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SMART WATER SOLUTIONS

FOR ENHANCED
LIVELIHOODS
AND PROFITABLE
AGRIBUSINESS

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**SMART WATER SOLUTIONS FOR ENHANCED
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Farmer to farmer exchange visit at a lead farmer's farm

Credit: Jackline Muturi

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01

INTRODUCTION

Box 1

The Smart Water For Agriculture Project (Swa)

The Dutch government-funded SWA project focuses on the needs and opportunities of Kenyan Small and Medium-scale Entrepreneurial (SME) farmers with as little as 0.1 to 5 ha of irrigated land, commercialized to a smaller or larger extent, often growing high value crops.

In its four-year period (2016 to 2019), the project's main objective has been to facilitate 20,000 SME farmers to have improved access to and adopt SWS in order to improve food and income security, as well as increase water productivity by 20%.

The project's design is unique in targeting the entire irrigation sector, and not only farmers. This approach

allows the project to identify and address systemic constraints and opportunities at all levels of SWS value chains.

The main project components are thus quite diverse – from the development of irrigation technologies and strengthening their supply chains, to the set-up of innovative irrigation financing mechanisms and addressing market and policy constraints.

To support these diverse components, the project contributes to strengthening collaboration among key actors involved in the irrigation sector through multi-stakeholder platforms, both at county and national level.

1.1 This publication: content, purpose and target group

Taking stock of the Smart Water for Agriculture (SWA) project (Box 1) in Kenya, this paper discusses the nexus among Smart Water Solutions (SWS), agribusiness, water productivity and livelihoods of irrigating farmers, including women and youth. It analyses the processes used in promoting SWS, the impacts realized and the lessons learned.

Within the scope of the SWA project, SWS cover a wide range of SMART (Simple, Market-based, Affordable, Replicable and Technically feasible) technologies and practices across the irrigation system spectrum from water abstraction and storage to conveyance and on farm water application.

These are supported by improved access to finance, services, markets and knowledge and they contribute to an irrigated agriculture that is more economical with water; more climate change resilient; less laborious; and, more profitable and attractive to a wide range of people, including women and youth.

This paper focusses on the lessons learnt with regards to the promotion of SMART irrigation technologies, agronomic and water management practices, as well as enhanced knowledge during the four year (2016 to 2019) SWA project period.

For more information on SWS related to multi-stakeholder enabling environment support, finance, services and markets, refer to Thottoli et al., 2019 & Kariuki et al., 2019.

1.2 Water resources and irrigation development in Kenya

When it comes to water, Kenya is a land of contrasts. Though it is home to some of the great water catchment areas of East Africa, 90% of the country is either arid or semi-arid.

For agribusiness and the economy at large, local water stress is already a limiting factor, not only in the arid areas but also in the more water-rich regions where water-intensive economic and agricultural activity has grown rapidly, such as Naivasha, greater Nairobi and northern Mt. Kenya (GoK, 2007).

The Kenya Vision 2030 predicts that water demand will grow very rapidly, especially in the context of the ambitious agribusiness development plans outlined in the Agricultural Sector Transformation and Growth Strategy 2019-2029.

The water stress challenges are expected to continue and or perhaps even accelerate. Due to population growth and urbanization, farmers, who had enjoyed rain-fed farming systems or places with a relatively plentiful irrigation water supply are being pushed into drier, more

marginal areas, where they become increasingly vulnerable to drought and the unpredictability of weather patterns resulting from climate change (FAO, 2014).

To cope with the current and anticipated water stress challenges, the National Irrigation Policy (2017) is promoting an integrated agricultural water management approach, which includes irrigation technologies, field water management and appropriate agronomic practices.

This holistic approach is very much akin to the SWS-based irrigated agricultural development supported by the SWA programme as described in this paper.

Opportunities for irrigated agriculture growth are immense in Kenya. Despite the long history that dates back to the 16th century (Muthigani, 2011), only 13.5% of the 1.342

million ha potential irrigable land had been developed by 2015 (National Irrigation Policy, 2017).

As part of its BIG 4 Agenda, the Kenyan Government proposes to expand land under irrigation from an estimated 210,000 ha in 2017 to about 504,000 ha in 2022, which is expected to be highly productive, create employment and eventually lead to a society that is 100% food and nutrition secure. To realize these objectives with the dwindling water resources, there is a need to invest in SWS for agriculture.

1.3 The promises and challenges of SWS

In the past few years, a large range of irrigation technology and practices have been developed, and existing ones improved, mostly by business concerns.

These include different forms of water harvesting systems; automated water management systems; drip/sprinkler irrigation; sub-surface irrigation; greenhouses; low-cost solar pumps; lay-flat hoses; bio-degradable plastic mulch; products that improve soil moisture retention capacity; as well as pond liners and tanks and manual drilling services (Netherlands Water Partnership - NWP, 2009).

While some of these SWS have been introduced to Kenya, availability of these systems and adoption by smallholder farmers had been limited.

Among the reasons uncovered during the SWA programme inception phase is a lack of targeted coordinated outreach and services, which respond to the needs of: (a) specific contexts such as hydro-geology, market, buyer cash-flow characteristics; (b) user types - female-headed households, commercial horticultural



Farmer being trained on pond lining

Credit: Abraham Mehari

cultivators, fodder producers; and (c) organizational structures (individuals, out growers, user associations) that characterize the Kenyan landscape of SME farmers (SWA, 2017).

The other equally imperative factors that contribute to poor adoption and use of SWS in Kenya and beyond - across sub-Saharan Africa (SSA) include: land tenure insecurity; absence of supportive policy; inefficient supply and distribution infrastructure; weak farmer organizations, and ineffective private and public-sector institutions (Theis et al., 2018; Namara et al., 2014; Colenbrander and van Koppen, 2013).

Despite all these challenges, farmer-led irrigation is widespread across SSA with farmers developing irrigated agriculture in areas equalling or surpassing public irrigation schemes.

Thus, building on farmers' irrigation initiative and their demand for fitting technological solutions provides good opportunities to further expand and improve smallholder irrigated agriculture.

The socio-economic benefits from investing into addressing the above challenges and promoting SWS are significant. For instance, according to the NWP (2009), rural families can double their income if they have access to their own water well, while low-cost irrigation technologies can triple annual profits.

These technologies improve farmers' income and nutrition, while reducing the workload on women who are often the main users in smallholder agriculture (Huyer, 2018). Research by Taneja et al (2019), indicates that a net additional profit margin of 500 USD/ha can be achieved by introducing relevant SWS in the 240,000 ha considered to be of high potential for profitable smallholder irrigated agriculture in Kenya.

This can significantly boost the rural economy and reduce the unemployment rate by generating at least USD 120 million in revenue.

Evidence-based documentation by the SWA programme has shown that some smallholder farmers harnessed monthly gross income of about 750 USD/ha through SWS that combined raised beds, solar pumps, farm ponds and drip irrigation systems, which is an average based on a seasonal harvest from model farmers (SWA, 2018).

By comparison, Kenyan smallholder farmers who have not adopted improved water management and agronomic practices, and rely on inefficient surface irrigation systems have at best managed USD 210 monthly gross income (FAO, 2015). These examples illustrate the promise of SWS to significantly enhance and transform the livelihoods of smallholder farming communities.

1.4 Scope of the paper

The intended target group of this publication include private and public sector SWS suppliers and service providers; national and county governments; development and funding organizations and networks; and farmers, who may, in particular, be interested on the sections that discuss experiences of their fellow farmers. An analysis of the process used by the SWA project to promote irrigation technologies and its results is at the heart of this paper, which aims to provide information and useful insights to the varied actors involved in the development of irrigated agriculture in Kenya and beyond.

This paper discusses:

1. Mapping the SWA process, awareness creation, improved access to and creating demand and success factors for realizing adoption of SWS. It also lists, reviews, and provides rationale for the various irrigation technologies promoted by the project (Chapter 2).
2. Impact of SWS on farmer's income and livelihood improvement, economic empowerment of youth and women, enhancing water productivity and revitalizing small and medium-scale agribusinesses (Chapter 3).
3. Overall lessons learned on the process and impact of SWS, and the way forward for better promotion and upscaling of SWS.

02

THE PROCESS: TOWARDS INCREASED UPTAKE OF SWS

This chapter communicates the main principles, processes and activities that guided SWS promotion and impact. Figure 1 shows the link between the four major principles and processes at the heart of the SWA project implementation and upscaling endeavour, which are further elaborated in sections 2.1 and 2.2.



Guiding Principles

Intervene where the potential to build exists - do not unnecessarily invent the wheel

Farmers are more than just a target group - they are at the forefront of learning and exchange

Farmer-led initiatives have the best chance to succeed, but can only travel far and fast if supported by relevant technical, financial and market actors

Continuous learning and adjustments

Approaches and Activities

Mapping the potential: proven and innovative SWS and impact locations, motivated and committed farmers and their organizations, as well as relevant local actors

Showcasing the most promising SWS in the most promising locations through, among others, trials and demonstrations

Creating wider demand for promising SWS supported with evidence-based, documented knowledge and success stories

Identify and implement upscaling pathways for wider impact

Figure 1: SWA strategies and processes for SWS wider adoption and impact

2.1 Guiding principles for facilitating improved SWS supply and uptake

2.1.1 Building on existing farmer-led irrigation initiatives

The SWA strategy focuses on strengthening existing farmer-led irrigation initiatives and not (un)necessarily re-inventing the wheel. Areas with dynamic existing farmer-led irrigation development and sufficient natural, human and institutional capacity for expansion are considered as a critical point of departure for identifying and introducing promising SWS. Starting from a supportive environment has generated quick insights and a viable starting point for upscaling.

2.1.2 Farmers at the forefront of learning and exchange

The SWA farmer-led approach recognizes farmers not only as target groups, but as lead partners at the forefront of exchange and learning.

Working with experienced farmers has the advantage that the project builds on lessons learnt by farmers prior to the project and thereby generates quick results and a realistic evaluation of the potential of SWS to have a sustainable impact on (other) farmers' livelihoods.

Such farmers also possess key skills, such as drip and sprinkler installation and water pond lining, which they can provide to other farmers at an

affordable cost and no cost agronomic practices they can train other farmers on.

Among farmers, 'seeing-is-believing' is arguably the most powerful promotion method for any product or service, and SWS are no exception. Exchanging knowledge amongst peers allows people to shift from conceptual discussions to concrete ideas and critical reflections on the practical applicability of SWS.

2.1.3 Support from technical, financial and market actors needed for scaling

SWS that are either initiated or already fully embraced by farmers have the best chance to succeed in other places too. However, they can only spread fast and far across Kenya, if they are also supported by relevant technical, financial and market actors.

The main challenge that hampers the wider dissemination of SWS is that these actors rarely coordinate their efforts, often not knowing what the other is doing. The paper on Irrigation Acceleration Platform (IAP) (see Thottoli et al., 2019) explains how SWA created platforms to exchange and coordinate the actions of different actors. Conversely, SWS will not scale unless accompanied by corresponding services, access to finance solutions and information.

As detailed in section 2.2.2, SWA actively involves private technology suppliers in SWS demonstration and promotion and links them to relevant complementary service providers.

2.1.4 Continuous learning and adjustment needed to stay tuned

The engagement of relevant actors and facilitating the coordination of their activities is a central focus of SWA. These actors, along with the farmers and their organizations, are an integral part of the continuous learning and adjustment strategy adopted by the SWA project.

Continuous learning implies that at the end of each major set of activities such as, for instance, trials and demonstrations and farmer exchange events, lessons are drawn by the project team and partners on what went wrong and what was successful for informing future engagements.

2.2 The implementation processes and activities

The SWA project implementation approach for promoting and upscaling SWS consisted of four interlinked and complementary phases. Identifying priority SWS and high potential intervention areas was the focus of the first phase.

This has involved various activities including a rapid assessment (to quickly understand the environment and priority actions); baseline survey (to gather empirical information to support early decision-making); and, engagement with SWS suppliers and service providers. In the second phase, the priority SWS have been made available to farmers through, among others, demos, trials, field days and exchange visits.

These activities also identified the main challenges to adoption, which have been consequently addressed in the third phase to create and increase demand for the priority SWS. Upscaling has been the central objective of the fourth and last phase.

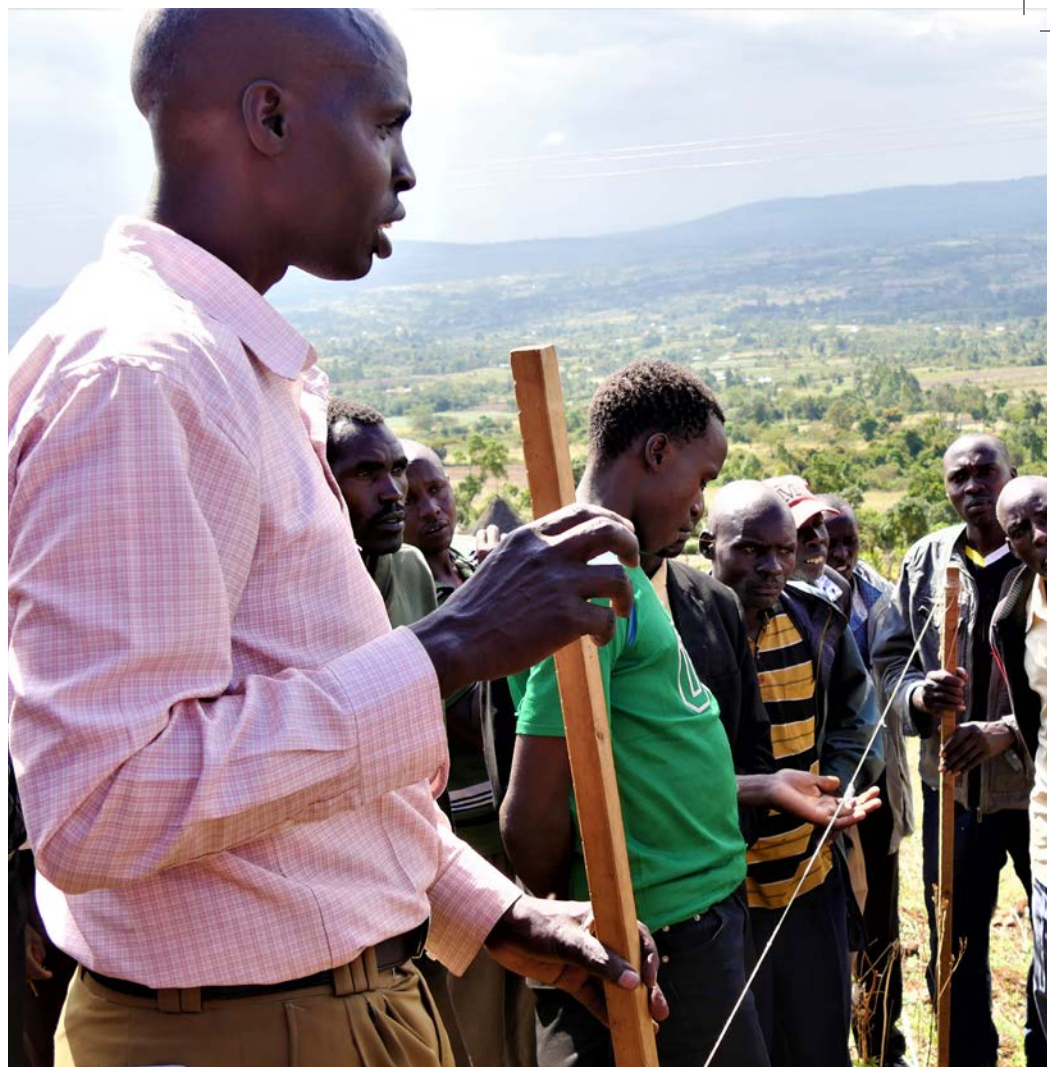
2.2.1. Phase 1: Identification of priority clusters and SWS in five focus counties

The identification of high impact clusters has been realized through county-level rapid assessments. A cluster is an area in the focus county with a substantial number of SME farmers (practising irrigation) and potential for SWS uptake.

At the same time, the rapid assessments and the baseline survey further discussed below informed the identification of proven and innovative SWS with a potential for upscaling. ‘Proven’ here refers to SWS that have been introduced in Kenya but on a modest scale at best, or that have been tried in other similar environments with good results. ‘Innovative’, on the other hand, are considered new or improved SWS that have not yet been introduced to the market but hold the promise of meeting the specific needs and local contexts of the SME farmer in Kenya.

I. County-based rapid assessments

As a first step in the SWA project, rapid assessments were carried out in various counties, fitting an initial profile of counties considered to have large clusters of farmers practising irrigation. In addition, the selection criteria were intended to



target Kenya’s main water towers. Therefore, rapid assessments were carried out in Machakos, Laikipia, Meru, Nyeri, Nakuru, Kajiado, Bomet and Uasin Gishu.

The objective of the rapid assessment was to select priority intervention clusters in each of the target counties that host the largest number of active suppliers and service providers and have the highest potential for uptake of both proven and innovative SWS. It is out of these counties and on the basis of this objective that five were selected to become the project focus counties: Machakos, Laikipia, Meru, Nakuru and Uasin Gishu.

The rapid assessment process started with county-level workshops, which involved a series of mapping exercises with purposively sampled farmers and officials (see Figure 2).

These farmers and key informants were selected on the basis that they were knowledgeable about the status and potential of irrigation development in the target counties. The mapping was followed by field verification visits and key informant interviews by an interdisciplinary team composed of farmers, SWA project staff and irrigation officials. Existing technologies and practices were listed and the potential for innovative SWS analysed and ranked according to their suitability to the local context and needs of small and medium-size. The relevant partners, who have the interest and prospective capacity to support the promotion and upscaling of SWS, were also identified.

Another important outcome was the determination of the cluster selection and ranking criteria.



Farmers being trained on soil and moisture conservation practices

Credit: Victor Lusweti

II. Baseline survey in focus counties

Relying on the key clusters identified in the process described above, a baseline survey was conducted to further refine the SWA target farmer typology.

To ensure statistical rigidity, the baseline survey interviewed 550 farmer respondents, a number considered statistically representative sample of the total 35,769 farmers in the high potential clusters. Selecting respondents randomly ensured a standard confidence level of 95% and 5% margin of error.

County	No. of clusters identified	Total farmers
Machakos	45	10,660
Laikipia	21	4,824
Meru	35	16,686
Uasin Gishu	19	2,193
Nakuru	17	1,406
Total	137	35,769

Table 1: Farmer populations in clusters in focus counties

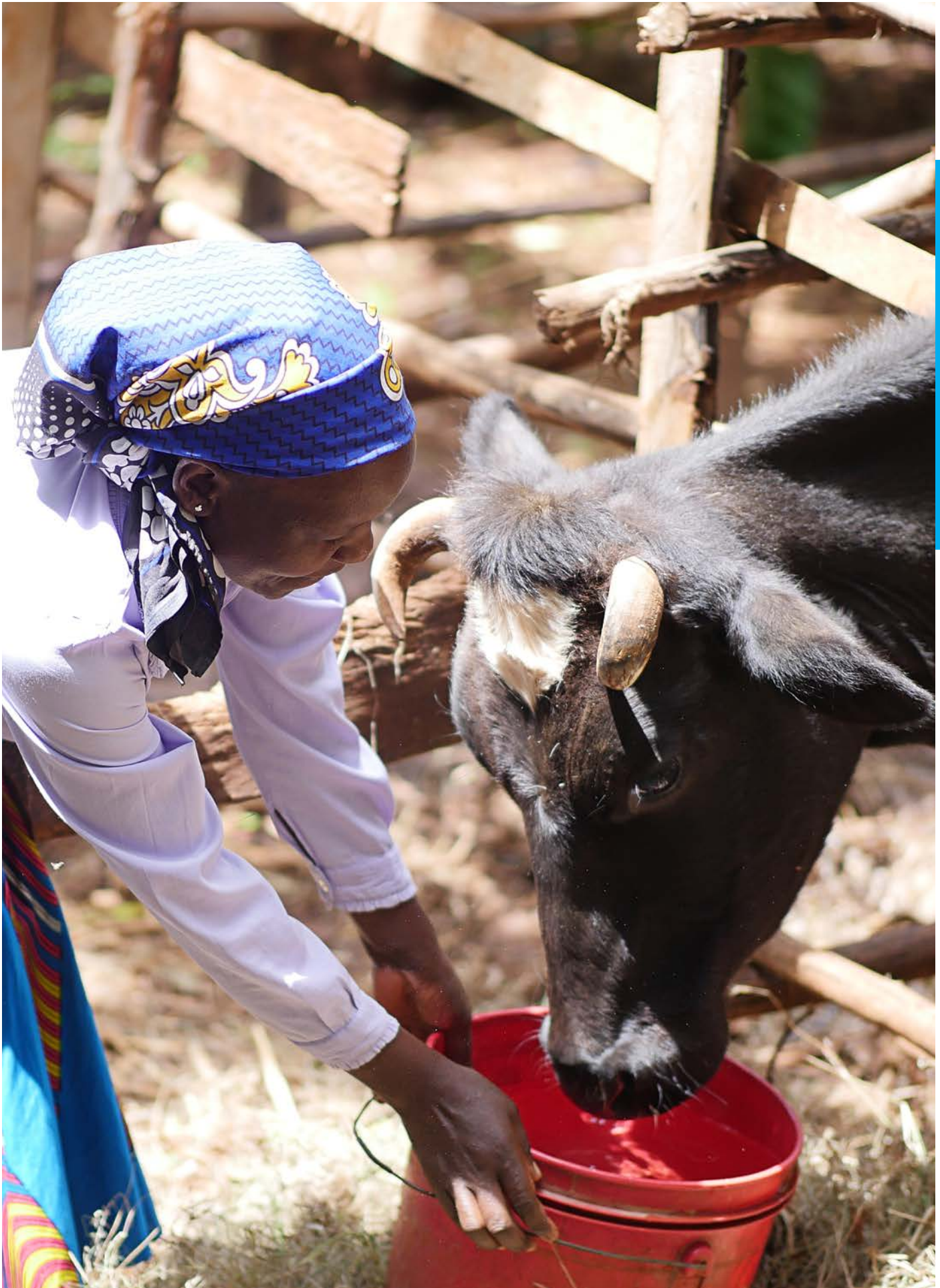
Overall, 137 target clusters were identified hosting 35,769 farmers in the five focus counties (see Table 1).

The target clusters were subsequently ranked to prioritize interventions based on the following considerations: (a) involvement of women in irrigation activities; (b) cluster size, since a high concentration of farmers presents a larger interest for SWS providers; (c) ready demand for existing SWS; and, (d) water availability for sustainable expansion.

Project interventions started in the 35 top-ranking clusters with the largest number of quick-wins where the project could easily and at reasonable cost meet its objectives. Benefiting from the lessons learned, activities were rolled out to the 56 second-rank and 44 lowest ranking clusters.

Adherence to well-established statistical practices was considered a critical success factor in ensuring that SWA made its initial investments dependent on a defensible characterization of the target population.

Chiefly, the survey gave further depth to the rapid assessment results through quantitative analyses of the opportunities and challenges that exist for promotion of SWS and improvement of the farmer-led irrigation sector in the target clusters and counties.



OPPORTUNITIES

8%

out of the sampled farmers were efficiently using SWS ranging from water abstraction and storage methods, conveyance, water application systems, and soil and water conservation methods.

50%

of the farmers interviewed were members of an organized farmers' group, who associate to either sell their produce together, learn from each other or were members of a merry-go-round association of an agricultural group.

SAMPLED

35,769
FARMERS

5
COUNTIES

100

SWS suppliers and service providers are active in the target counties.

CHALLENGES

60%

Over abstraction of water resources and over irrigation

15%

Exposure to relevant knowledge on integrated and improved water management

12%

Farmers indicating that they had access to credit.

Major opportunities:

- There are potential lead farmers - 8% out of the sampled farmers were efficiently using SWS ranging from water abstraction and storage methods, conveyance, water application systems, and soil and water conservation methods. These farmers are well connected to markets.
- More than 50% of the farmers interviewed were members of an organized farmers' group, who associate to either sell their produce together, learn from each other or were members of a merry-go-round association of an agricultural group.
- Over 100 SWS suppliers and service providers are active in the target counties.

Major challenges

- Over abstraction of water resources and over irrigation were the most pronounced challenges, as acknowledged by 60% of interviewed farmers.
- Only 15% of sampled farmers participated in relevant training and there was limited exposure to relevant knowledge on integrated and improved water management, efficient water application and farm planning and soil management.
- Access to credit facilities for the purchase of irrigation technologies and agricultural inputs was low with only about 12% of farmers indicating that they had access to credit.

These activities also identified the main challenges to adoption, which have been consequently addressed in the third phase to create and increase demand for the priority SWS.

III. Engagement with suppliers and distributors of SWS

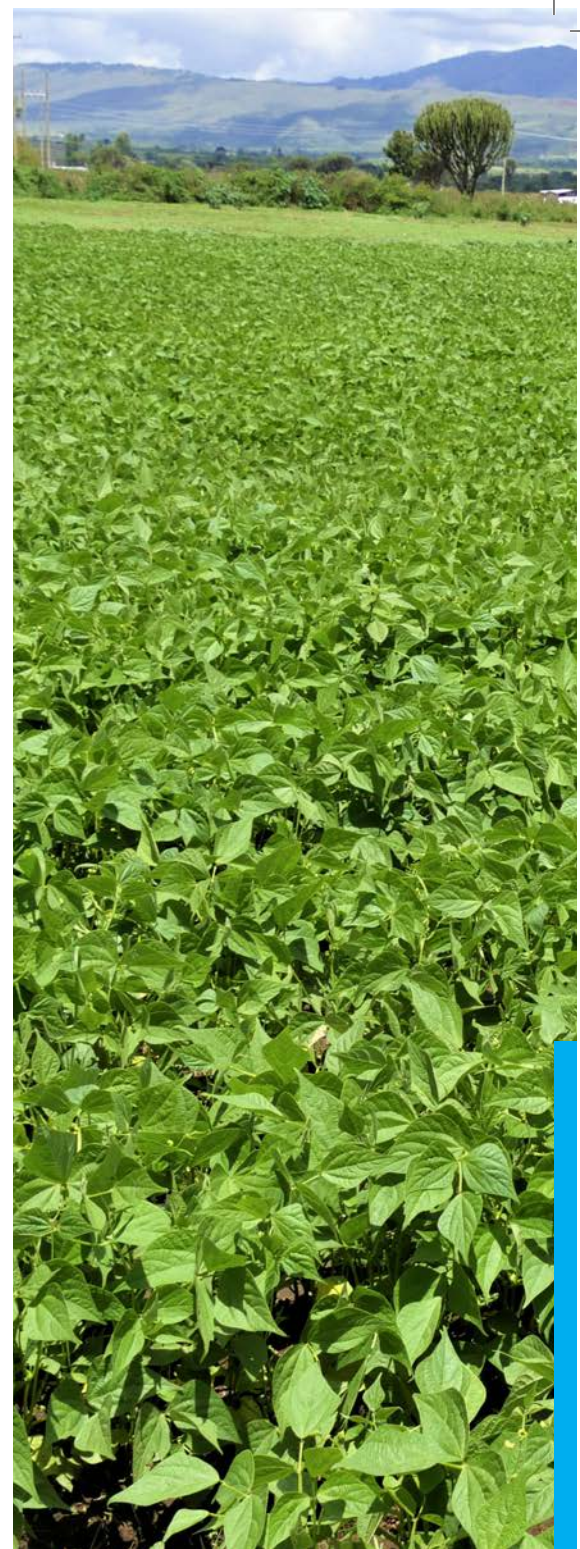
Building on the finding on SWS suppliers identified in the baseline and rapid assessment process (and specific challenges of ineffective product/service distribution channels), the SWA project specifically sought local enterprises with the capacity to provide after-sales services to reduce technology failure and extenuate the risks for individual SME farmers. Suppliers and distributors were interviewed to get an overview of which SWS were available in the counties. Engagement with suppliers was critical during the pilot and trial phases to enable continuous evidence-based learning from the field together and to incorporate feedback from users/farmers.

The suppliers and distributors of promising SWS were identified as follows:

- During the development of the project proposal, a set of potential quick-win SWS were prepared for introduction to SME farmers in the target counties.
- This provided an initial list of SWS suppliers and distributors that the project focused on.
- The national level SWS providers led SWA to their distributors at county and local market levels. Farmers also provided information about existing SWS providers within their region.
- During the project inception phase, the rapid assessment workshops brought together multiple stakeholders who shared useful insight of the SWS suppliers working in the respective regions.
- Other workshops and stakeholder discussions later in the project implementation period also led to identification of new SWS suppliers and distributors.
- The business investment and innovation project fund also provided an opportunity for SWS suppliers to present their products and business plans to the project. This way, the project knew about both existing and new irrigation solutions and their respective suppliers.

One of the project cross-cutting themes is socio-economic empowerment of women. Accordingly, special attention was given to identifying suppliers of irrigation technologies that respond to women’s needs: time and labour saving and local availability for purchase and repair services.

The most promising SWS for uptake in the target clusters are described in Box 2. These are SWS that: (a) match the needs of SME farmers in the majority of the clusters (b) have already been adopted by some farmers, including women; (c) are supported by suppliers with after sale services and the project has identified their respective challenges and possible solutions; and, (d) do not pose any socio-cultural and environmental issues.





Box 2

PROMISING SWS FOR WIDER UPTAKE BY FARMERS

Water harvesting and storage: This involves making a water repository on or off the farm to catch rain or run-off water for use during the dry season. The water can be used as supplementary irrigation for rainfed crops or for irrigation of horticultural crops when other water sources are unavailable or scarce. Specific water harvesting and storage technologies promoted included lined earthen ponds, concrete and plastic tanks.

Irrigation water application: This refers to the process of applying water to the crop in sufficient quantities and uniform distribution to support its development to maturity. Appropriate water application methods are selected based on several factors such as operating pressure, soil and crop types, and the desired irrigation scheduling.

Mist and drip, sprinklers and mini pivot systems are among the water applications methods promoted.

Water abstraction: Covers the withdrawal and conveyance of water from water sources (rivers, wells, springs, water pans and underground storage tanks) to the irrigated field. The amount abstracted depends mostly on the crop type, growth stage, soils and climate, water application system and size of the irrigated land. The project focus was on solar pumps, but we also conducted a comparative study on fuel and manual pumps. This informed the development of a pump selection app - a tool currently supporting extension workers within the focus counties to select appropriate pumps for their specific local context and needs.

Soil moisture management and agronomic practices: This comprises of practices that reduce surface runoff and erosion and increase infiltration and soil water holding capacities.

The practices promoted by SWA include mulching, zai pits, fertility trenches, raised beds, intercropping, crop rotation and seed dressing chemicals and treatments.

A female farmer works on her farm

Credit: Florence Kariuki



Mini Pivot, an innovative, low pressure and affordable technology with good water distribution uniformity successfully introduced from the Netherlands to Kenya with the support of SWA

Credit: Victor Gitonga

II. Field days and trainings

In agriculture extension practice, farmer open days (field days) are widely considered an effective method of fostering farmer learning and strengthening linkages between exhibitors (suppliers) and buyers (farmers). Illustratively, baseline survey findings indicated that farmers (more than 50%) learnt about new practice and techniques through field days.

Therefore, to increase farmers' awareness about existing irrigation technologies, the SWA project facilitated educational events hosted by different players in the irrigation value chain throughout the implementation period. The majority of events were either held on-farm or at agricultural training centres within the SWA focus counties. The field days included demonstrations of specific irrigation technologies, financial products, soil and water management practices, as well as connection to available outgrower services and products.

The organization and mobilization of farmers for participation in field days was a collaborative effort among the project and partners, including the private and public SWS suppliers and service providers, lead farmers, and various institutions supporting

capacity building initiatives at local levels.

III. Horizontal learning - working with lead farmers

The methods described above constitute vertical learning – where suppliers of technology or service transfer their knowledge and practices to farmers. However, SWA recognizes that farmers are repositories of vast knowledge.

Therefore, while promoting vertical knowledge transfer, SWA invested significantly in horizontal learning initiatives. Horizontal learning deals with the exchange of good practices, knowledge and ideas between peers or groups of peers, in which there is no monopoly on knowledge. It involves people coming together to see, observe, discuss and learn from people who have first-hand experience. Bringing groups together that have similar interests and challenges (farmers for instance) can unfetter much energy, both by learning from each other, as well as to create a self-evolving movement of proven and new SWS and institutions.

More than half of the farmers interviewed during the SWA baseline survey indicated that farmer-to-

farmer horizontal learning is their preferred pathway to learn about irrigation practices. This fact was further consolidated during the targeted farmer-to-farmer exchange events undertaken with the support of lead farmers in Laikipia and Meru counties. The interest and demand for such events was high: the first two test lead farmers, with limited support from the project team, nurtured an additional 10 lead farmers and trained 600 farmers on practical aspects of varied SWS as well as linkages to markets and finance.

Having documented the interest and impact of the initial lead farmers and how they contributed to horizontal learning, the SWA project expanded the horizontal learning component by engaging and building the capacity of 18 additional lead farmers for upscaling SWS. The horizontal learning approach has been adopted as a major scaling strategy, which is further elaborated in section 2.2.4 and Chapter 3.

More than half of the farmers interviewed during the SWA baseline survey indicated that farmer-to-farmer horizontal learning is their preferred pathway to learn about irrigation practices.

Lead farmer organized horizontal learning: exchange visit between Laikipia and Krinyaga county farmers. Water harvesting, agronomic practices and marketing were among the topics discussed



Credit: Abraham Mehari

2.2.3

Phase 3: Creating and increasing demand for priority SWS

As discussed above, the showcasing of suitable SWS and horizontal learning activities provided insights into the opportunities and barriers for adoption of the different SWS. The barriers can be broadly sectioned into technical, information and financial obstacles.

The financial barriers and potential solutions are discussed in the paper on Inclusive finance and business strategies for farmer-led irrigation development (See Kariuki et al. 2019). As for the technical barriers, each technology is characterized by specific conditions that makes it attractive

or valuable to farmers. Box 4 has illustrative examples.

The fact that the success of a specific technology or set of technologies is context-specific asks for practical and clear information provision to farmers and extension workers. Indeed, the lack of reliable, understandable and specific information is considered a major barrier to investment in SWS.

During the SWA implementation period, many farmers indicated that, often, they do not have the necessary information and knowledge to compare the technical suitability and cost-effectiveness of competing products.

Box 4

CONDITIONS FOR SWS TO BRING ADDED VALUE TO FARMERS

1. Water harvesting and storage: reliable water supply, favourable topography, interest in multiple cropping, local service providers of water pan liners
2. Solar pumps: small-to-medium scale plots (available and affordable solar-driven pumps cannot serve larger area effectively), availability of water storage facilities, efficient and automated application systems, high diesel and electricity cost
3. Efficient application systems: limited water resources, long supply canals and high evaporation and seepage losses, labour is costly or limited in availability
4. Soil improvement measures: land ownership, long dry spells and hence the need for better soil moisture holding capacity, knowledge on soils and nutrient deficits, alkalinity and salinity problem

Arguably, on a technical level, farmers usually rely on experiences from peers. When talking about petrol pump sets, most farmers know which brand provides a large flow and which one lasts longer. Such farmer experience is not present yet to an appreciable degree for the innovative SWS promoted by the SWA project.

For instance, there is a whole range of solar pumps in the market with different characteristics that most

farmers have not yet experimented with.

The technical information provided by suppliers is usually incomplete, biased or difficult to understand. This scenario is one reason why SWA constituted information provision as a major strategy to support farmers in obtaining SWS that are productive for their situation.

When technical information was not available, key studies were carried out

to provide more insight. An illustrative example on the comparative sprinkler test (see Figure 6) showed that under low (< 3 m) pressure, a common situation among smallholder farmers in the target counties, the low-cost Butterfly sprinklers perform better – covering a larger irrigated area (radius) – than all the other more expensive jet sprinklers.

The most affordable and best performing Yellow Plastic Butterfly sprinkler

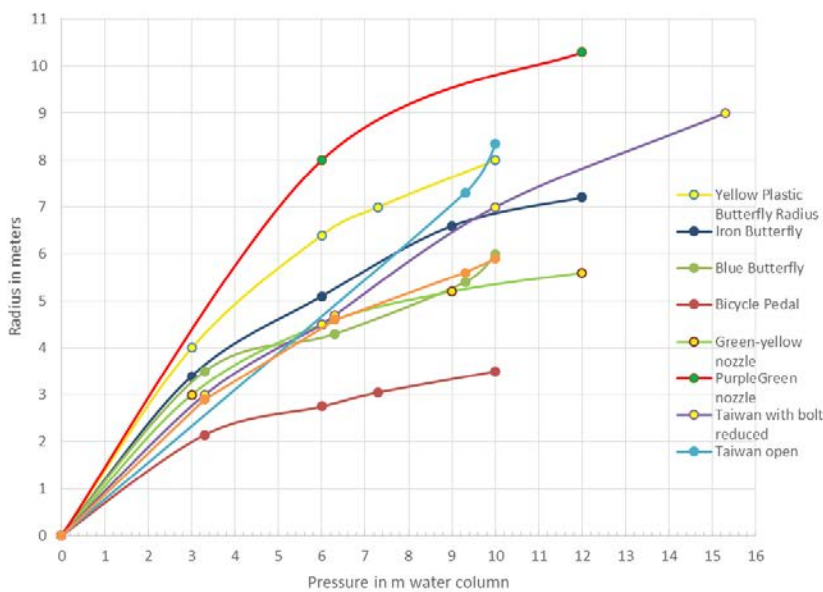


Figure 6
Comparative technical performance analyses of sprinklers conducted at Kaguru Smart Centre, Meru county, Kenya

Credit: Erik van de Giessen

The Yellow Plastic Butterfly sprinkler (Figure 3), which is the most affordable at USD 1 per piece, registered the biggest wetted radius even at higher pressure heads. It is outperformed only by the more expensive high-tech Purple Green sprinkler brought in by the project for testing, which is not yet locally available.

Gender and pump studies were the other two imperative studies conducted to understand the challenges, and hence enhance the opportunities, for adoption of SWS.

I. Gender study

This study focussed on understanding the specific barriers, needs and priorities of women in irrigated agriculture. The study established that, although men and women used different selection criteria for SWS, primarily driven by ergonomics, there were no such 'male' or 'female' technologies. Whereas men mainly gave more technical-environmental reasoning (topography and size of land, type of crop etc.); for women, socio-economic considerations (time and labour saving), as well as flexibility and safety, were more important. Another useful finding was that women prefer short cycle low-investment crops, while men tend to focus on long-term investments. This is partly because land titles and household finances are largely controlled by men. These results informed the indemnification of SWS suppliers that respond to the needs and challenges of women.

II. Pump study

The study's objective was to compare the performance of different pumps available in the Kenyan market with special emphasis to the SWA focus counties and examine how efficiently farmers use these pumps. There

are various pumps available in the Kenyan market and their applications vary from place to place and also depending on the user's knowledge of pumps. The data collected was intended to support the SWA project to develop an irrigation pump choice decision-making tool for small and medium-size farmers in Kenya. The resultant tool would then guide farmers in selecting the pump of their choice based on their irrigation situation, irrigation needs and willingness and ability to pay for both investment and recurrent costs of pump use. This tool will enable farmers to easily select pumps that are appropriate for their specific pumping requirements.

Farmers also indicated a lack of clarity when it comes to service provision by SWS suppliers. For example, warranties offered were not clearly described and promised after-sales services that could not be reached when needed. SWA deliberately included contact information and detailed descriptions of product warranties in the guides and sessions organized. Specifically, SWA, with contribution from leading technology suppliers, developed the 'Smart Farmers Guide' https://snv.org/cms/sites/default/files/explore/download/smart_farmers_guide_2019_181119.pdf, a descriptive compendium on best practice in the selection and application of commonly used and innovative irrigation technology.

Limited insights in the investment costs has also been a barrier to successful SWS adoption and implementation. The problem manifests itself especially for materials for which different qualities exist and, when purchased, quantities need to be tailor-made to unique farm situations. Both issues arise, for example, when investing in water pan liners.

To overcome the information barrier, SWA developed promotional materials as well as decision-making tools. The approach created awareness and increased demand for the priority proven and innovative SWS.

III. Promotional materials

The SWA project, in collaboration with SWS providers, developed and disseminated promotional materials designed to create awareness about available smart water products and services. The dissemination of materials played an important role in supporting increased demand by farmers and, improved sales and strengthened supply systems of the respective SWS providers.

The project aimed at creating demand and equally satisfying this demand by increasing access to required products and services. The promotional materials so developed were shared during project events including field days, training, workshops, farmer-to-farmer exchange visits and ad-hoc meetings. Some of the promotional materials developed include:

- The project brief: which mainly summarised the project goal and objectives and was distributed to different stakeholders during project workshops and meetings. The objective of sharing the brief widely was to inform different players about the project and reach even more stakeholders and enhance collaboration in the project.
- SWS suppliers and distributors product brochures: The project facilitated the development and dissemination of product brochures, mainly through the investment and innovation funds in support of the business partner companies

to make known their products to a larger pool of farmers.

- Promotional videos: The project developed video clips on some of its activities in the focus counties in an effort to increase SWS demand and adoption. These were then disseminated through the national TV stations, as well as social media including WhatsApp and YouTube. See for instance: <http://www.nation.co.ke/lifestyle/DN2/With-my-own-water-pan-I-can-farm-all-year-round/957860-4029100-149mc08/index.html>; <https://www.youtube.com/watch?v=gJtb2B9sF90&t=231s>
- IV. Decision-making support tools
- Decision support tools, both in print and digital, were developed to respond to specific information and knowledge demand among farmers to make informed selection of SWS to meet their needs and capacities. There were developed, in part, from the various studies and with input from farmers, extension agents and SWS suppliers. The main tools developed and disseminated are as summarised below.
- Smart Farmers Guide: This printed manual provides useful information to farmers on the priority technologies and products promoted by the SWA project: technical specifications; unique characteristics and benefit streams; how to assemble and disassemble them; where to purchase and where to repair them. The manual supported farmers in selecting irrigation technologies which best fit their farm and their socio-economic situations and was jointly

developed by the SWS providers and the SWA project. The manual also provides contact information for all SWS providers whose products are listed. The manual is disseminated through lead farmers, county irrigation departments, the IAPs and the SWS suppliers and distributors.

- Water pan-sizing tool/App: The App is a mobile-based tool which provides a convenient way for farmers to correctly size their water storage pans based on their geographical location, irrigated area, water storage needs and crop water requirements. The application also assists farmers in making cost estimates for excavation and lining of water pans. In addition, SWS providers of lining material can use the application to easily size water pan liners when making sales to farmers. The application responds to the widespread demand for water harvesting and storage in most of the SWA focus counties. The tool was tested in Machakos County and later scaled to the other four SWA focus counties. The application is available on Google Play Store and can be downloaded from the link: <https://play.google.com/store/apps/details?id=ke.co.sart.swa>
- Solar pump selection App: Solar irrigation pumps are considered a feasible pumping solution for small-scale farmers irrigating less than 1 ha of land. After an initial high investment cost, solar pumps reduce annual production costs by 30-60% in comparison to petrol pumps because no fuel is needed and maintenance costs are much lower. Compared to manual

pumping, such as treadle pumps or simple rope and buckets, solar pumps allow farmers to increase the irrigated size of the land and save significantly on labour costs and efforts. However, compared to fuel pumps, pressure and discharge are limited, making it difficult for farmers to irrigate more than 1 ha of land without a storage facility. There are numerous solar pumps on the Kenyan market – but selection of a specific pump for profitable production requires careful consideration. The pump selection App was developed to provide a simple way for farmers to select, among the list of solar pumps available in the Kenyan market, the most appropriate solar pump for their specific farm situation. The selection is based on the source of water, the field dimensions, the total pressure and volume of water needed, conveyance and on-farm water application options, and the purchase cost. The application provides a user/farmer-friendly interface, which is easy to use and understand while complex algorithms are worked out in the background. The tool can also be used by extension workers during training and field operations to support farmers in making informed decisions about the correct pump type to purchase. The app can be obtained at: <https://play.google.com/store/apps/details?id=nl.hiemstead.solarpumping>

2.3 Phase 4: Upscaling of proven SWS

Upscaling was the last phase of the project implementation period and focused mainly on addressing barriers to wider uptake of SWS that have already been adopted by some farmers. The barriers included knowledge gap, lack of adequate distribution networks, and financial constraints.

During this phase, four scaling pathways were identified:

1. Horizontal learning - making use of lead farmers, Smart Centres (SCs) and IAPs.
2. Local financial institutions - special financial organizations that facilitate SWS.
3. Value chain - involves linking up those seeking supplies of SWS to the suppliers and manufacturers of SWS.
4. Improved SWS supplier and distribution network.

In this paper, we dwell on the 'horizontal learning' and 'supplier and distribution network' scaling pathways. The other two scaling pathways are described in the papers, 'Inclusive finance and business strategies for farmer-led

irrigation development' (See Kariuki et al. 2019) and 'Multi-Stakeholder Collaboration for Farmer-Led Irrigation Development' (See Thottoli et al. 2019).

1. Horizontal learning - making use of lead farmers, SCs and IAPs

As described earlier, horizontal learning is widely regarded as a sustainable approach to learning given that farmers get first-hand knowledge from other peers and that the process is self-evolving and sustainable, considering that it is wholly determined by participants.

The SWA project is currently working with 30 lead farmers from within the SWA focus counties to reach more farmers. Within the last 6 months of the project, each lead farmer will have reached at least 300 farmers. This target is based on a successful trial described above, where a target of 300 farmers was determined to be optimal for sufficient follow-up support by the lead farmer. It is envisaged that the 300 farmers will, in the long term, also reach other farmers and this will continue in a snowball effect approach.

In the coming 5 to 10 years, the scaling opportunities that are likely to be realised will be achieved by

sharing and facilitating uptake of already known SWS, discovery of new ones and the development of new innovations and irrigation practices. Lead farmers will be at the forefront in achieving this.

To lay the foundation for harnessing the upscaling opportunities in the final year of implementation, SWA developed and implemented a 'lead farmer' capacity building initiative.

This included county-based training (Figure 7) at which SWA shared the long-term vision for the lead farmer initiative, co-developed (with farmers), a guideline to becoming a successful lead farmer, and the numerous revenue models a farmer could use to generate income from training other farmers. In addition, farmers developed individual work plans in line with their farm needs and their respective entrepreneurial farming business plans. These work plans were later analysed by SWA with subsequent priority given to more practical solutions proposed by farmers respective to their farm. All purchased material support by the project was carried out on a 50-50 cost-sharing basis.

The SWA project is currently working with 30 lead farmers from within the SWA focus counties to reach more farmers.

Lead farmers participating in SWA project organised training (note the youthful lead farmer trainer)



Credit: Jackline Muturi

Selection of lead farmers is as important as the process through which farmers are trained and enculturated to the process of training others.

Therefore, lead farmers were selected on the basis of two broad criteria, as described in Box 5. Regardless of the criterion, the project also carried out a validation process through which target farmer trainees (of the lead farmers) were interviewed to determine if the prospective lead farmer had the desired traits appreciated by the community.

Box 5

CRITERIA FOR SELECTING LEAD FARMERS

- i. **Location:** The farmer is located in an area accessible by farmers and belongs to a large farming community with at least 1,000 members.
- ii. **Technologies:** Owns at least 1 ha of irrigated land and hence can showcase various SWS packages. The farmer should have successfully adopted and used (with or without external support) SWS that address the most critical challenges faced by the majority of farming community members.
- iii. **On-farm water availability:** The farmer has sufficient water to irrigate.
- iv. **The farmer should possess acceptable personal attributes,** including willingness to allow farmers into their farms to learn; be trusted members of the community in which they live; are visionary about transitioning their farm to a training centre; and have previously hosted demos in collaboration with government extension workers and private sector players.

Partially in support of the lead farmer model, the SWA project also facilitated the set-up of two **Smart Centres (SCs)** in which SWS training, demonstrations and trials were carried out. The SCs are also convening points for open field days and knowledge sharing events organised by the IAPs, technology suppliers and other local partners.

Moreover, they also provide the platform for practical training of irrigation officials on SWS aimed at improving the quality of the extension services offered by the county department of agriculture and relevant private sector institutions. The two SCs developed by the SWA project are based at the Kaguru Agricultural Training Centre and the Egerton University.

Practical session at Kaguru Smart Centre during the SWA organized training (15 to 26 July, 2019) on SWS attended by 25 irrigation officials representing all eleven sub-counties of Meru county

Credit: Abraham Mehari)



In the second half of 2019, the SWA project invested in supporting the SCs to become recognized members of the Smart Centre Group <http://smartcentregroup.com> (which includes others in Tanzania, Malawi, Mozambique and Zambia).

This requires the strengthening of the SCs in four key areas: (a) quality in showcasing technologies and good agricultural practices; (b) quality in training and management; (c) networking and collaborating in outreach activities; and, (d) business and revenue generation.

These activities that will continue to be rolled out in the coming years are also expected to better position the SCs as major contributors to climate and water-smart agriculture, enhanced food security and livelihoods of farming communities, as well as support a dynamic private and public agribusiness sector.

II. Improved supplier and distribution network

During the SWA implementation process, it was determined that most SWS suppliers expressed minimum interest in working directly with SME farmers – last mile costs tend to be prohibitive for their sales and distribution models. Instead, the suppliers preferred to work with local distributors often based in major commercial centres in the counties.

The result of this strategy is that farmers often did not obtain timely and accurate information about available SWS, compounded by the

fact that distributors often stock supplies from various manufacturers and will ‘push’ sales, not because of the merit of a particular technology, but because of manufacturer incentives attached to certain SWS.

This informed the following processes and activities:

a) mapping the strengths and weaknesses of the major distributors and, accordingly, conducting capacity building programmes: such training was given in Uasin Gishu and Nakuru

counties, which had the largest per capita concentration of manufacture agents;
 b) Mobilize resources to support existing and new start-up distributors, prioritizing those willing to operate in the rural areas: this, for instance, resulted in expanding the distribution network of, for example, Sunculture and FuturePump (both manufacturers of solar-powered irrigation pumps); and,
 c) master classes – knowledge and experience sharing sessions – were organized that brought together varied suppliers and distributors.

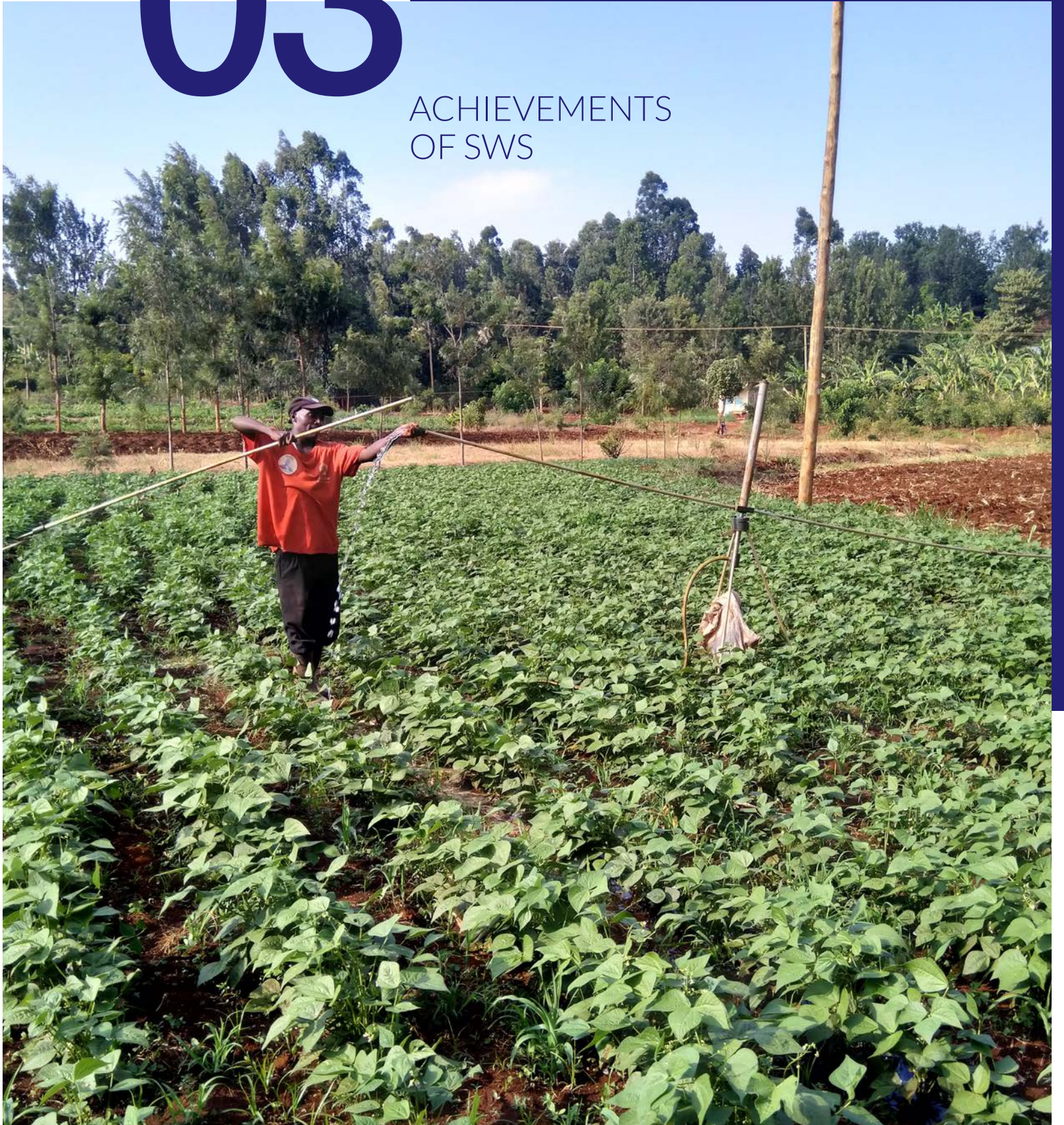
The farm manager, Charles, explaining to farmers and local SWS distributors on organic cultivation of cabbage at Egerton University Smart Centre on November 9, 2019

Credit: Antony Kibe



03

ACHIEVEMENTS OF SWS



In this chapter, we present and discuss what the activities - as described in Chapter 2 - concretely achieved, as well as how some objectives were difficult to realize. After highlighting key achievements, the remainder of the chapter is then structured into six topics – reflecting the general objectives of the SWA project:

- Farmers reached and uptake of SWS;
- Farmers income and food security;
- Women and youth economic empowerment;
- Improved water management and productivity;
- Increased job and business opportunities;
- Knowledge documented and disseminated; and
- Catchment management interventions.

3.1. Highlights of key achievements

Since 2016, 22,000 farmers have been reached and acquainted with varied SWS, out of which 7,500 farmers have actually used (adopted) at least one of the promoted SWS. Adoption here is directly linked to improved water management and increased income. A 30-50% reduction in water usage was reported by farmers who adopted efficient irrigation scheduling, water saving technologies and agronomic practices, such as mulching and rotational farming.

The income generated by some of these farmers was seven-fold compared to the average documented income of Kenya's smallholder farmers. For instance, ThirdEye, in one of the SWA's investment fund applications, confirmed a 20% increase in tomato and cabbage production which translated to €100 additional seasonal income for smallholder farmers cultivating less than 1 ha. ThirdEye's programme provides timely advisory and extension services to farmers. Using flying sensors mounted on unmanned aerial vehicles (drones) to capture water and nutrient stress, as well as pest and disease prevalence, two weeks before these can be detected with the naked eye, farmers can make informed decisions on productivity determinants such as irrigation amount, scheduling, appropriate inputs and agronomic practices, including preventive and safe chemical applications.

Women farmers who adopted SWS that saved time and labour could independently run vegetable and other short-cycle farm businesses. This, in turn, generated income while allowing additional time for their household errands, which ultimately resulted in increased socio-economic empowerment. Conversely, improved farm business profiles created job opportunities for their erstwhile unemployed working-age dependants. A clear example is the case of the ICT-powered extension service provided by ThirdEye's services which, at the writing of this article, has employed six young professionals in Meru County. The firm projects that, given its growth trajectory, similar opportunities are expected to expand further within Meru and other surrounding counties.

Hands-on practical knowledge has opened business opportunities for the lead farmers. Lead farmers are attracting large numbers of farmers from across the country willing to pay for training and other services such as installation of pond liners and improved water application technology, partially due to their proximity to farmers with similar constraints, knowledge dissemination style and linkages to SWS suppliers. The best lead farmers have been contracted by projects and county government institutions dealing with improved agricultural practices and attracted by the lead farmer client base, thus proving the self-sustaining potential of this extension approach.

On the supply side, several SWS suppliers and distributors have strengthened and expanded their market channels to better meet farmers' needs (who have greater decision-making knowledge) and other clients. Strengthening of marketing channels included facilitating linkage to wider distribution networks such as that of Davis and Shirtliff, the largest supplier of pumps, and other water related equipment in the East African region; and successful entry into new markets on the basis of the improved understanding of farmer typology. The expansion in business of the SWS suppliers and distributors shows promise in creating additional employment opportunities, particularly for the youth who are expected to be among the majority of adopters of SWS and also constitute sales teams for SWS.

In support of the structural improvement in SWS distribution, farmers and extension professionals were acquainted with the main contents of the Smart Farmers Guide, which communicates appropriate installation, operation and maintenance of varied SWS. The Guide also lists technology supplier contacts in case they want to purchase a technology or if they need after-sales support of the SWS from the suppliers.

The SWA project design has integral references to Integrated Water Resources Management approach to managing soil and water resources. Therefore, to reduce environmental degradation and ensure positive lasting impact of the achievements, the project trained farmers on various soil and water conservation measures

including mulching and minimum tillage, contour and bench terracing, fertility trenches and agroforestry. An illustrative example of success includes more than 20,000 trees planted by farmers abstracting water from the Olchoro River, a tributary of the Amala in the upper part of the Mara Catchment, Narok County. Such measures, accompanied by appropriate on-farm agronomic practices reduced recorded sheet erosion and gully formation in the downstream irrigated areas, resulting in increased water flow in natural water ways and reduced sediment load in the farmer-developed abstraction structures (irrigation water intake works) on the Olchoro river.

An illustrative example of success includes more than 20,000 trees planted by farmers abstracting water from the Olchoro River, a tributary of the Amala in the upper part of the Mara Catchment, Narok County.

3.2. Farmers reached and SWS uptake

The project monitoring and evaluation (M&E) data shows that 19,000 farmers (40% women) have been reached and acquainted with varied SWS (technologies, improved water management and agronomic practices). The project target is 20,000 producers.

Translating ‘reach’ to actual SWS uptake (adoption) was and remains a major but surmountable huddle. Data validated through regular field visits and other monitoring activities, including the project mid-term review and progress reports, indicates that about 7,500 farmers have adopted one or more SWS. There is much ground to be covered here (adoption) irrespective that accelerating adoption was the major

focus in the final implementation year of the project. Accordingly, four pathways were piloted and their reach to adoption efficiency analysed (Figure 10). These were: (a) horizontal learning – led by lead farmers and supported by SCs and IAPs; (b) local financial institutions; (c) SWS value chains; and, (d) improved supplier and distribution networks.

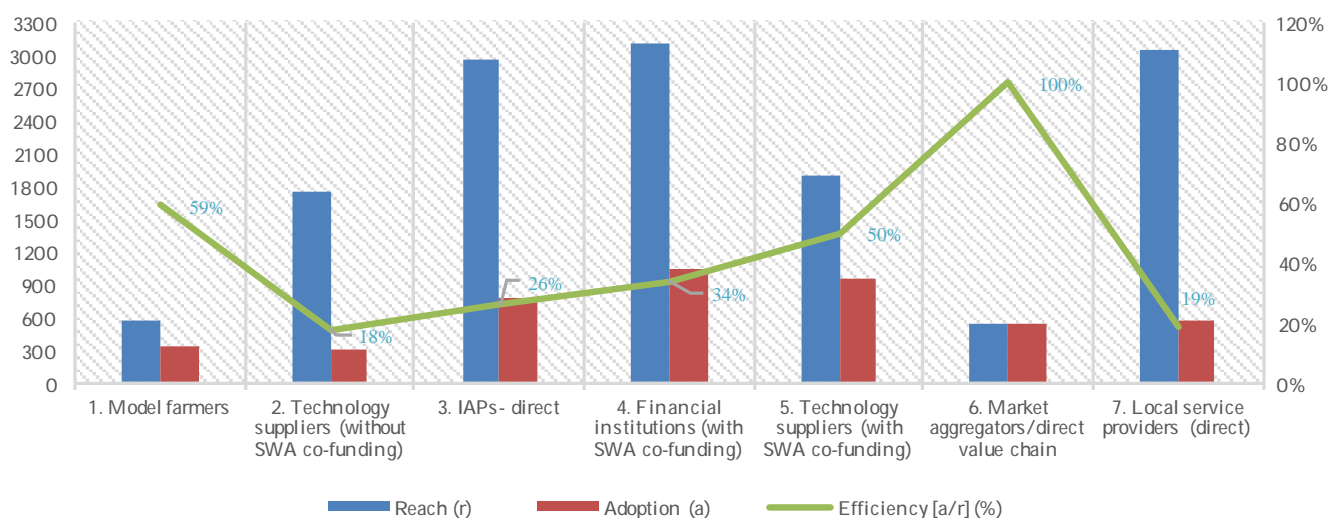


Figure 2: Pathways towards SWS adoption

The following has become clear:

There are three types of challenges to SWS adoption that have to do with the match between SWS and farmers’ characteristics and circumstances:

- 1. Knowledge:** Do farmers know of the technology? Do they fully understand it, its relevance and its implications?
- 2. Ability:** Does the technology work well in farmers’ situations? Are they capable of using it? Can farmers access and buy the technology? And can farmers manage the implications (ability to market and recover investment costs)?

- 3. Willingness/motivation:** Do farmers assess that the technology is worth adopting? How do the burdens/costs of using the technology compare to benefits obtained? What are and how do farmers perceive the risks involved?

The different SWA scaling pathways influence these challenges for adoption in various ways for farmers with different abilities and circumstances. Some SWS thus become adoptable by more farmers, but not by all. Some SWS require very

particular farmer characteristics that are also not easily changed through scaling strategies.

The large promise of horizontal learning and IAPs: Of the farmers that came to know about SWS through varied horizontal learning events organized by lead farmers, 60% started using one or more SWS. This is a strong indication that this approach is a viable and effective pathway for upscaling. Likewise, given that most of the IAPs became functional towards the end of the second year of the project (2017), the 26% reach to

adoption efficiency is significant and suggests that the IAPs, if supported to be sustainable, will be effective SWS adoption instruments.

The critical role of access to finance: The SWA Innovation and Investment Fund (IIF) that provided 50% co-financing to private Dutch and Kenya businesses (technology suppliers) interested in investing in SWS has led to tripling the adoption to reach ratio (see Figure 10). The IIF was primarily instrumental in financing market and business opportunity analyses and the expansion of value chains that start-up and young companies did not have the necessary resources or the business confidence to invest in.

The reward of mature value chains: A 100% SWS adoption rate is possible when the value chain guarantees reliable market, good technical and agronomic services and, most importantly, it is rooted in a

relationship among farmers and their investment partners (as was the case between Frigoken agroprocessing company and Kirinyaga French bean irrigating community) that has matured into trust and is guided by the principle of shared (financial) risks to achieve the common goal of producing all year-round production of French beans.

3.3. Farmers income and food security

Quantitative evidence, as well as testimonies from both lead and other farmers, indicate that SWS adoption can contribute to significant increase in farmers' produce, which translates into improved income and food security. For instance, as presented in Table 4, some lead farmers in Meru and Laikipia counties who adopted varied SWS accrued the net benefit of Ksh 632,900. This is seven-fold of the average income of small-

scale farmers in Kenya reported in a study conducted by the Food and Agricultural Organization (FAO) on economic lives of smallholder farmers (FAO, 2015).

The net income of Ksh 632,900 (€ 5,700) was obtained within a period of 7 months from a 0.6 ha field through a package of SWS that enabled the cultivation of different crop varieties: (a) the use of drip and solar pumps directly contributed to higher crop production and revenue, higher water productivity and reduced farm inputs (water, labour, time); (b) drip irrigation and proper land preparation, including raised beds, ensured even water distribution in the fields and this, in turn, resulted in uniform harvest of good quality; and, (c) water pond storage gave the opportunity to produce all year-round and overcome the challenges of climate change and market dynamics.

Table 4: Documented improved income of a lead farmer who adopted varied SWS

Crops	Irrigated area (ha)	SWS	Cost of production (Ksh) ^a	Yield (kg)	Total sales (Ksh)	Net income
Tomato	0.1	Drip kits	20,750	2,400	192,000	171,250
Carrots	0.2	Mist drips	12,250	2,800	224,000	211,750
Fine beans	0.1	Low pressure drips	17,000	1000	80,000	63,000
Pumpkins	0.2	Fertility trenches	13,100	4000	200,000	186,900
Total						632,900

^a - The production cost includes seeds, technologies, labour for land preparation, harvesting and all other farming activities

The significant net income contributed to acceleration of SWS uptake by other farmers who have continuously operated on very low gross margin and often on losses. Sixty farmers in the lead farmer’s neighbourhood adopted SWS as a direct result of his success in the 2018 February to September crop production season.

Fertility trenches and Mist drip irrigation are upcoming SWS promoted by SWA project. Fertility trenches is a simple agronomic innovation that involves digging of cubical pit 0.5 m by 0.5 m by 0.5 m with the topsoil kept on one side and the subsoil on the other. A bucket of manure is then added to the topsoil, mixed together and placed back to the pit to support fruit production as the primary crop while vegetables

are grown as cover crops. Fruits and vegetables as varied as avocado, capsicum, tree tomato, apple, passion, pumpkin and spinach are suitable for this farming system. For vegetables, a plant population of eight is adequate with a spacing of 0.3 m plant to plant. For fruits, a spacing of 1 m² square is suitable.

Fertility trenches are very productive - the only major upfront investment is labour input for initial land preparation. As illustrated in Table 5 below, a pioneer farmer in Laikipia county harvested about 2 tons of capsicum from a 0.2 ha land on a monthly basis for two continuous years following an initial 90-day maturity period. This translates into an estimated €400 monthly income, which could be doubled by intercropping pumpkin as a cover crop.

Table 5: Documented high productivity of fertility trenches (Ephraim Kahenya, lead farmer, Laikipia county, Kenya)

Irrigated area	0.2 ha
Capsicum plant population	6528 pieces
Estimated yield per month	2000 kg
Days to maturity	90 days
Duration of harvest	2 years continuous
Cost of production per kg	Ksh. 10
Estimated selling price per kg	Ksh. 30
Gross margin per Kg	Ksh. 20
Total income per month	Ksh. 40,000 (about € 400)



Vibrant growth of capsicum and pumpkin under fertility trenches



Credit: Ephraim Kahenya

Mist drip irrigation is another new innovation rapidly gathering wide reception among farmers particularly those in the driest parts of the SWA target counties. The technology has drip lateral pipes, but unlike the convention drip system, it sprays fine jets of water that overlap and form a wetted area with good distribution uniformity. It is becoming attractive to farmers previously using sprinklers which are more wasteful and have dry spots as well as occasionally cause water logging. Mist irrigation is best suited for crops that form dense canopies once established.



Mist drip irrigation system in operation

Several farmer testimonies gathered through interviews suggest that the use of mist drip irrigation and other SWS have contributed to increases in yield and net household income. To cite a few examples: a farmer from Laikipia county, who has started to use mist and conventional drip irrigation in combination with a solar pump and a shared pond, indicated that she has already created employment for her son, increased her irrigated land and significantly improved her income. A farmer in Ihindu, one of the driest parts of Nakuru, reported that the use of a farm pond, mist drip irrigation and agronomic practices, such as mulching and crop rotation, enabled him to conserve soil moisture and double his yield with a limited amount of water. A farmer in Uasin Gishu County, who has a pond and drip irrigation, harvested capsicum every two weeks for a period of five months. This has generated him a substantial income.

The ThirdEye programme, supported by the project, has improved the livelihoods of 527 tomato and cabbage producing farmers and their 2,477 family members. This programme, which relies on flying sensors (drones) captures images that depict water and nutrient deficiencies, as well as pest and disease prevalence two weeks before these could be visible to the naked eye. This enabled timely addressing the identified problems and increased the yield of tomato and cabbage by about 20% in comparison to farmers who have not benefited from the programme's services. As communicated in the programme's annual report, this yield increase translates to a total revenue of €50,865 for the season or nearly €100 additional seasonal income per farmer. This programme has already demonstrated its business viability as the farmers are paying for the advisory services provided.

3.4. Women and youth economic empowerment

The women who adopted SWS, albeit limited in number compared to men, have marginally economically empowered themselves. Labour and time-saving SWS, such as portable solar pumps and drip kits supported women to cultivate varied vegetables and other short-cycle crops and run this as a separate business from their husbands, who were mainly focused on long-term projects. In this regard, they solely made decisions on irrigation-related issues and, most importantly, had full control over the income accruing from vegetables sales. The mothers involved their unemployed children in their farm business as a way of protecting them from migrating to urban areas and being exposed to poverty-level wages, and perhaps even to social disorders and crimes.

The fundamental reason for the low uptake of SWS among the women was because the lands belonged to their husbands – less than 5% had land user rights. In the majority of African homes, males are the heads of the homestead, despite the women having access to easy, several and zero- interest loans for development by different micro-financiers. This land issue cannot, however, be solved within the project timeframe as it involves cultural and behavioural change.

Another important, though ancillary target demographic of the SWA project is the youth, who arguably constitute greater than 50% of the potentially productive rural population. The main challenge for the youth, related to investment in production factors, is that formal lending institutions are reticent to provide loans due to difficulties in ascertaining their creditworthiness. From the aforementioned reasons, youth are highly frustrated since they have the piece of land but no resources for development. To address this challenge, the project has focused on promoting SWS that are attractive to the youth. Examples include: (1) the ThirdEye programme has introduced ICT-empowered extension services that rejuvenated and generated interest among young people to join the agricultural extension workforce. The ThirdEye services uses drones that capture multiple images that cover an area of 40 ha within a ten-minute period and are thus less labour and time consuming - two attributes attractive to the youth; (2) the Mzuzu drill, a shallow water well-deepening

technology has received wide adoption among Meru County farmers with the youth leading its distribution and use; and, (c) a technology package consisting of solar pumps, water ponds and drip systems, which has become popular among the youth in Uasin Gishu County following demonstration by the project that such a package - when combined with high value vegetable production - can generate significant profit within short, 3month period.

3.5. Improved water management and productivity

The concept of ‘water productivity’ (yield or income derived per unit of water) and its application to farmer-led smallholder irrigation development is an essential component of the SWA programme. For the project, determination of a positive change in water productivity indicates wholesome success in the project’s effort to increase per unit area food production while increasing food security. For the farmer, understanding water productivity and its precepts provide important decision-making criteria in SWS selection – and particularly, in measuring the effectiveness of improved water management practices and specific technologies. In essence, water productivity is a factor of efficiency in the use of scarce resources. Thus, the measurement of water productivity is of interest to the project and to its key clients - farmers.

Various approaches exist in determining SWS efficacy in

contributing to increased water productivity. During implementation, SWA used multiple ways to determine the degree to which varied SWS contributed to water saving, improved water management and productivity. Primarily, this information was captured through interviews with the lead and other farmers, as well as the quantitative reporting of the ThirdEye programme, in addition to referencing FAO’s Water Productivity Open Access Portal (WaPOR) database (<https://wapor.apps.fao.org/home/WAPOR/1>). Some of interviewed farmers indicated that by shifting from broken furrows to sprinkler and drip irrigation, they managed to reduce their water use by about 30 to 50%. This assessment was based on the fact that farmers could now irrigate 0.1 ha of land in 30 minutes using sprinklers, while it took at least a day in the past when using broken furrows. Other engaged farmers explained that the use of lined farm pond minimized the uncertainty of water supply which, in turn, contributed to reducing excessive water application and more efficient irrigation scheduling. The farmers who applied grass mulch on nascent avocado trees, for instance, reduced both the frequency and the amount of irrigation. Instead of irrigating every evening, they could now apply water once every two weeks, which is estimated to lead to 30% less water use.

Similarly, the ThirdEye programme has illustrated the power of timely and accurate information on improving water management and productivity. A ten-day irrigation schedule that responded to the actual water

demand of tomato and cabbage crops, saved a total of 130,950 m³ from about 230 ha of land. This enhanced water management, combined with timely identification and addressing of pest and disease infestation, has resulted in a 26% increase in water productivity (kg/m³ water applied to the field). Table 5 has the summary.

3.6. Increased job and business opportunities

In Kenya, the concept of a fee for service in agriculture extension is acknowledged as a viable business model for sustaining knowledge gathering and sharing, especially for high-value commercial agriculture and in the dairy sector. By applying this concept to lead farmers, the SWA project achieved two key objectives: imparting rapid incentive driven knowledge in SWS and enhanced training capacity, and the creating of revenue-earning opportunities for lead farmers. Whereas prior to project support, training was offered free-of-charge, there is now huge interest among farmers to pay up to Ksh 150 per half-day practical session. Similar payments are acquired for services such as fixing dam liners, setting up greenhouses and drip kits both locally and outside their counties. Some lead farmers have gone beyond the farmer to programme level. For instance, a lead farmer in Nanyuki has won contracts on setting up of greenhouses in Isiolo County under the programme of the

Table 5: Documented water productivity change in farmers' fields
(Source: ThirdEye programme)

Water productivity without ThirdEye intervention	26 kg/m ³
ThirdEye farmers' water productivity	32 kg/m ³
Change in water productivity	6 kg/m ³
Percentage change in water productivity	27%
Benefiting farming households	527
Benefiting individual farming family members	2,477
Estimated selling price per kg	Ksh. 30
Gross margin per Kg	Ksh. 20

Food for the Hungry (FH), a Christian relief and development organization active in Kenya and several other African countries (<https://ngoaidmap.org/organizations/28>).

For the technology suppliers, the SWA project has enabled them to widen their market and better understand their customer needs. For example, Future Pump (K) Ltd. managed to eventually plug into the Davis and Shirliff distribution network creating jobs for many young people. In addition, Sunculture succeeded in entering into a new market for their rainmaker pump in Uasin Gishu County. They have trained and employed 10 young students with the intention of reaching more farmers. Other local distributors of agricultural farm inputs and irrigation technologies have added to their list of products by stocking the technologies promoted by the project. In addition, their products were able to penetrate to the farmers better by collaborating with organizations that have already earned credibility and trust among various categories of farming communities.

The ThirdEye programme has created job opportunities for six young agricultural extension workers

in Meru County. The programme, which started field operations in 2018, has established partnerships with complimentary companies such as Soil Care, Amiran Kenya Ltd and Agrochemical Associations of Kenya. This partnership has further strengthened the market demand for ICT-empowered extension services. As indicated in its 2019 report, the ThirdEye programme is ready to expand to the other counties and create more opportunities for youth and others.

3.7 Knowledge documented and disseminated

Several easy to read and understand documents both on-line and in-print were developed to guide the design, installation, operation and maintenance of various technologies. The Smart Farmers Guide was developed together with relevant technology suppliers and lead farmer representatives. The guide has all the necessary information on how-to-use and where-to-find several water harvesting, abstraction, conveyance and application technologies. The lead farmers were acquainted with the content of the guide during various practical training sessions. This



knowledge product was widely shared through the extensive IAP networks and other organizations, including county government, private sector, NGOs, and farmer groups.

A group of 18 lead farmers have developed the skills and are using smart phones to produce short impact videos and are widely sharing self-document success stories using WhatsApp and other platforms with thousands of their fellow farmers and other actors. Several farmers have WhatsApp groups and this trend will continue as there is a rapid expansion in the use of mobile technologies in Kenya and the price of mobile services is falling and technologies are becoming more affordable. These lead farmers along with 25 irrigation officers representing all 11 sub-counties in Meru County were also trained on the Pan Sizing App developed by the SWA project.

3.8 Catchment management interventions

The project has initiated catchment-wide soil and water conservation and management interventions to reduce environmental degradation

and realize lasting positive impact of adopted SWS. In 2018, we supported community-led plantation of 20,000 trees in the degradation-threatened Amali sub-catchment of the larger Mara Basin. Although, it is still early to draw conclusions, we have already observed some indicators of success: erosion and sedimentation problems have reduced, and the Amali river flow in the dry periods has significantly improved.

To lay the foundation for similar future interventions; professionals, lead and other farmers have been trained on varied catchment management techniques and practices including land use planning, terracing and contour farming, conservation and minimum tillage, and agroforestry.

Training was also conducted on the five key pillars of “how-to” plan and implement catchment interventions: resource mapping; challenge or problem identification; stakeholder consultative meeting and sensitization; demonstration; and upscaling.

For the technology suppliers, the SWA project has enabled them to widen their market and better understand their customer needs.

04

OVERALL LESSONS LEARNED AND WAY FORWARD

Reflecting on the process used by the project to promote SWS and the achievements recorded in the preceding chapters, this section presents the main lessons learned at operational and strategic levels.

The operational lessons capture all the processes and ground operations while the strategic lessons capture major directions taken during the project planning and implementation.



4.1

Operational lessons

- Demos where the technology suppliers took the lead in their establishment and operation were more impactful than those run by the project team. These gave technology suppliers ownership and more direct access to farmers and ensured a short-cycle feedback mechanism.
- Our operational resources were devoted to the promotion of solar pumps without prior adequate reflection on the optimal conditions for their use. We realized late in the implementation phase that solar pumps were not a perfect replacement for fuel and electric pumps in the case of medium-scale farmers irrigating more than 1 ha, nor for farmers with limited investment capacity.
- Early on, we missed the opportunity of fully engaging the public extension service workforce in technology promotion. This oversight was influenced by our understanding that they are hugely understaffed and overburdened, but we could have benefited from their closeness and the trust farmers have in them.
- Following showcasing, and prior to final selection of priority SWS, we did not sufficiently capture and integrate farmers' perceptions nor the diversity of their conditions and aspirations. This could have improved targeting the technologies to the varied needs of farmers.

- The local Capacity Builders (LCBs) – Kenyan organizations on the ground that supported the operation of demos and trials as well as farmer trainings - had a positive impact in promoting SWS adoption as they are locally based, have linkages with farmers and other local institutions, and are thus effective implementation actors. It is worthwhile to invest more resources in developing LCBs' capacity.
- Our intervention entry point was individual farmers. The long-term impact of this approach could have been enhanced if it was complemented with integrated (sub) basin water management initiatives.
- The establishment of the SCs started late in the project because we viewed them as being specifically instrumental for the scaling stage. Our experience has shown that they are also important players early in the process.

4.2

Strategic lessons

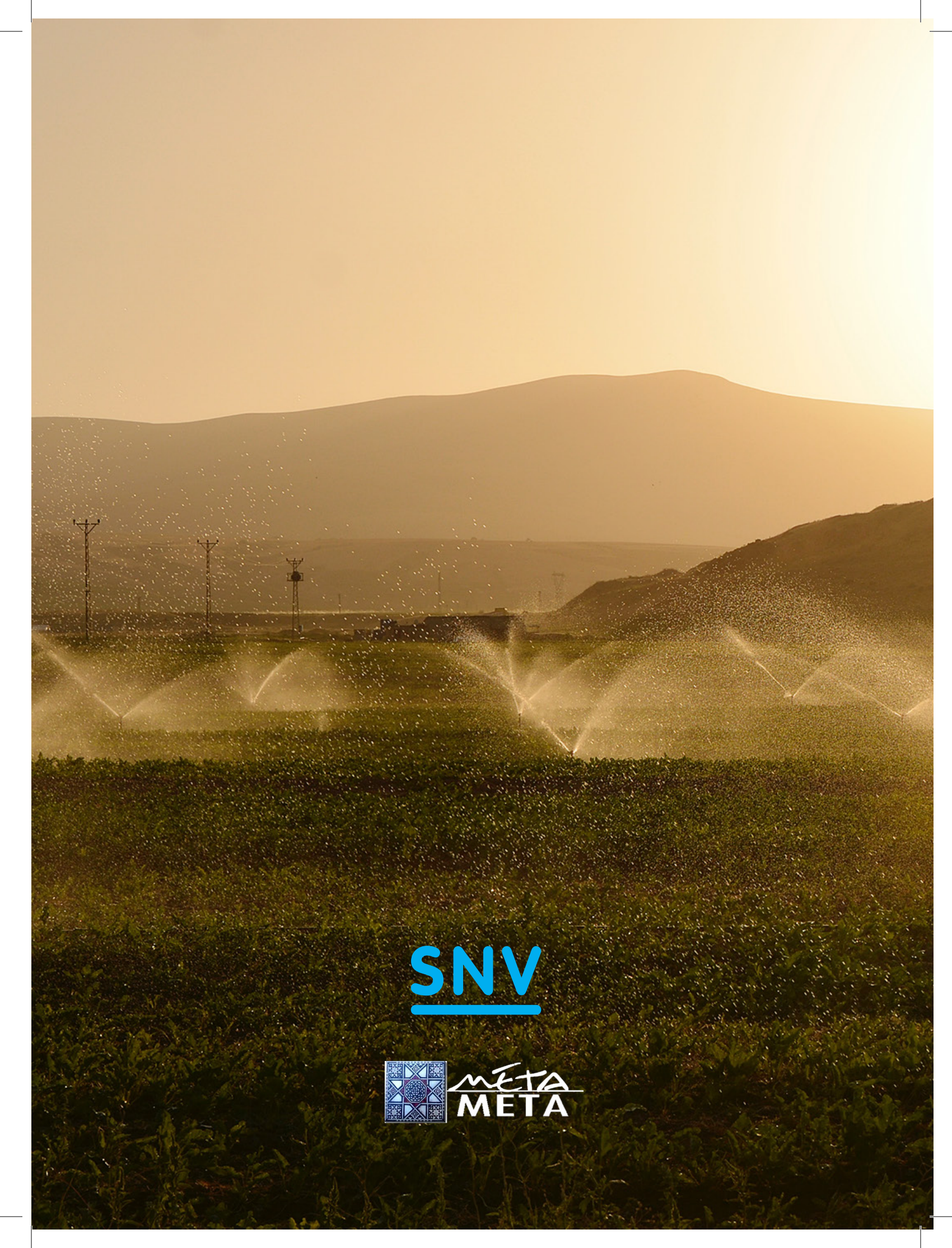
- The involvement of lead farmers as key actors in technology dissemination was successful, but this strategic choice was taken late and its full potential was not be harnessed within the project timeframe.
- The lead farmer approach could benefit from selecting more diverse lead farmers in terms of scale, crop choice, gender, market orientation and investment capacity, in order to

be an appropriate model for a wider variety of farmers.

- The focus on a market-based approach had limited impact on the spread of low-cost technologies, as well simple soil and water management and agronomic practices. This approach could have been balanced with the horizontal learning.
- The farmer-led and market-based approach facilitated supply-demand interactions, which helped farmers to provide feedback that, in some instances, was integrated into technology development and adaptation to local needs and context. This, in turn, contributed to further demand for the technologies.
- NGOs can make a contribution to irrigation development by increasing the quality and accessibility of information and disseminating it in an easy-to-understand format; this does not often get priority.
- We could have gained more if we had an organized and structured approach to better understand and make use of the databases and networks of our partners, the technology suppliers and the lead farmers in particular.
- Our target was mainly technology suppliers who had a Dutch and or Kenyan connection; including technology supplier companies from other countries would have provided a wide range of irrigation technologies thus creating an even more vibrant SWS market.

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