adopt irrigation or better water management practices.
  - ✓ Semi-structure interviews were conducted with value chain actors such as vegetable wholesaler and retailers, one stop shop (farmer center), input suppliers, traders to understand how the products are supplied to and sold in the market, demands and prices of the products, and challenging in having the product supply.
  - ✓ Semi-structure interviews were held with irrigation suppliers such as private and public irrigation equipment shops, local mechanics and local well diggers to collect information regarding products, prices and supply and production of irrigation equipment.
- Identify technology options and scaling possibilities: The team first laid out and reviewed the vegetable value chain map and discussed among members about suitable technology options and scaling possibilities.

In the co-develop step, stakeholder consultation workshops on scaling of water innovation within irrigated agricultural value chain were organized to:

- Explore further the challenges, technology and scaling options/possibility,
- Co-design the technology demonstration with farmers,
- Explore possibilities to scale the demonstrated irrigation practices/technology to other irrigation schemes within kebele, from one kebele to other kebeles, and from one woredas to others,
- Investigate conditions for successful scaling of irrigation practices,
- Identify key value chain actors to be involved to enhance the successful scaling and how to involve them,
- Identify local partners for collaboration in the scaling of water innovations, and
- Plan the implementation of the demonstration and scaling possibilities with stakeholders.

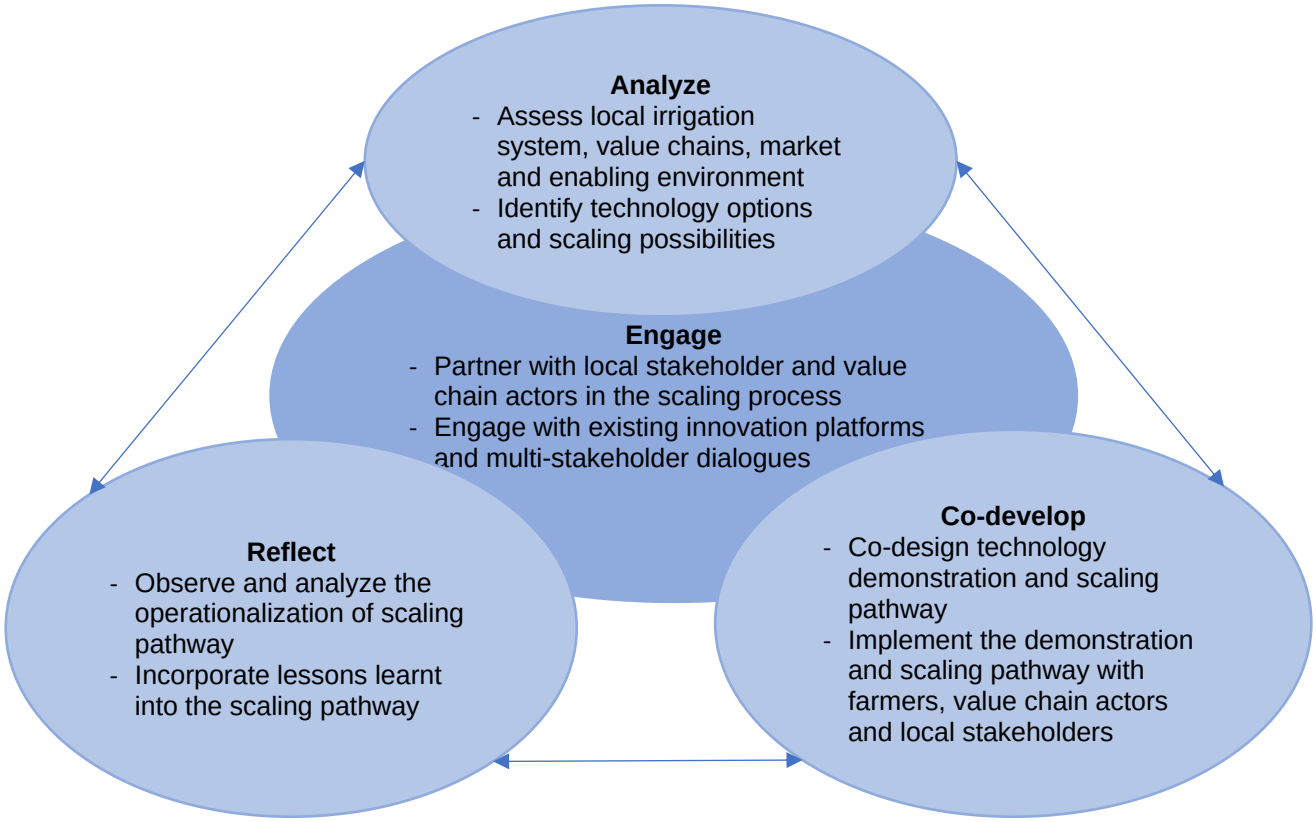

Figure 1. Action research process: Steps and activities

In Basona Worana woredas, the stakeholder workshop involved 35 participants from Office of Agriculture and Natural Resources of Basona Worana, College of Agriculture and Natural Resources of Debre Birhan University, Debre Birhan Research Center, water user association, farmer cooperative, Development agents in Bakelo, and farmers from Bakello, Adisge, and Dibut kebelle. In Lemo woredas, the workshop involved 36 participants from ANR Office of Lemo, Development agents in Lemo, and farmers from Jawe, Shurmo and Dubancho kebeles (Lemo woredas) and Kerekicho Kebele (Angecha woredas).

The demonstration is implemented in Bakello irrigation scheme, Basona Worana woredas where flood irrigation is commonly practiced and farmers volunteered to participate and work together with the IWMI-Africa RISING project. IWMI worked further with local partners (ANR Office, Debre Birhan University, and Debre Birhan Research Center) and farmers in Bakello irrigation scheme to prepare the demonstration protocol and demonstrate alternative best water management practices. The protocol details the type of crops/vegetables, number of farmers involved and modality to involve farmers, size of demonstration plots per farmer per water management, establishment of the seed bank, especially potato seed, modality to involve local partners, and roles and responsibilities of partners.

In Lemo woredas, results from the stakeholder consultation workshop show that simple water lifting technologies such as rope and washer pump, and solar pumps have been tested and farmers are interested in using these technologies, especially for smallholder farmers with limited financial capacity. Government agencies are demonstrating complex solar energy system for household consumption and irrigation. Therefore, testing suitable scaling pathways in partnering with the existing innovation platforms and with private sector actors were identified as the main focus in the next step. Interaction with local partners have been continued to analyze the availability of these technologies (and more),

identify local partners for scaling, and engage with the local innovation platform coordinated by the AR project.

The reflect step is undertaken by the research team throughout the testing process to:

- Gather and analyze feedbacks from farmers and partners participating in the testing of demonstration and scaling pathways and integrating them into adapting the tested pathways,
- Reflect on tested technologies and scaling pathway, how to continue with the tested scaling pathway, how local partners and participants appreciate the scaling approach, and how they react to it,
- Incorporate these reflections into the new scaling pathways to be tested in the future, and
- Prepare for the further stakeholder engagement process (see the next step).

Specific activities in the reflect step include, but not limited to:

- Monitor the technology demonstration and scaling pathways together with collecting data.
- Organize the field day and stakeholder consultation workshop for reflecting of the current demonstration and the planning of the next activities.
- Conduct follow-up research about the scaling pathways and technology adoption to investigate if the scaling pathways are evolved further.
- Document lesson learnt, policy and technical brief for learning and sharing purpose.

The engage step is carried out throughout the action research process, aiming to interact with stakeholders and participants during the testing process, engage with the existing innovation platforms and multi-stakeholder dialogues, and identify and involve new relevant actors and stakeholders. In Basona Worana woredas, for example, actors newly entering the irrigated agricultural value chain have been identified. These are brokers, Senselet potato chip company, individual and institutional consumers, financial institution, and office of trade and industry. In Lemo woredas, the local innovation platform established and coordinated by the AR project is likely to be a catalyst in scaling of irrigation solutions.

Specific activities in the engage step include, but not limited to:

- Organize technology awareness campaigns in the villages together with development agents, department/office of agriculture at woredas and Zone levels and NGOs.
- Participate in the innovation platform as an active member.
- Engage private sector in demonstrating and supplying technologies within the communities.
- Share experience and lessons learnt with the zonal/regional/and national relevant multi-stakeholder platforms.

Dataset and data analysis

Qualitative data on irrigated agricultural value chain and enabling environment to the scaling of irrigation technologies and practices were collected in both Basona Worana and Lemo woredas during November 2019 to May 2020. Table 1 presents an overview of collected data. In total, six group interviews, 30 individual semi-structured interviews, and two consultation workshops with multi-actors and stakeholders involved in irrigated agricultural value chains, were conducted in local language, recorded, transcribed and translated into English for data analysis.

Table 1. An overview of collected data

Method	Organization/ location	Topic/data collected
Basona Worana woredas		
Group interview with office head, horticulture team leader, irrigation team leader	Office of agriculture and Natural Resources	- Brief discussion about Africa RISING project - Highlight of IWMI's activities, - Collaboration between the three offices and IWMI
Group interview with 03 researchers	Debre Birhan University	
Semi-structure interview with researcher	Debre Birhan Research Center	
Group interview with irrigation development agent, water user association, and 03 farmers	*Bakelo* irrigation scheme	- Farming system and irrigation practices - Irrigation scheme: infrastructure, operation, governance, water availability, constraints - Vegetable value chain structure - Interest in irrigation technology
Group interview with irrigation development agent and 03 farmers	*Adisge* irrigation scheme	
Transaction walk and discussion with irrigation development agents and horticulture experts	*Dibut* irrigation scheme	
Group interview retailors at Farmer Center	Farmer Union, Debre Birhan town	- Input and irrigation equipment supply business - Business plan
Interview retailor at irrigation equipment shop		
Interview staff at public irrigation equipment shop	AMBASEL	
Interview 01 onion wholesaler, 02 vegetable retailers, and 01 garlic vender	Debre Birhan town market	- Business practices, challenges and opportunities - Demand and supply of vegetable
Stakeholder consultation workshop		- Constraints of irrigation in kebele - Scale the irrigation practices and conditions for the successful scaling - Key value chain actors to be involved to enhance the successful scaling - Improve vegetable market linkage
Lemo woredas		
Group interview with bureau of agriculture experts	Lemo	- Intervention support irrigation development
Interview 02 farmers (and garden observation)	Shurmo	- Farming system, and experience irrigation and type of technologies applied - Interest to use the different water lifting technologies and interventions - Market access and marketing channel - Observation: existing crops and irrigation, borehole, water availability, water harvesting trial
Interview 06 farmers (and garden observation)	Dubancho	
Interview 04 farmers (and garden observation)	Kerekicho	
Interview 01 farmers (and garden observation)	Jawe	
Interview 05 farmers (and garden observation)	Kerkicho Kebele	- Farming system, and experience irrigation and type of technologies applied

Interview 03 farmers (and garden observation)	Dubanicho Kebele	- Interest to use the different water lifting technologies and interventions - Market access and marketing channel - Observation: existing crops and irrigation, borehole, water availability, water harvesting trial
Interview with 03 farmers (and garden observation)	Shurmmo Kebele	
Interview local pump manufacturer	Lemo woredas	- Manufacturing business: products and market - Challenges and opportunities - Supply of irrigation equipment
Interview local well digger (and garden and field observation)	Shurmmo Kebele	- Farming system and irrigation practice, constraints and trend - Well digging business and challenges - Irrigation and water availability in the area - Supply of irrigation equipment
Interview local trader	Kerkicho Kebele	- Trading business - Opportunities and challenges - Interests in other business
Participatory market transaction walk	Angecha markets	- Products and price
Stakeholder consultation workshop with 36 farmers from three kebele,	Lemo woredas	- Constraints of irrigation in kebele - Scale the irrigation practices and conditions for the successful scaling - Key value chain actors to be involved to enhance the successful scaling - Improve vegetable market linkage

The collected dataset was analyzed using content analysis guided by a set of question, covering four major themes as the follows:

(i) Irrigated production and value chain:

- Which major crops are irrigated? How is irrigation applied for these crops?
- How do the farmers market their agricultural products? What are obstacles limiting farmers' marketing their products?
- What are market demands and opportunities for these products?
- Who are value chain actors and what are their roles in the irrigated agricultural value chain?
- What are services provided to farmers along the value chain and who provides these services?

(ii) Irrigation and access to irrigation equipment and technologies:

- What irrigation practices, technologies and services are used?
- Where can farmers access the irrigation technologies and services?
- Who provide the technologies and services to farmers and how do they provide them?

(iii) Scaling option of technology and service and scaling pathway

- What irrigation technology and services are suitable and show potential for scaling?
- How could agricultural value chains support the scaling of these options?
- Who are key value chain actors to be involved to enhance the successful scaling and how to involve them?

- What can be solutions to enhance farmers' access to output market which in turn, enhance farmers' adoption of the identified irrigation practices, technologies and services?
- How to scale the irrigation practices, technologies and services in the kebele, to other kebeles, and to other districts?

(iv) Enabling environment supporting the identified scaling pathways

- What are alternative investment opportunities that compete with investments in irrigation technologies and improved agricultural practices?
- What are conditions for successful scaling of irrigation practices?
- What are factors influencing scaling of irrigation practices, technologies and services?

Each transcript was read several times and all texts were examined in order to identify and categorize emerging concepts based on similarities and differences between them, grounding and refining themes from the concepts, and discussing and interpreting the defined themes. This procedure is an open-ended process, moving back and forth between the guiding questions, data, and emerging concepts to refine the themes.

Scaling of bundled technologies and services in Basona Worana

Irrigated vegetable value chains in Basona Worana

In Basona Worana district, the dry season extends from November to May. Irrigation is applied mainly to vegetable production for home consumption and local and regional markets. Irrigated vegetable value chain in Basona Worana consists out of potato, garlic, onion, carrot, and cabbage. Figure 2 illustrates the structure of irrigated vegetable value chain in Basona Worana.

Market demand: Amongst these vegetables, potato, garlic, and carrot are grown and sold to both local markets and other markets such as Addis. Moreover, potato is also sold to the newly constructed Senselet Potato Chip Company by a Holland investor in the area which processes potato and supply to both domestic institutional consumers and export markets. The company has been experimenting with contract farming in two kebeles and plans to expand into four more kebeles this year. Demand for irrigated potato, therefore, is predicted to significantly increase. Garlic is a high value crop and always in high demand, especially for big city markets such as Addis. Recently, garlic production is reduced in the area due to serious fungi diseases which damages harvests as well as the seed preserving for the next season. This creates a shortage in the supply of garlic to markets as well as seeds for the next season. Demand for onion is very high, especially during the festival season and the harvesting season of barley. A big share of onion is, therefore, transported from other low land areas as the local production is not adequate for the demand.

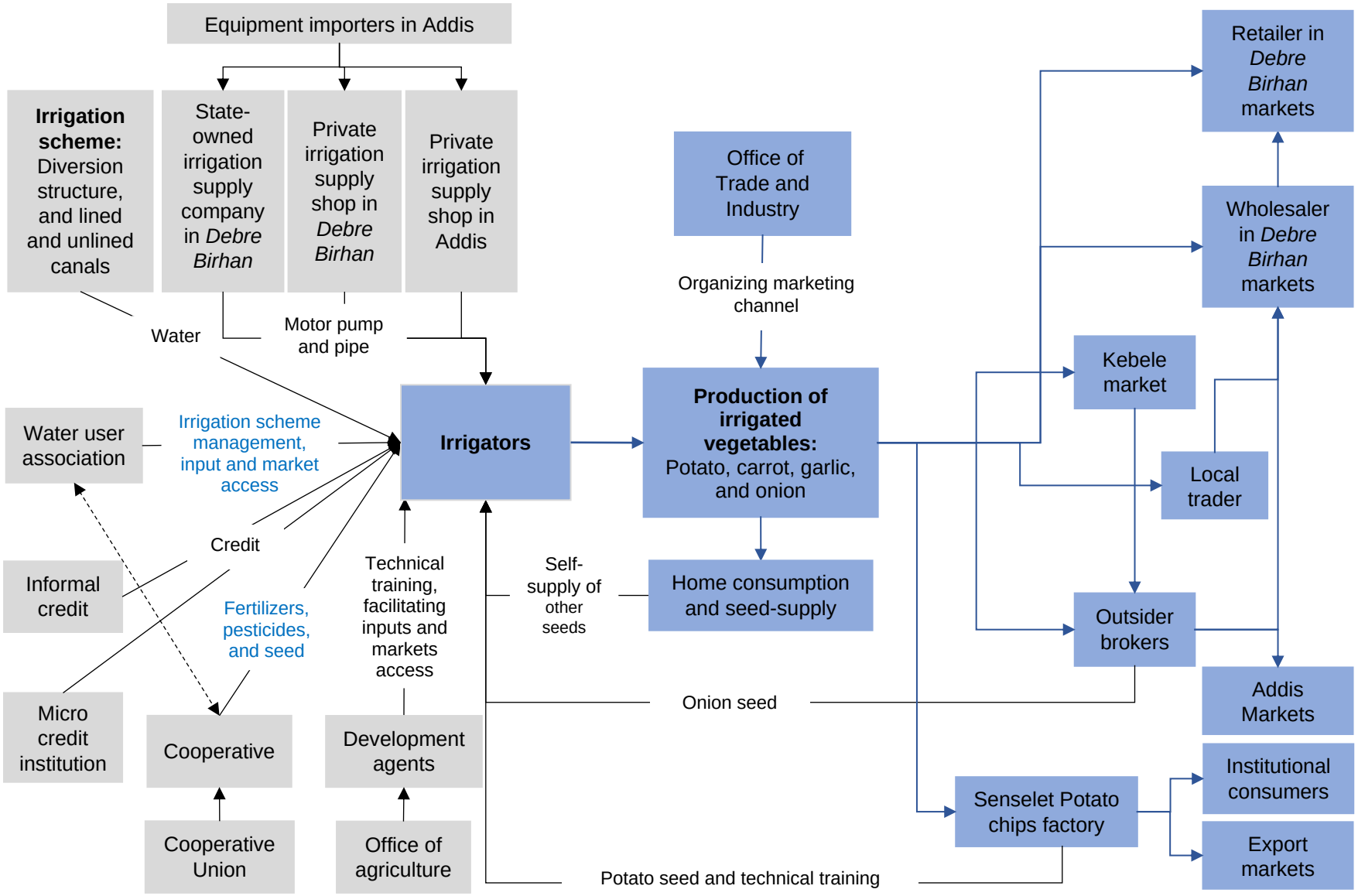

Figure 2. Irrigated vegetable value chain in Basona Worana

Marketing Channels: Farmers deploy different ways to market their vegetable products. The common marketing channel is to sell irrigated products to brokers directly from farmers' field after harvesting, or at the kebele market. Two kinds of brokers are found in the area: outsider brokers and local trader. The outsider brokers are 'professional' collectors and traders, mainly from Debre Birhan. As it is their business, these brokers often have good connections to markets, a big trading network with wholesalers, and more capital for investment. In some cases, they also sell inputs to farmers. For example, farmers in Bakello informed that: 'Garlic is very expensive and we cannot have seeds due to the fungi disease. The outsider brokers sold garlic seeds to us at the planting time. They came back to buy all garlic products and paid after they sold all garlic to the market,'. In many cases, with the advantages and the 'closed cycle business' they carry out with farmers, these outsider brokers are retaining a big share of the profit. The farmer brokers are farmers doing both farming and brokering of vegetable products from other farmers in the same kebele. In Dibut, for example, these brokers collect and buy potatoes upon which they transport them to the nearest markets. Some of them are young entrepreneurs trying to set up a business. Compared to the outsider brokers, farmer brokers often have less connections to markets, limited market information, and lack of capital for investment.

A third channel is self-marketing by which farmers bring their products to wholesale and/or at the retail markets. However, these ways of marketing products are not common and mainly occur in the kebeles with good road access. Some farmers gather products together and bring them to the markets or send these with public bus using good delivery services. In this case, farmers have strong connection with wholesalers at the markets, either in Debre Birhan, Addis Ababa or other cities. Farmers decide the selling prices after checking with other farmers about market prices as well as with wholesaler and/or retailers who they have had business with before. Farmers in Addisge, for example, call to wholesalers in Addis to check about carrot's price.

Support to market access: Recently, several initiatives have been invented by public and private actors to support farmers with better market access. For example, the Office of Trade and Industry has organized farmers and linked them with wholesalers in Debre Birhan: 'I know that the Office of Trade and Industry is helping farmers to sell onion together with a big enough amount. It is better for us too as we often want to buy a big amount. So, I prefer to buy onion from these groups of farmers' (Onion wholesaler in Debre Birhan market). For potato, the potato chip company is also acting as market actor, buying all potato from their contract farmers.

Irrigation-related organization: **Water User Association** (WUA) have been informally established among farmers having access to the same irrigation scheme. The association is governed by a chair person and secretary with other farmers as a member. This structure helps the association control the operation of scheme, manages conflict amongst users if any. Some associations also provide inputs and market access to their members. Recently, many kebeles have an irrigation development agent who is responsible for providing guidance about agronomic management practices (seed variety selection, land preparation, plantation techniques, pesticide management, and irrigation water management awareness). They link farmers with cooperatives for seed supply and market linkage. When there is a problem in the irrigation scheme, WUA's are responsible to inform to the irrigation development agents.

Irrigation equipment supply: There are two shops in Debre Birhan town selling irrigation equipment, mainly fuel-pumps and plastic pipes. One shop is owned by a private owner and irrigation equipment account only for a small ratio of his business. Fuel-pumps are sold to different clients for various purposes such as construction and irrigation. The owner claimed that: 'I bought fuel-pumps directly from an importer in Addis. My selling price is lower than the retail price of the same product in Addis. However, farmers do not know about the competitive price. They thought that buying from Addis is cheaper.' Another shop is a branch office of the state-owned company in this zone. This shop mainly

sells fuel-pumps and plastic pipe with fixed prices based on the given prices from the mother company. In both shops, there are no pre- and/or post-services provided to irrigators and technologies or services to support agricultural water management in farmer fields is absent.

Input supply: Farmers access inputs such as seeds, pesticides and fertilizers from different supplier sources. Majority of farmers access these inputs through cooperatives that get supply of inputs from Cooperative Union. The supplying of inputs to farmer members is one of important mandates for the cooperative and cooperative union. The cooperative in Bakello mentioned that they get a special discount price of inputs from the Cooperative Union and that allows them to sell inputs to their farmer members at a cheaper price. In Debre Birhan town, the zonal Cooperative Union hosts a farmer center, an input shop operated under the initiatives of ATA program. This so-called on-stop-shop sells inputs to both cooperative and individual farmers. Water user association and outsider brokers also provide inputs for farmers as a part of their business (see the information in the outsider brokers and Water user association). The Potato Chip Company also involves in supplying potato seeds to their contract farmers. These dynamics highlights the involvement of diverse private actors in supplying inputs to farmers.

Innovations and extension services: In each Kebele, there are three extension agents for crop production, livestock raising, natural resource management. They are responsible for providing extension services to farmers in forms of technology transfer, training, and demonstration, emphasizing agronomic techniques for main rain-fed crops. In the potato farming contract scheme, an agronomist from the potato chip company provides farmers with potato cultivation techniques to be accompanied with the contract. Irrigation-related extension services are limited, even neglected in this area.

Finance services: In the first months, the team could not meet the credit institution in the area due to the challenges in setting up a meeting. Given the current Covid-19 restrictions the team is hoping to complete the information in the next reporting period. Current information suggests that farmers still heavily rely on informal credit systems. The system includes personal and family networks, purchasing inputs from brokers and pay at harvesting, and group-based credit scheme.

Bundled water management and services for scaling

The data analysis highlighted several key issues in relation to the irrigation scheme and new infrastructure, irrigation practices and farming system, and overall constraints to irrigation in Basona Worana.

Irrigation scheme and infrastructure: In the three kebeles, physical infrastructure of irrigation scheme caters insufficiently for water storage and conveyance. For example, in Bakello, Agricultural Growth Program (AGP) has constructed additional canals next to the old irrigation canals to improve and expand the command area aiming to increase beneficiaries especially those with land located at the tail of the scheme. However, farmers observed that the newly constructed scheme does not operate well. The diversion structures in Addisge irrigation scheme are newly constructed by Agricultural Growth Program (AGP) and going to be used but the accumulation of sediment and debris already creates clogging and gully formation problems. In Dibut, the scheme reservoir and canals were constructed twenty years ago and needs maintenance. The water from the reservoir seeps to the downstream farming areas and causes water logging problems in both the dry and rainy season.

Irrigation practices and farming system: Irrigation is applied mainly to vegetables such as garlic, onion, potato, carrot, and leafy cabbage. Common irrigation technique applied to vegetable is flood irrigation and negatively affects crop and water productivity. The WUA leaders and some farmers in Bakello irrigation scheme mentioned that most farmers are not aware about negative effects of over irrigation

and do not know about furrow irrigation. Diseases are listed as some major constraints to vegetable production in the dry season and farmers are not aware of close relation between over-irrigation and crop's tolerance to diseases.

Constraints to irrigation: Although farmers are aware of benefits from irrigation practices, limited access to output markets, good seed quality, and labor availability constraint farmers' adoption of these practices. Moreover, access to extension services is also limited, especially extension targeting irrigation information and practices.

Based on findings from the assessment, bundled water management and services were identified for irrigated vegetable value chains, including onion, potato, garlic, etc. The package consisted of three key components:

- **Improve water application and scheduling**: combining furrow irrigation and agronomy practices to enhance farmers' decision making in application of suitable irrigation techniques.
- **Seed bank credit service**: providing vegetable seeds which are not locally available to the farmers who are considered as the early adopter and establishing the seed bank to be used as revolving fund to scale the crop in the coming years.
- **Extension services**: Providing training on irrigation and water management techniques, and vegetable cultivation techniques to farmers to enhance probe application of irrigation and agronomic practices.

Demand-driven pathway to scale bundled water management and services

The data analysis indicated five components which construct the so-called demand-driven pathway of the bundled technology and service package along the irrigated vegetable value chain in Basona Worana (Figure 3). The farmer-led demonstration of bundled technologies and services (see details in IWMI technical report 'Enhancing water and potato productivity in Bakello Irrigation scheme, Basona Worana District, Ethiopia') is the core component by which farmers decided to test irrigation coupled with agronomy techniques. The type of tested techniques in the bundled package are decided by farmers, depending on their interest and need, farming conditions, and available resources. Training involved farmers and interactions (including training) with other farmers in the same irrigation scheme and in other schemes during the demonstration are organized to raise awareness on the bundled package as well as create communities of common interests for the scaling.

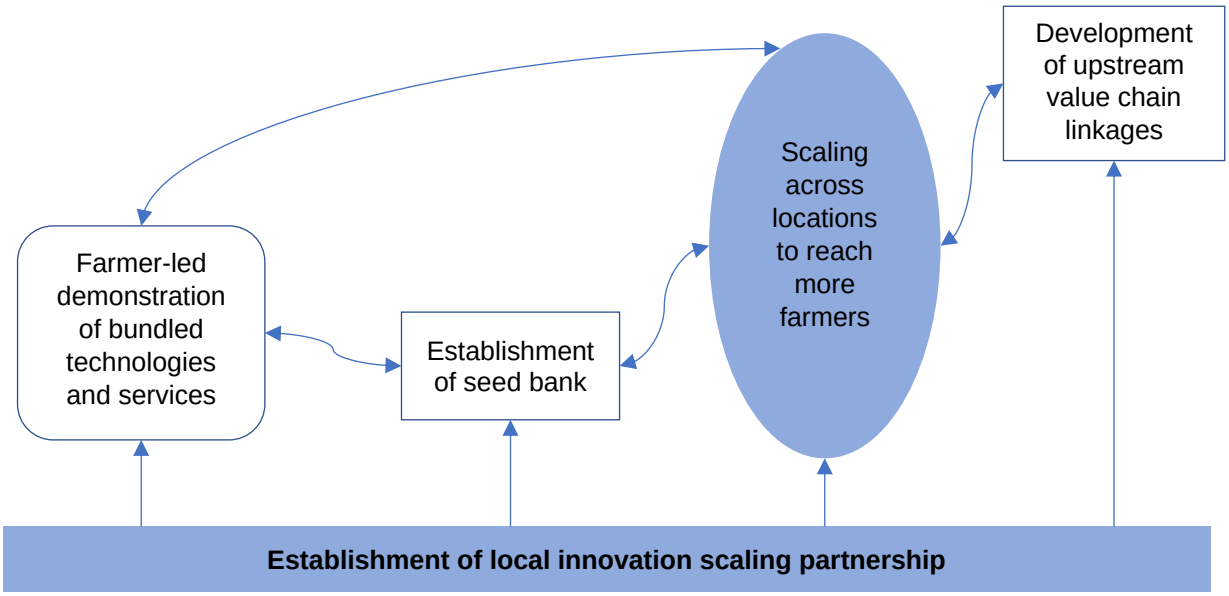

Figure 3. Demand-driven scaling pathway

The seed bank is established in which the seed funding is given to buy seed - it is potato seed in the first farmer-led demonstration in Bakello irrigation scheme - to overcome the shortage of vegetable seeds in the dry season. For example, potato and garlic seeds are not locally available, seed funding is used to buy the seeds from research institutes. Farmers will pay equal amount of seed during harvest and this seed will be used as revolving fund to scale the crop in the coming years. Seed bank is tested as a financial mechanism to scale the bundled technology package.

The local innovation scaling partnership is established and coordinated by local government agencies and research organizations and universities partners to facilitate the demonstration and the demand-driven scaling. In this partnership, each partner is responsible for activities that are within their expertise. For example, research institute and university provide technical support and seed. ANR Office coordinates, through development agents, the demonstration and scaling process. The office, as per its mandate, is also responsible for further moving the scaling beyond the kebele.

The scaling across locations to reach more farmers involves different actors to work together to scale the bundled technologies and seed bank model to other kebeles and other districts; each actor has roles and certain ways to undertake their roles and activities in the reaching. Examples of actors' roles and activities include:

- The ANR Office develops a plan to scale the bundled technology and service package. This plan can be internalized into the mandates of this office as it is aligned with the implementation of the government's current policy on rural and irrigation development. The ANR Office coordinates implementation of the scaling plan through development and irrigation agents working at the kebele level. Moreover, in its mandates, the ANR Office organizes and coordinates cross-kebele and cross-district scaling activities. Finally, the ANR Office can coordinate the local innovation scaling partnership as well as facilitate linkages between farmers and the upstream value chain actors like Senselet Potato Factory to enhance the marketing of irrigated vegetable products.
- The development and irrigation agents carry out activities in the scaling plan at the kebele and cross-kebele level, including, for example, training farmers on irrigation and agronomic

techniques, establishing and managing the seed bank and facilitating the collective marketing of input and output products.
- WUA organizes farmers' engagement in scheme-based irrigation activities, collective marketing of input and output products, and establishing and managing the seed bank wherever they are willing and capable to do.
- Research organizations and universities provide technical training to the development and irrigation agents on irrigation practice, agronomic techniques and vegetable seeds to farmers.

The development of upstream value chain linkages enhances farmers' market access and commercial marketing of irrigated vegetable products, especially when the scaling of bundled technology and service package reaches the scale. Various upstream value chain actors were identified for the development of linkages. For example, the Senselet Potato Factory which is newly established in the area in 2018 plans to expend its contract farming areas yearly. Currently, the factory is collaborating with the ANR Office in order to establish contract farming to three kebeles in 2020. This is one possibility for the ANR Office to link the factory with farmers. Another upstream actor is wholesalers. Currently, Trade and Industry Office has been working on enhancing collective marketing of agricultural products through linking farmer cooperatives' members with the wholesalers in the region. This intervention can be further used to directly link farmers with output market.

Factors influencing the demand-driven scaling pathway

Results from the enabling environment analysis shows that there are several factors potentially enabling or hindering the scaling of bundled technology packages within irrigated vegetable value chains in Basona Worana woredas highlights. One of enabling factors is the new economic development reform. The current reform in the woredas has prioritized irrigation as intervention to boost agricultural productivity. Irrigation development agents are assigned as an additional development agent at the kebele level to promote irrigation. Moreover, there is high and stable market demand from Addis Ababa. The woreda is located around 150 km from Addis Ababa. With good transportation system and relatively close distance, Addis Ababa always has a high demand for vegetables from Debre Birhan, especially in the dry season. In addition to new establishment and operation of Senselet potato factory, other food processing factories such as milk factories have been recently developed in the area and along the road to Addis Ababa. Located not far away from Addis Ababa, Basona Worana woredas is experiencing the dynamic development of food processing industry, creating opportunity for irrigated vegetable value chain actors to provide raw material for food processing. Finally, Debre Birhan research center and Debre Birhan university are two important sources of innovation, including irrigation and agronomy. These organizations can act as innovation brokers and support scaling.

However, the hindering factors do exist. One of the hindering factors is the lack of input and credit services. Finance/credit supporting farmers' investment in irrigation is dominated by informal systems. There is a strong missing linkage between value chain actors, especially irrigators with formal credit system. These obstruct farmers' investment to expand irrigation, especially when scaling beyond the irrigation scheme. Lack of seed supply hinders farmers' investment into irrigation as emphasized by many farmers and development and irrigation agents in the interviews. Another factor is the missing tradition of collective action to materialize sustainable supply to market in farmer communities. Sustainable operation of the irrigated vegetable value chain requires a continuous supply of vegetables throughout the year which is often a challenge in the dry season. This requires a more organized collective action from producers in production planning and increasing the quantity of various types of vegetable. However, this tradition of organized collective action is missing in farming communities although the presence of the WUA could provide these services.

Moreover, innovation scaling is dominated by supply-driven approaches. Government agencies and public service providers have been embedded in a supply-driven approach rather than a demand-driven approach in providing support and services to farmers. Their proposals to scaling of suitable irrigation technologies to other farmers in the kebele and beyond, include mainly "traditional" modalities of scaling such as field demonstration, farmers' field days and exchange visits, providing training to farmers by development agents and experts, using champion/model farmers to create awareness on irrigation technologies, and using multimedia to advertise the technology. These, to a certain degree, constraints the institutional capacities and changes towards demand-drive approach to innovation scaling. Collaboration and coordination among these supporters are limited. The mandates of government agencies and research organizations lend itself towards activities to support farmers' adoption of irrigation and other innovations. However, collaboration and coordination among these supporters are limited.

The successful demand-driven scaling pathway lays a set of key actions to respond to these enabling and hindering factors. First, engagement of key actors in the irrigated vegetable value chain need to be strengthened. These actors include private and public service and input providers (farmers center, development agents, input shops, local traders) who can provide irrigators with inputs such as good quality seed, irrigation knowledge, organization of production; these are pre-conditions for farmers' adoption of irrigation practices. The Senselet Potato Factory has been acting as a lead-firm in the potato value chain in the area for almost three years. The established factory provides contract farmers with additional services e.g. seed/fertilizers input on credit and best agricultural practices (extension and trainings) aside from buying the produce. Further investigation on the factory's operation, market, and business strategy is needed to identify ways to engage the factory into scaling of irrigation packages for potato. With the existing functions, water user association can become a local operational hub connecting irrigators with almost all services and resources required for the irrigated agriculture. These services and resources include extension, trading, credit, and market information as well as inputs, water governance, and irrigation equipment. The hub's function also helps to enhance linkages among actors in the irrigated vegetable value chain.

Second, enhancing the collaboration among local stakeholders and partners by facilitating and strengthening local innovation scaling partnership. The field coordinator of Africa RISING project, in collaboration with IWMI team, can provide technical support to the ANR Office and the development and irrigation agents to run the partnership. Moreover, the ANR Office can mobilize engagement of potential partners into the partnership. These partners include water user associations, farmer cooperatives, and NGOs as well as other sectoral offices like water and energy offices, trade and industry, and cooperative development offices. With the engagement of these actors, existing interventions supporting farmers' adoption of irrigation and agronomic techniques as well as inputs and market linkages can be leveraged in the demand-driven scaling pathway.

Third, strengthening farmers' collective action is key to farmers to organize their input and output market access and to manage the seed bank for the next crop season. Farmer cooperatives have provided inputs such as fertilizers to the members and marketed farmers' products. However, the cooperatives mainly focus on providing these services to major rainfed crops. Moreover, each cooperative often has a large number of members, covering majority of farmers in one kebele. Hence, promoting collective actions in the cooperative seems to be challenging. The promising form of farmer organization to promote the collective action is water user association often established amongst farmers in the same irrigation scheme. Another one is the development unit which comprises out of 15-30 farmers living next to each other in a cluster.

Scaling of water lifting technologies in Lemo woredas

Irrigated vegetable and fruit value chain in Lemo woredas

Lemo has a bimodal rainfall pattern and the dry season is from December to March. Irrigated vegetable and fruit value chains in Lemo consists out of 1) potato, carrot, garlic, onion, cabbage, kale, and chili; 2) avocado, mango, apple, and 3) seed production of vegetables and avocado. Figure 4 illustrated the irrigated vegetable and fruit value chain structure. Initial analysis of qualitative data from Lemo highlights several issues in the value chain: market demand and marketing power, under-developed irrigation equipment supply chain, and limited input supply and extension services.

Market demand and marketing power: As indicated in Figure 4, vegetables and fruits produced in Lemo supply different markets through various channels. Farmers also expressed that there are always high demands for vegetables and fruits, especially during the dry season. Farmers can sell their products at kebele markets or to outsider and/or local traders at their farms. The sale price is often fixed '… as the daily market price fixes the sale price and all traders buy for same price'. Farmers prefer to sell their products to local traders as farmers can have better bargaining power and sometime, local traders can advance cash for farmers. In some kebeles, especially ones far away from the main town, local traders - mainly local young entrepreneurial farmers – organize themselves in a group of 3 to 4 to help each other in trading businesses. They also corporate with public and private transport systems to carry vegetables to the markets. At the same time, they have developed trust-based relationship with the farmers who they buy products from as stated by a farmer in the interview: 'As the price is the same when I sell my vegetables to traders., I prefer to sell to ones living nearby my home because they sometime inform us about the market price and they also provide loans for us if we need.'

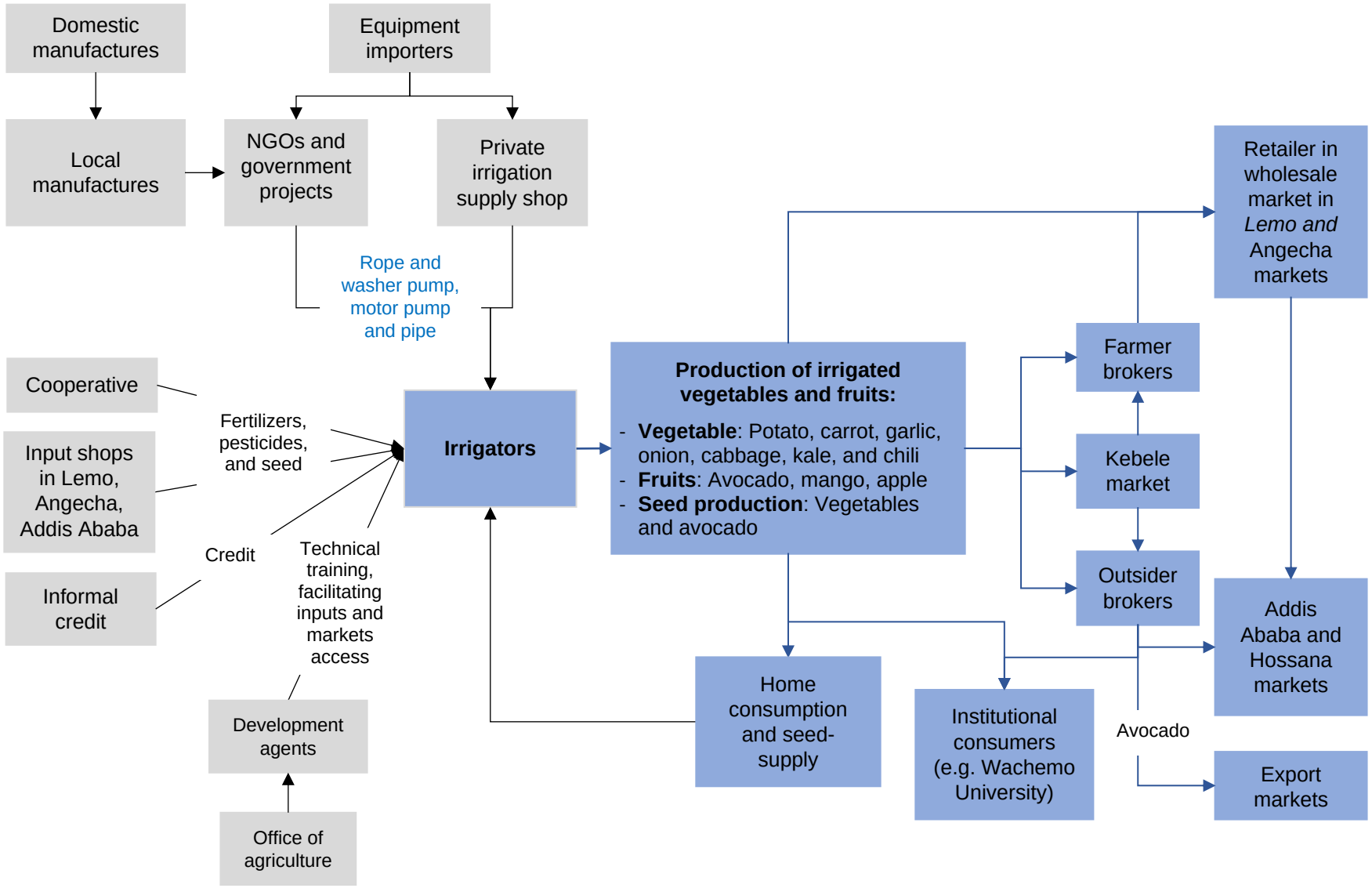

Figure 4. Irrigated vegetable and fruit value chain in Lemo

However, marketing challenges for farmers lie in the conventional ways of using quintals as the purchasing unit. Traders often pay farmers with quintal unit prices while sales to the wholesaler market is a price per kg as mentioned by participants in the consultation workshop and other farmers in the interviews: 'We usually sell our products to the brokers who come to our farms. They [brokers] put a price for a quintal, and sell the products to the market with price based on kg. So, we can see they make profit from this selling unit but it is nothing we can do.' The difference in prices could be double as shared by a local trader in the interview: 'Vegetable price depends on season and production volume. For potato, I buy a 1000 and sell 1300 birr per quintal at the market after considering transport and labour. For cabbage I buy 300 birr and sold for 600 Birr per quintal at the market.' Although farmers are not challenged by market demand, they have less marketing power.

Under-developed irrigation equipment supply chain: The existing structure of the irrigation equipment supply chains is very limited as stated by many farmers in the interview: 'There are no local suppliers, only few individuals. We have to get irrigation equipment from Addis'. Water lifting equipment such as rope and washer pumps, diesel pumps or solar pumps, are mainly accessed via government and NGO projects who have obtained equipment from somewhere else. Moreover, irrigators often have problems with operation and maintenance, even with simple techniques as rope and washer pumps. It is commonly seen that the rope and washer pumps stop working after 5 to 6 months or one year at the latest due to insufficient rope replacement, and/or low discharge when groundwater levels drop. Frequently, farmers are not aware where to buy 'the rope' to repair the pump and to obtain the appropriate technical support and maintenance services: 'I can do maintenance for this pump [rope and washer pump] but the issue is accessory and parts…. the spare rope and other parts we buy at the market are not matching…. After replacing, the pump become too heavy to operate.'

Limited input supply, credit and extension services: Provision of inputs, credit and extension services is limited to few actors – both in terms of number and capacity – in the value chain. Credit service is limited leading to the shortage of credit access for smallholders to invest in irrigation. Often, good quality seed and improved varieties are not available at the local shops and nearby areas. There is a serious knowledge gap in the extension system when it comes to irrigation, agronomy techniques, pest and disease management, especially for the improved varieties: 'In our case, getting the appropriate technical support is not possible. There are many other cases where good irrigation technologies and equipment are just sitting without use because we don't know how to use and maintain them.' (Participants in the consultation workshop).

Water lifting technology options

A rapid assessment was conducted in three kebele, namely Kerkicho, Dubanicho, and Shurmmo, highlighting several opportunities for irrigation. The households in the kebeles are characterized by relatively large cultivated home gardens and farms with fertile land, and good access to road and transportation, inputs and output market. With these conditions, irrigation activities carried out so far indicate increases in farmers' income and productivity during the dry season, even when carried out to only a portion of the land area.

However, water access is one of major challenges to irrigation. At the middle of the dry season, underground water level drops significantly and farmers can irrigate predominantly in the early morning. Taking water from wells to farm is labor intensive. In some cases, the wells are not deep enough and/or strong enough to be used. Cost of digging one well is expensive, around 5,000 to 10,000 Birr (USD 156 to 312) depending on the depth, but it is not always successful with conventional tools. In addition, irrigation-related knowledge and experience of farmers and professionals (well diggers, development agents) are rather limited as in many areas, irrigation is newly applied. Good technologies

and equipment, that have been introduced to the region, are not in use predominantly because of knowledge gaps. Finally, farmers' agronomy techniques are also limited, especially for cultivating improved varieties such as avocado and tomato. This gap negatively reduces benefits from irrigation.

Results from the assessment and consultation workshop showed that shallow groundwater irrigation has been practiced for a long-time for home gardening and farming in some areas (e.g. Kerkicho Kebele). In some other areas such as Dubanicho and Shurmmo, shallow groundwater based irrigation is more recent (approximately three years). Farmers are interested to use water lifting technologies such as solar pumps, diesel/petrol pumps and rope and washer pumps. In its project, ATA provides solar-powered pumps to a few model farmers in Lemo woredas. Most farmers who know about the demonstrated solar pumps, are interested in using solar pumps. However, there are a few constraints:

- Technologies' supply chain is under-developed;
- The technology demonstrated is also way to expensive compared to the same pump in other countries like Kenya;
- The demonstrated solar-powered pump systems are in some cases oversized for its purpose; and
- Majority of farmers have limited financial capacity to afford owning the expensive demonstrated pump.

Therefore, option for scaling of irrigation technology is to 1) facilitate the development of supply chains of water lifting equipment and services as well as finance or credit modalities into the region, and 2) build irrigation capacity (irrigation-related knowledge and skill) for farmers, and public and private service providers. Irrigation equipment and services as well as knowledge and skill to be scaled include:

- Water lifting technologies such as rope and washer pumps, diesel pumps or solar pumps, with a low cost drip system,
- Water storage like boreholes, ponds and tanks,
- Water management techniques, irrigation schedule, etc., and
- Agronomy techniques for vegetables and fruits.

Private-led scaling of water lifting technologies

Data analysis indicated three components which can be used to construct the private-led scaling of water lifting technologies as illustrated in Figure 5. The establishment of local irrigation equipment supply chain is a core component by which local equipment manufacturers develop their business with suppliers from big cities and manufacturing companies to enhance the availability of irrigation equipment stock. Dominant market segment for local irrigation supply is low cost water lifting equipment like rope and washer pump, targeting smallholder farmers. On the one hand, local equipment manufacturers can produce and/or assembly the low cost water lifting equipment and sell directly to farmers using two financial modalities as indicated by the local manufacturer in the interview:

> 'The lower income and smallholder farmers come to my workshop to buy pump. I have a loan system for the ones who cannot pay up front. For loan buyers, the payment agreement is usually for three months. They pay additional 250 birr every month. So, for a pump costed 5000 birr, the final price will be 5,750 birr at the end of the third month.'

On the other hand, the manufactures can establish their distribution and technician networks to farming community by partnering with local trader system and farmer/community-based organizations. These local traders can support irrigators in many other ways by undertaking multiple roles of local distribution of irrigation equipment, and maintenance or service provision. These networks help to provide technical support and maintenance services to irrigators. One local trader had showed his interest and willingness

in the interview: 'Providing spare parts to farmers here can be difficult as it is a permanent or main business, but bringing for couple of spare parts when there are specific demands for a period of time can be good business for me to do'.

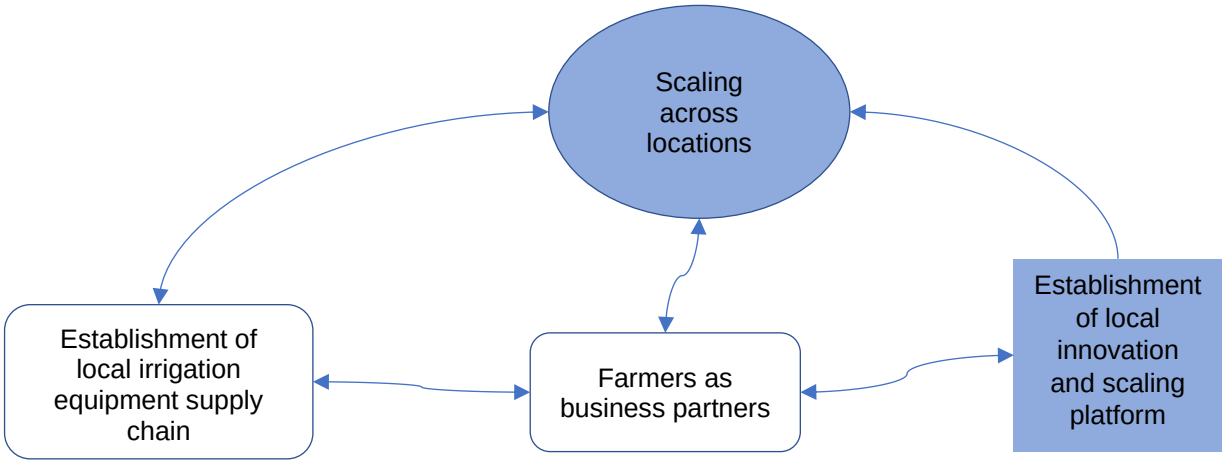

Figure 5. Private-led scaling pathway of water lifting technologies and services

The farmers as business partners is another core component in which farmers and their organizations such as producers group, community and religious platforms are seen as business partners. To strengthen their business capacity, it is necessary to build farmers' irrigation knowledge and skill and their collective organization of production and marketing, enhance their access to input market and services, and link farmer organizations with local irrigation equipment suppliers. Participants in the stakeholder consultation workshop suggested a set of actions, including:

- Kebele's development and irrigation agents articulate farmers' irrigation knowledge demand and experiences with the demonstrate to show the results to neighboring farmers.
- Social learning within community need to be strengthened with the use of informal community-based organizations and platforms like 'edir' to discuss and exchange of knowledge and information. Farmers' field is their research center and it is better for farmers to see and learn from each other. Using community and religious platforms to promote learning is recommended.
- Direct linkages to output markets can be done by organizing farmers' collective marketing and creating enabling environment for groups to deliver directly to the market or to sell to consumers themselves. Capacity to making deals with businesses like hotels is needed to enhance the direct marketing of products. Producing good quality products will also increase the chance to access more markets and get better returns.

The **local innovation and scaling platform** is established by local government agencies in collaboration with development organizations to provide space to connect farmers and suppliers, promote interactive learning among farmers, and exchange and create opportunities for business and collaboration between farmers and other businesses, and between actors promoting irrigation. The platform can act as an innovation and communication hub where different functions can be undertaken:

- Knowledge management and sharing: There are particularly good examples of successful irrigated production from farmers in different kebeles. One example is the drip irrigation using water bottles for fruit trees like avocado and mango. There are also number of ongoing research and development projects introducing and testing irrigation and farming innovations like solar-powered water pumps by AR in phase I and currently ATA. These innovation and practices can be documented and widely share with farmers and relevant stakeholders. Different means can be

used for sharing the knowledge such as workshops to bring producers and suppliers and consumers, preparation communication products like flyers and posters with visual depictions of items and share with farmer learning center, and mass media communication of new irrigation and agronomic practices.

- Creation of opportunities for joint-developing irrigation and water solutions: through the platform, actors in the local innovation and scaling platform have chances to interactively learning from others' work, thereby raising awareness and interests to collaborate. Wherever and whenever possible, the platform actors can collaborate to test and/or develop suitable irrigation and water solutions to local context. These joint-work will feed to the knowledge management and sharing function.
- Facilitation of market linkages: Input and output market linkages are crucial for the scaling of water lifting technologies. The responsible actors like Woreda Agriculture Office can conduct a seasonally market study to update and share information about vegetable and fruit market development, supply and demand, seasonal changes, and prices. The platform is also providing a space for linking market actors (e.g. wholesalers, traders) with farmers and farmer organizations. These actions support farmers' decision making on irrigation investment and market access.
- Capacity development: Continued technical support form development, extension and irrigation agents is important for farmers to enhance the return from their investment into irrigation. The platform can create space to strengthen the development, extension and irrigation agents' technical capacity and soft skill to support farmers with knowledge sharing and technical trading.

With the functional farmers as business partners and local innovation and scaling platform, the scaling across locations is critical to stabilize/strengthen irrigation supply and services to farmers in the region. First, for supplying of water lifting technologies, connecting national factories with local manufacturing can enhance the mass supply of the technologies. Second, for provision of additional services such as borehole digging and maintaining, mechanizing, it is important to meet the increasing demand on quantity and quality of boreholes in the region as expressed by the local professional borehole digger in the interview: 'I have been doing this business for 7 years, digging boreholes manually. More and more demands for boreholes now and I am trying to get machinery from the local government. However, it is too expensive with 120,000 birr for one machine'. Finally, for distributing equipment and spare parts as well as for the maintaining services, capitalizing the existing local business system such as local traders, professional borehole diggers, and artisans can ensure the more efficient and sustainable providing of these services to the large number of farmers.

Factors influencing the private-led scaling pathway

Similar to enabling factors in irrigated vegetable value chain in Basona Worana woredas, high and stable market demand is one enabling factor in the vegetable and fruit value chain in Lemo. Road and transportation system is rather developed, connecting the area with many big markets as indicated in Figure 4.

Three hindering factors were identified. One of the factors is the limited facilities and soft structures, in terms of knowledge, skill and public and private services, to support farmer-led irrigation. As the main water source for irrigation is groundwater and local challenges exist in bore drilling capabilities and services, farmer-led irrigation is not yet popularized in the area. Both public and private sectors are still so new to farmer-led irrigation that their services are far from adequate to support this type of irrigation. Moreover, public supporters such as NGOs, development organizations and government agencies are championing the promotion of irrigation in the area. However, their approach to promoting irrigation is using technology demonstration as a 'free-gift' to farmers with assumption that technologies will be spontaneously adopted in the farming community. They often bring and install "foreign to the

location" irrigation technologies to the area. Consequently, this does not support the development of local irrigation equipment supply chain. Furthermore, the lack of services, spare parts and knowledge hampers expansion of farmer led irrigation in these farming communities. Finally, there is a missing tradition of collective action to materialize a sustainable supply to markets throughout the year as also indicated for the case in Basona Worana woredas.

Condition for the successful of private-led pathway

The successful private-led scaling pathway lays a set of conditions to firstly enable and then facilitate the establishment of irrigation supply chain in the region. For example, in the kebele where farmers have long term experience with water lifting but limited access to water lifting equipment and output markets, the critical actor to the private-led scaling pathway is the existing local trader system such as self-organized young local farmer entrepreneur groups. They have the potential and interest to act as end-point distributors providing water lifting equipment to farmers. In locations where farmers have limited irrigation experience but good access to irrigation supply and output markets, the critical actor is service providers such as local professional well-diggers, local entrepreneur technicians and development agents. These public and private service providers are key actors in facilitating irrigation knowledge transfer, enabling the scaling of water lifting techniques.

Conclusion

Throughout the action research process of co-identifying value chain-based scaling pathway in Basona Worana and Lemo woreda, various technology and service options were identified for the scaling. In Basona Worana, the bundled packages of improved water application (e.g. furrow) with irrigation scheduling, best agronomic practices for vegetable, and the seed bank, to increase access to potato, onion and garlic seeds, improve and sustain productivity of land and water. In Lemo Woredas, bundling of increased access to (mechanized) borehole drilling, low cost water lifting technologies or financial services for more expensive water lifting technologies, and water management techniques were identified to enhance irrigation access for, and water use in, home gardens and farms (mixed vegetable and fruit farming system).

Pathways for the scaling of these bundled technologies and services consist of different components that go along with irrigated vegetable and fruit value chains. For example, the demand-drive pathway in Basona Worana encompasses farmer-led demonstration, setup of seed bank, establishment of local innovation scaling partnership, and scaling across locations to reach more farmers, and development of upstream value chain linkages. The structure of irrigated vegetable value chain in this region highlights that input and service providers, trader, and Senselet potato factory are key factors influencing farmers' decision on irrigated vegetable production while the locally established scaling partnership facilitate the collaboration among local stakeholders and partners to support farmers' investment into irrigation, thereby enabling the scaling of the bundling package to reach scale. The private-led scaling pathway in Lemo consists of establishment of local irrigation equipment supply chain, farmers as business partners, establishment of local innovation and scaling platform, and scaling across locations. The structure of irrigated vegetable and fruit value chain in this region highlighted that irrigation technology and service providers are key actors influencing farmers' decision on the irrigation adoption. Linking farmers with irrigation technology and services suppliers using local trader systems was identified as a key condition to reach scale. The bundled technology and services packages results in more efficient investment into irrigation, leading to higher crop and water productivity and income.

Across these regions, factors enabling successful scaling are new economic development reform, dynamic food processing industry, high and stable market demand for vegetable and fruits, and the

existing sources of innovation. At the same time, the factors hindering successful scaling are lack of credit services, missing tradition of collective action to materialize the sustainable supply to market, dominance of supply-driven approach and free-gift mentality, and limited collaboration and coordination among supporters.

These scaling pathways and influencing factors highlight that successful scaling of bundled technologies and services requires bundling interventions that enable the irrigated commercial vegetable and fruit value chain. These interventions include, but are not limited to, extension and credit provision, input and output market linkages, and innovation brokerages. The local farmer entrepreneur groups, private irrigation service providers and technicians remain key value chain actors to enhance the reliability of the local irrigation supply segment and well-functioning of irrigated agricultural value chains in the two scaling pathways. Facilitating the local innovation and scaling platforms is sufficient condition for the successful value chain-based scaling pathways. Hence, it is essential to identify the roles of different actors involving in the different components and facilitate the actors performing their roles in the scaling process. The actors and their performances, in turn, come together at the farm spontaneously to support farmers' adoption of and investment into irrigation.

From the methodological perspective, one lesson learnt is that the use of an action research process facilitates the identification of technology options that support field demonstrations and enhance the demand-driven and the private-led scaling of water solutions to support irrigated agricultural value chains. Hence, in the short term, Africa RISING should support connecting farmers and local mechanics with water lifting technology suppliers and local traders to enhance access to irrigation technologies and services as well as facilitate newly established local innovation and scaling partnerships to enhance the scaling of the bundled technology and services across kebeles, districts and regions. Over the long term, the partnership would evolve into a local innovation platform which the AR project plans to establish. IWMI also is concerned with the fact that Lemo Woredas is a region with high dependency syndrome as a result of several NGOs and Government projects providing water lifting technologies 'for free'. This will affect the private-led scaling pathway which is based on demand-driven principles. IWMI recommends to support the innovation platform established by the Africa Rising project with sharing the findings and insights from introducing water lifting technologies into irrigated vegetable and fruit value chain in Lemo as well as incorporating the private-led scaling of water lifting technologies into the platform's operation.

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