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HOW-TO GUIDES

IN AGRICULTURAL MARKET SYSTEM DEVELOPMENT

Smart Water and Climate-Smart Solutions for Horticulture

Guiding farmers to invest in smart water technologies for climate-resilient horticulture

CHAIN

SNV

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How-to Guides in Agricultural Market Systems Development

Smart Water Solutions and Climate-Smart Horticulture

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Foreword

Schweizerische Eidgenossenschaft
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Cambodia's agricultural sector continues to show strong growth both in production and exports, despite the Covid-19 pandemic. Horticultural production, in particular, has increased by 11% over the past few years. Agriculture continues to dominate the Cambodian economy, accounting for 22.8% of GDP. It absorbed about 35% of employment in 2020 and is also expected to gain importance in the livelihoods of young people migrating back to rural areas. Poverty remains largely a rural phenomenon, as about 80% of the 2.5 million poor live in rural areas.

Most Cambodian farmers are smallholders with less than two hectares of land per household. With 65% of Cambodian women engaged in farming, women-headed households and children (with a 30% malnutrition rate) are considered vulnerable. The low productivity of smallholder agriculture is the result of limited access to quality agricultural inputs, technical know-how and innovation, as well as limited marketing opportunities and market information. Pressure on water resources and the effects of climate change are additional challenges. Limited involvement of the private sector in agricultural extension services and weak cooperation with public sector actors restrain the development of prosperous smallholders.

Cambodia is not self-sufficient in vegetables yet. Imported vegetables are often associated with high contamination of chemical and pesticide residues. Fast economic growth has resulted in a higher demand for safe and quality local fruits and vegetables. This provides a huge opportunity for smallholder farmers and processors, particularly women, to increase incomes and food security. Moreover, improved rural infrastructure has increased the mobility of rural populations, providing them access to diversified markets and job opportunities.

Responding to these challenges and opportunities, the Swiss Agency for Development and Cooperation (SDC) carried out the Cambodian Horticulture Advancing Income and Nutrition (CHAIN) 2014–2022 programme in close cooperation with the Ministry of Agriculture, Forestry and Fisheries (MAFF) through the General Department of Agriculture (GDA) and the Provincial Departments of Agriculture, Forestry and Fisheries (PDAFFs). CHAIN has used a market development approach aimed at strengthening the inclusion of the poor (with a strong focus on women) in the market to secure better access to agricultural goods and services and raise incomes. The key element in this approach is a facilitation process to involve private and public partners as well as civil society organisations in the delivery of goods and services on both input and output sides of the horticulture value chain (e.g. extension, inputs, marketing and market information) that appropriately meet the needs of poor farmers and processors.

Over the past eight years, we were able to achieve impressive results. Vegetable production in Cambodia has increased significantly over the last three years and is now fulfilling 68% of domestic demand (700,000 metric tonnes in 2020). This is a great achievement!

Sustainability is at the core of CHAIN as it aims to strengthen horticultural market systems and the capacity of sector actors to provide services to targeted farmers. CHAIN has established a network of interactions between market stakeholders to ensure access to supplies, knowledge and technologies, as well as marketing of local production. The established networks, policies and market systems will continue to function once the programme ends, as sector actors and farmers will have reached a critical mass large enough to become a profitable and self-sustaining market.

I would like to thank MAFF, GDA, PDAFFs, provincial authorities, SNV and all those involved for an excellent collaboration and for actively contributing to the implementation of CHAIN.

Markus Buerli
Director of Cooperation

Preface

The Cambodia Horticulture Advancing Income and Nutrition (CHAIN) project is an eight-year development programme mandated by the Swiss Agency for Development and Cooperation (SDC) to improve smallholder vegetable production and trade in four of Cambodia's poorest and remotest provinces: Oddar Meanchey, Preah Vihear, Stung Treng and Kratie.

The CHAIN journey has evolved over the years as the subsector has matured. CHAIN has worked with a wide variety of market actors (farmers, traders, national buyers, and both local and national input suppliers), bringing them together in various partnerships whilst also collaborating across different levels of government. As befits a highly experimental project, it has used its failures as well as its successes to learn and adapt.

We realized that in Cambodia there is a dearth of material on practical approaches to agricultural market systems development. We hope to address this gap by documenting the CHAIN experience in a series of How-to Guides that focus on the practical application of certain methodologies developed during the project's life cycle.

Each issue in the series addresses one of the following topics:

- Introduction to market systems development
- Facilitating cluster development
- Facilitating B2B relationships
- Lead farmer incubator approach
- Rural business accelerator approach
- Developing crop budget
- Farmer video for digital extension

These guides can be useful for different agricultural value chain initiatives, as most of the principles and interventions they describe are widely applicable. They are intended for actors in the Cambodian development space, such as government technicians and extension staff, NGOs, students and those working for private sector companies that participate directly in the value chain. We expect that some of the practical tips and lessons will also be useful for practitioners outside Cambodia. We hope that applying the recommendations outlined in these guides will lead to better, more inclusive, equitable, sustainable food systems.

We thank all those who have contributed to these guides by writing and critiquing, as well as those who applied the methods in practice. We express our gratitude to the CHAIN staff who worked tirelessly throughout the years of the project's implementation, as well as the staff of our partners – SwissContact, the Provincial Departments of Agriculture, Forestry and Fisheries (PDAFFs) in the four target provinces, the General Department of Agriculture (GDA), input companies, seed companies, buyers and local NGOs. Finally, our heartfelt appreciation to SDC for funding this programme for eight years, their willingness to do much of the thinking along with us, and their openness to adaptive management based on continuous learning and reflection.

Aukun charan!

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1. Introduction

The Cambodia Horticulture Advancing Income and Nutrition (CHAIN) project has produced a series of How-to Guides (HTGs) that are meant to be practical, informative instruction manuals for those who would like to replicate and improve the successful approaches used during the three phases of CHAIN. Each HTG provides an overview of the methodology, step-by-step guidance, tips and recommendations, and illustrative success stories.

We hope that these HTGs will be useful to many types of organizations globally – in both public and private sectors, and in civil society – especially those involved in agricultural development projects applying a market systems development approach (see Box 1). However, we have written these HTGs with specific Cambodian stakeholders in mind, mainly the Ministry of Agriculture, Forestry and Fisheries (MAFF), the General Department of Agriculture (GDA), the Provincial Departments of Agriculture, Forestry and Fisheries (PDAFFs), and local NGOs.

Box 1
Market Systems Development (MSD)

The MSD approach covers the entire system that surrounds a market. In the case of horticulture, this holistic view of the market includes all the relevant participants ('actors' or 'players'): the farmer who grows the crops, the retailer who sells seeds and other inputs to the farmer, the trader who buys the crops once harvested, and the wet market seller who sells the vegetables to consumers. It may also encompass services that support the core market, such as government extension agents who provide advice to farmers and the local market structure that makes physical space available for buyers and sellers to meet.

MSD aims to address poverty by inclusively improving the performance of markets, especially by modifying the incentives and behaviour of businesses and other market players to ensure large-scale change that is lasting and beneficial.

Cambodia is one of the most vulnerable countries in Asia to the impacts of climate change. In all climate change scenarios, the average temperature in Cambodia is expected to rise considerably. This will most probably increase total rainfall and rain intensity, leading to a higher chance of flooding. At the same time, there is a chance of increased droughts, with some areas experiencing a longer dry season. More rain and higher humidity will increase disease and pest pressure, and make sun-drying of harvested crops more difficult. Water resource management will become more important to deal with floods and droughts, especially in horticulture.

CHAIN has supported the transition from homestead horticulture to commercial horticulture for many smallholder farmers in the four target provinces. This graduation to commercial operations included adopting climate-smart production technologies, linking with market clusters and agreeing on production plans with buyers. CHAIN stimulated many micro and small businesses to provide the right inputs for this transition. Commercial horticultural supply chains require year-round supply, since consumers demand vegetables every day. Year-round production is therefore a prerequisite to transform the market to a commercial level. Water access to irrigate crops is often a problem in the dry season, while flooding and waterlogging are challenges in the rainy season. Realising the need to manage water appropriately to achieve year-round production, the CHAIN team started to experiment with and promote smart water solutions (SWSs), such as solar pumps, water storage ponds, boreholes and communal water reservoirs. CHAIN initiated discussions on collective water resource management at the village and district levels, and co-invested in simple infrastructure. We also experimented with low-cost greenhouses, nethouses and solar installations, as well as the associated maintenance and repair services.

In 2020 CHAIN started with field assessments in one province and did pilot demonstrations of various water management technologies. Testing with farmers gave us clear indications of what would work, what farmers liked, what they could afford, and what knowledge they would need in order to manage water more efficiently, become more climate-resilient, and be able to produce vegetables year-round. This HTG summarises CHAIN's findings and recommendations on the adoption of **SWSs and climate-smart technology** by Cambodian smallholder farmers.
The SWS farmer-led methodology is a process for developing market-based solutions for irrigation,

drainage, water abstraction, storage and water conservation. It is characterised by its small scale; the use of appropriate, low-cost technologies; and a bottom-up approach. CHAIN collaborated with local and national private sector players (both start-up businesses and existing entrepreneurs) by linking them with farmers to promote a menu of suitable SWS products and services. Offering a menu of different technologies enables farmers to choose the best solution for their individual situation.

As water is a collective resource, there is also often a need for collective resource management solutions for water storage, abstraction and regulation. To avoid over-exploitation of water resources and conflicts in times of scarcity, user rules & rights must be agreed upon. With investment, water resources can sometimes be enhanced, for example by deepening a communal water reservoir to store more water. It is important to determine and agree who will contribute to the costs and who will have water abstraction rights. CHAIN co-invested with water user groups and local governments to enhance access to collective water sources for irrigation during the dry season.

In order to cope with and adapt to climate change effects, farmers will need to adopt climate-smart technologies. These are interventions that minimise the negative effects of changing weather patterns on agricultural production (climate adaptation), while at the same time reducing the emission of greenhouse gases (climate mitigation). In CHAIN we focused on greenhouses/nethouses and solar pumps. Greenhouses and nethouses enable farmers to regulate the microclimate and protect their crops from heavy rains. Solar pumps use solar panels to power water abstraction, as opposed to gasoline and diesel pumps, so they avoid emitting greenhouse gases.

2. Background

Horticulture is an essential part of the agricultural economy of Cambodia due to the rapidly increasing urban consumption of fruits and vegetables. Until recently, more than 50% of all vegetables were imported from neighbouring countries that are capable of year-round production. Imported vegetables allegedly contain significant amounts of pesticide residue and are therefore a food safety concern. CHAIN has worked on promoting safe, locally produced vegetables in four of Cambodia's northern provinces (Oddar Meanchey, Preah Vihear, Stung Treng and Kratie).

To date, CHAIN has achieved the following results through its SWS and climate-smart interventions:

- Over 1600 semi-commercial and commercial smallholder farmers have achieved year-round vegetable production. Farmers invested in various SWSs in order to do so, including increasing water storage capacity, applying small-scale irrigation techniques and working to conserve soil moisture.
- Trainings of trainers (ToTs) on smart water practices and water resource management options were provided to PDAFFs, Provincial Departments of Water Resources and Meteorology (PDWRAMs) and district and commune government staff who, in turn, could support farmers. These government officials discussed with community members how to prioritise investments in water resource management and small-scale, farmer-led irrigation in their community development investment plans.
- CHAIN provided support to over 200 farmers to co-invest in solar water pumping systems.
- CHAIN co-invested in five collective water resource systems providing water to 1,500 smallholder farmers and indirectly benefiting 7,500 people.
- CHAIN supported 20 local and national SWS suppliers linking them with farmers.
- CHAIN supported local micro businesses to provide installation and repair services of solar facilities (20 businesses) and greenhouses/nethouses (two businesses).
- CHAIN facilitated the production of videos by farmers to share their experiences with their peers via social networks.

3. Methodology Overview

What were the problems?

- Many farmers do not have enough water in the dry season to irrigate their farms (water storage ponds, if they exist, dry out regularly during the dry season), so they cannot grow vegetables year-round. Commercial horticulture, however, requires year-round production, which can be achieved through SWSs.
- Vegetable production in the rainy season needs protection from heavy rainfall, which causes crop damage and increases the occurrence of disease.
- Climate change will likely lead to more extreme weather patterns; irregular rainfall will increase the probability of repetitive floods and prolonged droughts. This will lead to a greater dependence on groundwater and surface water.
- Farmers are often unaware of the available options for efficient, smart water management, including increasing water storage capacity, soil moisture conservation, sustainable use of groundwater reserves and enhancement of groundwater recharge. Even when they are aware of these solutions, farmers may have insufficient knowledge to select the right one for their farm.
- Technical SWSs are not readily accessible in Cambodia's provinces/districts. There is a lack of local service providers and shops selling reliable products.
- Irrigation with diesel and gasoline pumps has become more expensive. Solar solutions have become cheaper, but farmers distrust them due to bad experiences with cheap panels that break down frequently. Repair and maintenance services are not available locally and are thus costly.
- Water investments beyond individual farms need collective solutions. Most water investments are large-scale, big-budget, top-down projects aimed at rice irrigation. Few investments focus on small-scale, bottom-up irrigation projects for higher-value crops, or on upland areas.

What did we expect to achieve?

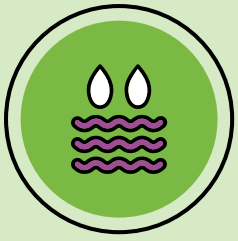
- Farmers are able to access water and irrigate sufficiently for year-round production. The market offers a variety of appropriate products and services to abstract, store and supply water to farms at an affordable price.
- Individual farmers possess basic know-how to select the proper pump system and the correct pipe size, pump capacity and storage pond dimensions. They can invest according to their payback capacity once they have reduced production costs and increased profits.
- Local SMEs can install, maintain and repair solar pumping systems and green- or nethouses.
- Farmers can share their experiences and knowledge with other farmers via social networks (such as Facebook and Telegram) to stimulate market uptake of SWSs and additional market offerings.
- PDAFFs can facilitate the adoption of climate-smart technologies for horticulture.
- Farmers and other community members can analyse their water situation and agree on collective solutions to manage water resources equitably and sustainably.

What were the solutions/methods?

1. Identify the SWSs available at district and national level. Draw up a list of SWS products and service suppliers who can advise farmers on selecting a solution that is appropriate for their situation.

2. Demonstrate and promote water and climate-smart technologies with farmers through co-investment. Show nearby farmers how pilot farmers are able to access and abstract sufficient water in the dry season, irrigate year-round and practise soil moisture conservation using SWSs.

3. Demonstrate low-cost greenhouse and solar pump installations, and incubate local installation and repair businesses for these types of equipment.



4. Demonstrate and co-invest in collective infrastructure for water storage and water resource management.

5. Provide ToTs to government and NGO extension staff/field facilitators who can advise farmers on suitable options.

6. Influence local development plans and budgets to include small-scale SWS interventions.

7. Encourage and train farmers to share their SWS experiences through social media (Face-book, Telegram and YouTube), especially via videos filmed with smartphones.

4. Steps to Implement SWSs and Climate-Smart Technologies

Farmers need to access water during all seasons and use it efficiently to be able to produce and supply vegetables year-round to their buyers. Field facilitators and extension officers should understand each farmer's specific situation and their main challenges in order to identify water solutions jointly. Below are several steps to assess a farmer's water situation, analyse the issues and challenges, and identify the critical actors who are needed to solve them sustainably.

	Methodological Step	Objective	Output
1	**Preliminary district assessment and SWS/ climate-smart technology menu**	• Investigate the availability of different SWS and climate-smart technologies, and their suppliers and prices. • Understand the main climate change and water management issues in the district.	• General information on SWSs • Menu of SWS and climate-smart options • Supplier list with indicative prices
2	**District dialogue**	• Support stakeholders in understanding the main water and climate challenges in the district. • ointly identify possible solutions and investment options.	• Information on district-level SWSs, climate issues, potential solutions, stakeholders and service providers • Project initiatives • List of interested farmers
3	**Individual farm assessment / site survey**	Through discussions with each farmer, define the problem for individual farms and identify the best solution to achieve year-round production. For a collective solution, a site survey and costing of the collective infrastructure should be done, as well as an assessment of stakeholders' willingness to contribute to or pay for maintenance.	A viable solution and estimation of total investment costs
4	**SWS and climate-smart technology selection and co-investments**	Agree with lead farmers or early adopters to implement a SWS or a climate-smart solution that can serve as a demonstration to other farmers of the technology's viability. Let the farmer or community choose the SWS and corresponding supplier from the menu.	• Signed co-investment agreement • Installation of solutions to serve as pilot demonstrations • Local suppliers contracted and supported to expand their business operations
5	**Training of trainers / SME support**	Train extension staff on various SWS practices and how to devise appropriate solutions based on farm size, water needs, water availability and investment/pay-back capacity. SMEs who sell SWS technologies can be trained in technical and business skills to expand their markets.	• A critical mass of extensionists, lead farmers, PDAFFs and local NGOs who are capable of analysing water problems and recommending the right solutions to farmers • SMEs supported to expand their offerings and area coverage
6	**Farmer learning & sharing using social media**	• Provide video training to PDAFF extension staff and farmers. • Organise cross-farmer and inter-district learning visits.	• Videos shared through Telegram, Facebook and YouTube • Increased learning through observation (seeing is believing)

5. STEP BY STEP GUIDANCE

5.1. District assessment and SWS menu

District assessment

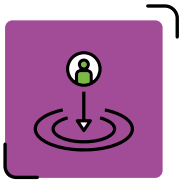
If your organisation already works in the area, you probably have a good overview of the challenges faced by farmers with regard to climate change and water resources. Otherwise, do a quick reconnaissance study or rapid appraisal of the local farming communities, their farming systems, current water use, and water and climate challenges. Study secondary data and publications, and conduct key informant interviews with farmers, NGOs, PDAFF and PDWRAM staff, and local government officers. Prepare a simple visual presentation about your findings, then discuss them with the relevant provincial government departments for verification. (See **Annex 1** for a suggested list of topics for the assessment).

With the collected information you can then score each district in the target area on four criteria:

1. Technical feasibility of solutions, including water resources available.

2. Economic viability, i.e. whether investments will have a payback in benefits.

3. Motivation – the interest expressed by authorities and stakeholders to work on these issues.



4. Impact potential, taking into account the number of people and the surface area (in hectares) potentially impacted.

SWS supplier inventory and menu of options

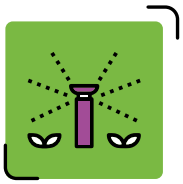
Make a sample inventory of shops and suppliers of climate-smart technologies and service providers in the district or province. Sometimes you can get such a list from the Ministry of Commerce, otherwise you can collect this information through interviews with owners of machinery shops, agri-input dealers, hardware stores and pump dealers. Ask national companies if they have distributors in the province and visit them. Service providers include drilling companies and civil construction companies that have excavators. Usually, two shops or suppliers per category will give you sufficient information. Ask the businesspersons about their products, services, benchmark prices, quality attributes, and so forth. Inquire also about their challenges as an enterprises, and probe them for ideas on how to expand their business. Make a list of all the local suppliers you meet and their contact details.

After you have compiled the supplier inventory, make a list of all available and potential SWSs and climate-smart solutions. Listing all the SWSs and climate-smart technologies in one document, thus creating a menu of options, makes it easier for extension workers to explain to farmers how the various technologies work to improve water access, use and conservation. The menu also allows for price comparisons among suppliers, so that farmers can find the best and most competitively priced products and services.

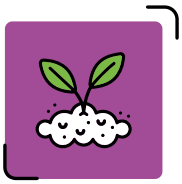
In the menu, SWSs and climate-smart technologies can be categorized into five types:

1. Access to water: Excavated Pond, pond lining, drilled borehole, small check dam along a natural steam.

2. Abstraction of water: Submersible pump, electrical pump, diesel/ gasoline pump, solar-powered pump.



3. Water application: PE/ PVC pipe, flat hose, drip line, sprinkler system, rain tube.



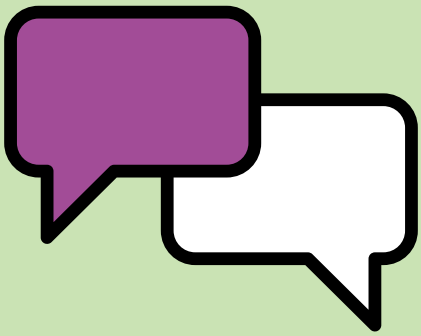
4. Soil moisture conservation: Plastic mulch, organic mulch, compost fertilizer, soil cover crop, soil moisture sensor controller.

5. Microclimate control: greenhouse or nethouse, hydroponic system, protection roof, windbreak.

TIPS

1. Interviewing suppliers on products and services, especially their prices, can be challenging. Suppliers may be unwilling to divulge this information unless youíre prepared to buy their product immediately. Therefore, you should inform providers clearly about the purpose of this data-gathering exercise: it will help promote their shop or services to farming communities and open up opportunities for co-investment by farmers and the project

2. Choose a convenient time to speak with providers, such as the afternoon, when they are typically less busy attending to customers. Ask them in advance for permission to take photographs of their shop and products.



3. Ask providers whether they are interested in offering demonstrations, attending a cluster meeting or a farmer field day, or co-investing in a marketing campaign. Inform them about the upcoming district/provincial dialogue as well.

4. Sometimes, contacting providers and businesses from other provinces and inviting them to attend a farmer meeting to discuss SWS investments can create competition and lower prices.

See **Annex 2** for a list of potential technologies.

5.2. District dialogue

The district dialogue is a multi-stakeholder meeting at the district level to discuss water and climate issues and identify solutions. The main objectives of the dialogue are to understand the water and climate problems better, collect relevant information, connect with stakeholders and formulate potential solutions. The suggested solutions can then be piloted through co-investments involving interested farmers, the local government, the private sector and the project. Later, these pilots can be presented to and discussed with policymakers at provincial level through a provincial knowledge-sharing workshop.

Specific objectives include the following:

1. Engage key stakeholders, including the public and private sectors and development partners, in discussions of water constraints to year-round horticulture production, and relevant SWSs.

2. Seek collaboration between the private sector and government/policymakers and identify potential joint solutions to address enabling environment constraints.

3. Identify SMEs in the water sector who can provide services (borehole drilling, pond excavation, pump repair, etc.) and products (drip irrigation or sprinkler systems, water tanks, pipes, pumps, etc.) and link them with farmers to fully develop their market potential.

4. Facilitate communication between vegetable traders and producer/farmer groups to explore market linkages and make pricing agreements that will give farmers the confidence to make the necessary SWS investments.

Agree with local authorities on the dialogue and invite stakeholders

Confirm the interest of the local authorities (at village, commune and district level) to do something about the water challenges. Propose to have a district dialogue and agree on a venue, attendees and a date. Set aside a small budget for snacks and drinks.

Support the local authority in identifying all stakeholders and send out invitations. Relevant stakeholders are (1) public sector actors such as PDAFF, PDWRAM, and the Provincial Departments of Women Affairs (PDoWA), Commerce (PDoC), and Environment (PDoE); (2) private sector actors such as SMEs that supply SWS inputs, vegetable buyers and microfinance institutions (MFIs); (3) NGOs and development agencies; and (4) producers/farmers.

District dialogue

The purpose of the dialogue is to identify and discuss the main water challenges faced by all stakeholders, especially those affecting year-round horticulture production, and to come up with solutions involving smart water interventions. On the day of the dialogue (see Annex 3 for a sample agenda), opening remarks and introductions can be followed by a short presentation by local extension agents (PDAFF or PDWRAM) to highlight the technical constraints and proposed solutions in smart water management during the dry and wet seasons. The presentation will help demonstrate the understanding, commitment, and achievements of the public sector in agricultural water management.

The next item on the agenda can be a brief presentation by project staff about the findings of the previously conducted district assessment, including introduction of the SWS menu, followed by the first interactive part of the dialogue – a brainstorming session on water challenges. The next step is for attendees to break out into small group discussions, with a mix of representatives from each stakeholder group, to determine the appropriate solutions, who should finance them, how responsibilities among actors ought to be divided, and to define the interaction/collaboration between actors.

After the group discussions, conduct a plenary session to present the main conclusions and gather all recommendations and action plans, with a question-and-answer period at the end of the plenary. Then facilitate an informal matchmaking session where traders and SWS suppliers can meet with each farmer group or community to discuss appropriate solutions and assess how many farmers would be interested in investing in SWSs. This will give everyone an idea of the demand for SWS products and services in each locality based on the potential extension of the growing season and expansion of growing areas enabled by investments in SWSs.

During a wrap-up session, summarise the discussions and propose further steps. At the end of the event, farmers interested in smart water co-investments can register with their name, location, contact number, the type of SWS intervention they need, and the amount they are willing to invest. This list can be confirmed during individual farm assessments (see section 5.3). If several farmers are interested in a particular SWS, you can organise a learning visit to some farmers who have already applied that SWS.

SWS FARMER'S EXPERIENCE:
District water dialogue

Mrs. Han Choen, a farmer living in Preah Vihear province, produced vegetables using a diesel pump. Her pump broke down frequently interrupting the irrigation schedule for her crops. "It was hard because I wasn't confident to make a contract with my buyer since I could not guarantee supply. My crops often spoiled because no water to spray which resulted from the delay of repairing my pump." She joined the district water dialogue initiated by CHAIN where she could discuss her water problems. She learnt about the solar pumping solution, and invested 1800 US$ with CHAIN's co-investment of USD 500 to buy a solar pump system. The solar pump can deliver water to irrigate her farm up to 25 cubic meter/day. As she has enough water to irrigate the crop, she is now able to meet the demand of the buyer and supply consistently.

5.3. Individual Farm Assessment / Site Survey

An individual farm assessment needed to understand a farm's specific requirements of SWS and provide the farmer with various SWS options. The investment costs and financial affordability of each solution can then be calculated. Farm assessments should be done with farmers who expressed an interest in co-investment. Farmers can also be recruited through other channels, such as local government extension officers, NGOs and farmer associations working in the same target area. Other local farmers can participate in the assessment as observers to learn about SWSs.

During a farm assessment, the assessor will ask the farmer questions about production practices, water use and abstraction rates, plot sizes, current infrastructure and financial resources available for investment (see **Annex 4** for sample questions). This is also an opportunity to introduce farmers to options they may not yet be familiar with (refer to **Annex 2** for a list of SWSs), and ask them which solution(s) they may be interested in. Through discussion with each farmer, the assessor can determine which water management method should be prioritized to achieve year-round production, and whether it is financially viable and technically feasible.

Site survey for collective intervention

For collective solutions where a community investment may be needed, such as a communal reservoir or small check dam, a thorough site analysis is recommended. Because this analysis has several technical components (including a geo-physical investigation and a socio-economic study), a civil engineer with expertise in hydrology should be contracted to study waterflow and water storage capacity, map the area, and do a technical design. An estimation of the total investment cost can then be made. The number of potential users and benefits should also be assessed, as well as users' willingness to pay for operation and maintenance of the facility.

5.4. SWS / Climate-Smart Technology Selection and Implementation

Once the district dialogue and individual farm assessments have taken place, a farmers' meeting can be conducted to select the right SWS interventions and agree on implementation. Farmers can choose more than one solution from the SWS menu to achieve year-round production, but the extent of co-investment provided by your organization will of course depend on funding.

Also, farmers opting for the same solution can sometimes be grouped together to share the cost of the intervention and obtain a better price. For example, if several farmers whose farms are adjacent to each other choose to invest in drilling boreholes, then it makes sense to negotiate with the drilling company as a group, and drill all the boreholes in the same period. This reduces the costs related to transport of machinery and creates economies of scale, which can lower the amount charged by the provider.

The meeting is also an opportunity to bring farmers and providers together, so inviting service providers and product retailers to present their services or products is highly recommended.

SWS FARMER'S EXPERIENCE: Borehole

'I have a water storage pond and a small solar pump with a battery, which did not have enough pumping capacity and broke down. I wanted another solar pumping system but I didn't know any companies with high quality and performance in solar system design,' explains farmer Mach Hong from Srayang commune, Kuleaen district, Preah Vihear province.

'Fortunately, the CHAIN team told me about other SWS options, such as a borehole with submersible solar pump, and introduced me to a drilling company. I opted to drill a 120-mm diameter borehole to a depth of 75 meters. It cost me only USD 1,000 from the recommended company, though the usual price is USD 1,200, so I saved quite a bit of money.'

Collective water resource management

Water is a common good, a collective resource that needs a collective approach to ensure equitable access and sustainable use. Regulation is often needed to avoid over-exploitation and to reduce risk. Large collective infrastructure such as community reservoirs and small check dams can be a good solution for water storage. It can be used by communities for farm irrigation by establishing an agreement among all stakeholders. It should include rules on abstraction volumes, water source protection and maintenance payments. Sometimes, commune or district development funds can be used for the installation of communal infrastructure, but the maintenance and operation costs are normally financed by the users. In many irrigation schemes, water user associations are created to pay for these costs. A lot of community organising work needs to be done prior to the investment to ensure good functioning of such schemes.

Investments in collective infrastructure are often too large for farmers to bear. CHAIN and its associated farmers approached PDWRAMs and district governments to explore co-funding. As a result, five collective solutions were implemented: a canal to connect a communal reservoir with a natural stream to supply year-round water; enlargement and deepening of a communal reservoir; installation of a conveyor pipe to a reservoir; and construction of a small check dam to create a reservoir. In the district dialogues, these investments were prioritised were later included in commune development budgets, and subsequently implemented.

SWS FARMER'S EXPERIENCE: construction of check dam and communal water reservoir

The indigenous Prao community in Katot, Stung Treng Province did not have enough water in the dry season. A drilled borehole produced water with too much iron. In the district dialogue the community identified a stream which could have a small dam to create a small water reservoir. With the district engineers and support from the provincial governor a site survey and design was done. CHAIN co-invested with fuel for the excavation and the local government financed the machine, and the small dam construction. Mr. Sowan Piseth, the chief of the district, said that the small check-dam project shows the good results possible from the cooperation between partner organizations and the Royal Government. It meets the needs of the local people, for water for household daily use and to irrigate vegetable farm.

Greenhouse/nethouse

Even if water access during the dry season is resolved, farmers still face challenges due to heavy rainfall in the rainy season, which can cause problems for vegetables, especially leafy ones. Greenhouses and nethouses are available in various configurations at different prices. They can prevent damage from rainfall by covering crops with plastic roofs, and from insects by surrounding them with nets. However, greenhouse installations must take various factors into consideration, such as excessive build-up of heat and potential damage or displacement due to wind and stormy weather. Farmers need to monitor their greenhouses continually. For example, if the temperature inside a greenhouse becomes too high, they need to make temporary adjustments, such as opening the ventilation shafts in the plastic roof, rolling up shade nets, or turning on an exhaust fan to dissipate the heat.

SWS FARMER'S EXPERIENCE: Nethouse

Mrs. Plouk Sith, a farmer living in Kratie province, expressed her satisfaction with the greenhouse maintenance service she contracted with CHAIN co-investment and facilitation. Sith mentioned that "I paid USD 300 to replace my old greenhouse with UV plastic and USD 2000 for installing another new greenhouse. After this upgrading, I can now grow leafy vegetable consistently. As I can grow year-round, I got a high price during the rainy season. I and my husband are now thinking of installing two more greenhouse for a bigger scale of vegetable production and earning more income."

5.5. Training of trainers / SME support

The ToT is intended for government extension field officers, commune/district government officials and field staff from other development agencies. Through farm visits and demonstrations, the training helps trainees understand the concepts behind various SWS and climate-smart practices.

Start by setting out specific objectives and training methodologies, preparing a participant list, and estimating the cost of the training, then draw up a lesson plan and a list of required materials. The curriculum should cover the basic principles and practices of SWSs and climate-smart horticulture. It should include exercises so that participants can calculate water needs (based on crop area) in a specific case study. The classroom session should address four main topics: soil and land management, water management, appropriate SWS interventions, and climate-smart technologies.

After one or more classroom sessions, the training continues in the field via site visits, where trainees can observe the application of SWSs and climate-smart technologies and have the opportunity to speak directly with farmers and technicians. In addition, small group discussions can take place involving the commune chief or district governor and PDAFF officers to learn about how to integrate SWS investments in the commune development plan.

TIP

The ToT learning material is a combination of agronomy and hydrology. Thus, if the facilitator is an agronomist, it is best to consult a water engineer when preparing calculations of water needs, pipe sizes, water flow capacity, generator capacity and pump capacity.

SME Training

The CHAIN team found that many of the companies selling SWS materials and technologies wanted to advise farmers, but lacked the technical know-how. Some training on the technical aspects of SWSs helped. More importantly, the companies wanted to expand their market offering and learn how to formulate a business plan to get a loan, and what marketing methods to use. CHAIN helped some of these businesses to expand via co-investments. Business training support to SMEs is described in greater detail in another CHAIN HTG titled Rural Business Accelerator.

Nethouse installation business start-up

Mr. Ben Hongly, a young farmer living in Kratie province, wanted to have a nethouse but was deterred by its high cost. He had seen some greenhouses made with bamboo and searched YouTube movies how to construct them. He constructed 2 small greenhouses and became experienced in installing his own net house. He heard many complaints from the farmers on the damage of plastic roofs of their nethouses and the difficulty in having them got repaired. After conversations with CHAIN staff, he proposed to start a nethouse repair and installation service, offering new metal pole supported nethouses at a third of the cost of established companies. With business training support from CHAIN and a co-investment in working capital for materials and tools, the young farmer started his own business. As result now, farmers in Kratie now have access to locally built low-cost nethouses.

Service provider: Solar Repair service- SOGE

Solar Green Energy Cambodia – SOGE is a solar company providing high quality solar smart water solutions. Their platform with automatic sun tracking rotating 6 solar panels and pumping system can be monitored remotely. SOGE installs, maintains and provides a guarantee for 5 years. Lifespan is up to 15 year with proper maintenance. In order to provide a better service to their customers who are often located far away from their Phnom Penh office the company decided to look for local distributors who can also provide installation and repair services. Together with CHAIN the company called local farmers, and local technicians to join a training course to become an accredited SOGE repairer and installer. The training course was given online through Zoom and face to face for the practice. The costs for each participant was 50US$ to be paid upfront. Consequently over 200 people expressed their interest to join this training, but only 40 were admitted. Out of the 35 who finalised the course, 20 were chosen to set up a small business with support of some tools as co-investment.

5.6.Knowledge-sharing via a digital platform

Once farmers have implemented the most appropriate SWS or climate-smart technology (e.g. drilling a borehole, installing a solar pump or a greenhouse, or applying rice straw as organic mulching), they will hopefully achieve their desired goals: year-round production, increased productivity, regular supply to buyers and enhanced market opportunities. However, only their immediate neighbours may be aware of these success stories and how they were achieved, while other farmers in the district or province are unlikely to witness these SWSs in action. To allow other farmers, field staff and extension workers to access the know-how developed by farmers who successfully implement SWSs, CHAIN promoted farmer sharing via social media in three simple steps.

Below are the recommended steps:

1. Encourage a habit among farmers of sharing their good field practices.

2. Train farmers to use their smartphones to shoot videos of their farming techniques and results.

3. Use a digital platform or social media channel to share learning videos, market data and other useful information related to farming.

Most young farmers already use smartphones for communication and to access entertainment via popular social media such as Facebook and YouTube. Messaging apps like Messenger or Telegram are excellent platforms for farmers to form chat groups of like-minded colleagues, communicate with each other and share information related to farming, such as farm calendars, market opportunities, good farming practices, SWS products and services, pest management, and so forth.

Most smartphones have advanced photography and video editing functions with related app support, but many farmers don't know how to use these functions effectively. Please refer to CHAIN's HTG titled Farmer Videos for Digital Extension for guidance on how to train farmers in videography and how to organize video competitions to encourage the creation and exchange of farmer videos.

TIPS

1. Set up knowledge-sharing groups using social media that farmers are already familiar with, such as Facebook and Telegram.

2. When suggesting mobile apps for video editing, make sure they are available in both Android and iOS formats. Choose simple apps that do not involve too many steps.

SWS FARMER'S EXPERIENCE: mulching

'I learned from the PDAFF officer about mulching and practised using rice straw on my vegetable beds,' says Im Naisreng, a farmer from Srayang commune, Kuleaen district, Preah Vihear province. 'The mulch keeps the soil most, so I can use less water. I got a high yield of green mustard and can do twice as many cycles now with the same amount of water in my pond!'

6. Conclusion

Future climate change will require investments in SWSs and other climate-resilient technologies. A flexible approach with a menu of options can enable farmers to choose the most appropriate solution, be it for an individual farm or collective infrastructure. A participatory process involving government, businesses and farmer groups will create local capacities and networks so that the solutions are sustained and serve as demonstration sites for others to learn from. Identifying the interest and demand of farmers to invest in these solutions, and linking them with suppliers and service providers who offer SWSs as a business, will strengthen the market system so it can face the challenges of the future. Promoting locally offered climate-smart investments will create higher productivity, profitability and resilience to climate change for many farmers.

ANNEXES

ANNEX 1

Topics for preliminary assessment

Topics to cover in the assessment

Main farming system:

- Specific crops
- Crop production issues
- Market and profit potential of crops

Water:

- Main water bodies such as rivers, lakes, reservoirs
- Water source protection areas (riverbanks, catchments, hillsides), vegetation (include maps if available)
- Water abstraction, storage, conveyance and application methods in the district – individual and collective
- Total irrigated area and methods
- Groundwater levels and wet/dry season fluctuations
- Groundwater quality

Main climate challenges:

- Probability of floods, drought, heat stress, rain damage, wind damage, pests & diseases
- Climate changes observed by farmers
- Solutions already implemented in the district

Potential for SWS interventions:

- Identified farms/plots that can serve as demonstration sites of already implemented solutions
- Observed common mistakes in solutions
- Technologies/solutions not yet implemented in the district
- Potential for improving dry season solutions, wet season solutions
- Indicated interest and motivation of authorities
- Potential financing in the district (government funding, project funds, financial institutions, willingness of farmers to pay, potential marketable product & profit increase)

ANNEX 2

Menu of SWSs and climate-smart technologies

List of SWSs and climate-smart technologies

Solution/Technology		Main function	Indi-vidual	Collec-tive
Access to water / developing a water source				
1	Borehole	Accesses to a reliable groundwater source	X	
2	Check dam	Creates a barrier in a natural stream to raise the water level and thus enable pumping	X	X
3	Farm pond	Stores water on the farm	X	
4	Pond lining	Avoids seepage loss from a farm pond	X	
5	Elevated water tank	Stores water for gravity-fed irrigation	X	
6	Spring protection	Protects a well or water source with vegetation cover		X
Abstraction of water / water lifting				
7	Borehole	Water lifting and pumping using solar power; it can be done with a sun tracker to maximise power output	X	
8	Check dam	Water lifting and pumping at low upfront investment cost	X	
9	Farm pond	Water lifting for larger plots and larger volumes of water	X	
Water application and soil moisture conservation / micro climate				
10	Plastic mulch	Protects from soil erosion, reduces soil evaporation, regulates soil temperature and suppresses weeds	X	
11	Rice straw / organic mulch	Protects against soil erosion, reduces soil moisture loss, regulates soil temperature and suppresses weeds	X	
12	Cover crop	Protects against soil erosion, reduces soil evaporation and creates additional organic matter	X	
13	Micro basin	Collects surface run-off and is an efficient irrigation around trees crop	X	
14	Ridge planting	Enables controlled field irrigation and good root aeriation in areas prone to waterlogging, and reduces erosion	X	
15	Precision land levelling	Spreads water evenly across a field	X	
16	Soil compost & biochar	Increases water and nutrient retention capacity of soils	X	
17	Drip irrigation system	Precision irrigation, fertigation	X	
18	Micro sprinkler	Spreads water at surface, precision irrigation, even distribution of water	X	
19	Rain spray tube/ hose	Irrigation pipe with small holes, also known as a rain spray hose, to create a fine mist of droplets, especially useful for leafy vegetables	X	
20	Nethouse	Protection from heavy rain, reduces evaporation loss, controls temperature and air moisture	X	
21	PVE pipe	Conveys water from point A to point B while avoiding water losses, can be used to overcome height differences, can be buried in the ground	X	
22	Lay-flat hose	Conveys water from point A to point B while avoiding water losses, can be used to overcome height differences	X	
23	Moisture sensor	Measures soil moisture for high-precision water supply, ensuring irrigation at the right time and in the right quantity	X	
Collective water resource management				
24	Communal reservoir	Stores surface water in large volumes for community use		X
25	Feeder canal with water gate	Conveys large volumes of water from a permanent source to a reservoir		X

List of SWSs and climate-smart technologies

No. 1	Borehole
Category	**Water resource development**
Short description	Boreholes drilled by a drilling rig go to depths of 30–200 m in order to reach an aquifer. A borehole is a reliable water source in the dry season, compared with dug wells and shallow tube wells. It can ensure on-farm irrigation for 0.5–1.0 ha depending on water flow. If it feeds a farm pond, it can irrigate an even larger area.

Advantages	Disadvantages
• Refilling a farm pond after irrigation ensures good water availability year-round. • Some farmers also pump and irrigate their crops directly. • It is the best choice for farmers who have small plots of land and can only afford small ponds.	• Initial drilling cost of USD 800–3,000. • In some places, it is difficult to find service providers for large borehole drilling operations. • A reliable electric power source is required to run a submersible pump. • Unchecked borehole pumping can lower the water table of the aquifer. Hydrological studies would be needed to estimate the maximum extraction rate for all users.

No. 2	Check dam
Category	**Water resource development**
Short description	A small structure made of rock, wood or concrete that obstructs the flow of a natural stream, thus creating an elevated water basin for additional storage capacity or to reduce the water's flowing speed so that it can be pumped out.

Advantages	Disadvantages
• Can raise water levels and increase storage capacity; makes irrigation pumps easier to manage. • Takes advantage of a natural water source without digging ponds, especially streams with flowing water in the dry season. • Pumping from a check dam costs less than pumping from a well. Only small pumps are required.	• Building it requires technical design skills. Some small service operators lack the know-how to calculate water flow force and robustness for long-term use. • Agreements on abstraction volumes must be made among all users who have access to the stream. • May negatively impact the ecosystem.

List of SWSs and climate-smart technologies

No. 3	Farm pond
Category	**Water resource development**
Short description	Multi-purpose water collection and micro storage facility that can hold rain water, surface water or water pumped from a borewell. It can provide water for the home consumption, animals feeding, fruit trees and vegetables watering, and in some cases fish farming or raising ducks raising.

Advantages	Disadvantages
• Conserves water and creates year-round production capacity by storing water for use in the dry season. • Enables diversified production, such as planting high-value crops, raising ducks and fish, etc. • Windbreak trees can help to reduce evaporation.	• Risk of leakage and water loss, increasing pumping costs. • Risk of pollution, as the water surface is open and unprotected. • Risk of breeding mosquitoes, though it can be controlled by planting certain tree species around the perimeter. • Takes up land space.

No. 4	Pond lining
Category	**Storage**
Short description	An impermeable protective cover on the bottom and sides of the pond to avoid water seepage loss.

Advantages	Disadvantages
• Can lengthen a pond's water holding period, and save pumping costs.	• Costly and needs regular replacement.

List of SWSs and climate-smart technologies

No. 5	Elevated water tank
Category	**Water resource development**
Short description	Elevated tanks use natural force of gravity to produce consistent water pressure in an irrigation system.

Advantages	Disadvantages
• Once filled, enables drip irrigation without a pump. • Easy to operate. • Convenient SWS because only need to open the valve to operate. • Can be connected to a smart valve for automatic irrigation control via a smartphone or moisture sensor.	• Requires a significant initial investment. • To bear the weight of the water in the tank, a strong steel or concrete construction is required. • Relative small water holding capacity so quickly emptied, then needs refilling through pumping again.

No. 6	Spring protection
Category	**Water resource development**
Short description	It is where underground moving to find an opening to emerge on the land surface. By maintaining standing vegetation around the spring, or building a fence the water source can be protected from erosion, intrusion of livestock etc. It is also important to protect the spring's recharge zone, with agreements that tree vegetation be kept intact, and even enhance recharge with specific measures (infiltration bunds and trenches, half-moons or recharge ponds).
Advantages	**Disadvantages**
• Secures freshwater of good quality. • It is safe for humans to drink and is not easy to dry out.	• In some areas, natural springs are declining due to deforestation, road development and neglect.

List of SWSs and climate-smart technologies

No. 7	Solar water pump
Category	**Pumping**
Short description	A solar powered pump is mostly a submersible pump which runs on the power generated by solar panels. The higher quality installations have a sun tracker and control unit.

Advantages	Disadvantages
• Once the initial investment in the solar installation has been made, the cost of abstracting groundwater is close to nil. • Solar pumps work best on sunny days; these are also the times of the year when irrigation is needed the most. • They reduce production costs and increase market opportunities, especially with the high price of gasoline.	• High upfront investment cost, usually between 1000-3000 US$ • Free pumping can encourage uncontrolled use of the groundwater, leading to the depletion of groundwater resources. Therefore, solar pumping should be complemented by local groundwater governance. • After 10-15 years, solar panels need to be replaced. • Cheap solar panels have a shorter life-span and break down frequently creating distrusting attitude of the farmers to solar powered pumps.

No. 8	Gasoline pump
Category	**Water lifting / abstracting water**
Short description	A gasoline driven centrifugal pump.

Advantages	Disadvantages
• Low initial upfront investment cost (ie 150 US$). • It are small capacity pumps and light weight, easy to use and move from one plot to another. • Appropriate for small plots. • Appropriate for water sources that are 10 m deep or less. • Can be repaired by most mechanics.	• Consumes considerable amounts of gasoline. • Operating costs are higher than for a diesel pump. • Water pressure is around 1 bar, which works well with drip lines but is too low to pump large volumes of water.

List of SWSs and climate-smart technologies

No. 9	Diesel pump
Category	**Water lifting / abstracting water**
Short description	A diesel engine, usually between 10-15 HP which drives a centrifugal pump for pumping surface water (up to 60 m3/hour). A diesel engine can also power an inverter which generates an electric current and can power a submersible electric pump.

Advantages	Disadvantages
• Operating costs are lower than for a gasoline pump. • Large pumping capacity and water flow are suitable for irrigation on a large farm. • High water pressure suitable for sprinkler spray.	• Heavy and hard to move from one plot to another. • Requires frequent maintenance and has high operating costs (fuel). • Unless it's fitted with a battery, it requires a manual kick start.

No. 10	Plastic mulch
Category	**Water saving / soil moisture conservation**
Short description	Plastic mulch reduces soil evaporation and hence the amount of irrigation needed. It influences soil temperature and thus accelerates seed germination. Black-coloured plastic can be used to increase soil temperature, while reflective white plastic cools the soil.

Advantages	Disadvantages
• Reduces soil evaporation and regulates soil temperature. • Suppresses weeds.	• Plastic mulch disintegrates and pollutes the soil with long-lasting plastic remnants. In some countries, discarded plastic mulch is collected for reuse to reduce pollution. Bio-degradable mulch is being developed, but it is still expensive and not durable.

List of SWSs and climate-smart technologies

No. 11	Rice straw / organic mulch
Category	**Water saving / soil moisture conservation**
Short description	Using rice straw as mulch reduces soil evapotranspiration and regulates soil temperature, though it is less effective than plastic mulch. Other organic byproducts, such as banana leaves, may be used as well.

Advantages	Disadvantages
• Reduces soil evaporation and regulates soil temperature. • Protects topsoil against wind and rain. • Increases soil organic matter. • Biodegradable and environmentally friendly.	• Can bring certain diseases linked to fungus or other pathogens. • Less effective in weed control.

No. 12	Cover crop
Category	**Water saving / soil moisture conservation**
Short description	A permanent or annual crop which forms a green vegetative cover on the soil and sown especially to enrich and improve soil fertility without yielding a harvestable product.

Advantages	Disadvantages
• Low cost. • Protects soil and increases organic matter. • Nitrogen-fixing if from the legume family.	• In the case of intercropping the farmer needs to understand crop management in order to reduce competition. • Requires labour to sow and manage, whilst there is not product to harvest and sell.

List of SWSs and climate-smart technologies

No. 13	Micro basin
Category	**Water saving / soil moisture conservation**
Short description	A small earthen basin around a tree trunk helps to retain irrigation water. It is often built to reduce water flow off and to store water rainfall in the soil for crop to absorb.

Advantages	Disadvantages
• Effective and low-cost. • Can be combined with a drip pipe. • Better soil moisture reduces flower blossom fall and increases fruit development.	• Establishment cost. • Risk of waterlogging in soils with poor drainage.

No. 14	Ridge planting
Category	**Water saving / soil moisture conservation**
Short description	Elevated ridges to create raised planting beds.

Advantages	Disadvantages
• Good aeration of the roots. • Makes harvesting easier. • Avoids waterlogging.	• Labour-intensive if not mechanised.

List of SWSs and climate-smart technologies

No. 15	Precision land levelling
Category	**Water saving / soil moisture conservation**
Short description	Laser technology is used to ensure there is no variation in the height of the soil, so water can spread evenly across the field.

Advantages	Disadvantages
• Avoids patchiness of field water application, i.e. when some areas get too much water and others too little.	• Need precision laser technology and tractor service.

No. 16	Soil compost & biochar
Category	**Water saving / soil moisture conservation**
Short description	Soil water retention capacity is improved by adding organic matter. There are many types of non-chemical soil additives: vermi-compost, biochar, olivine rock dust, etc. They can be applied everywhere on the field or just in specific places, such as in micro basins.

Advantages	Disadvantages
• Improves soil moisture and water holding capacity of the soil. • Improves soil structure, life and fertility, and gradually releases nutrients. • Reduces the need for irrigation.	• Large plots require a lot of compost, which may not be available in large quantities. • Labour-intensive.

List of SWSs and climate-smart technologies

No. 17	Drip irrigation system
Category	**Water saving**
Short description	By releasing water in small quantities close to the root of the plant, water is distributed efficiently. A large range of drip systems is available.

Advantages	Disadvantages
• Can deliver liquid fertiliser mixed with irrigation water – a combination known as 'fertigation'. • Saves time and increases productivity.	• Relatively costly, though there is a wide range of options with different price points. • Risk of nozzles becoming clogged. • Needs regular replacement and causes plastic pollution. • Risk of inducing shallow rooting of fruit trees, making them more vulnerable to drought and wind.

No. 18	Micro sprinkler
Category	**Water saving**
Short description	A small sprinkler spreads water evenly over the surface of crops. Suitable for root vegetables.

Advantages	Disadvantages
• Spreads water evenly over the field. • Suitable if root irrigation risks rotting of the vegetables, e.g. with carrots and onions. • Can be operated automatically. • It helps decreasing water use, fertilizer and labour requirements.	• High investment cost. • Relatively high water consumption due to spreading and evaporation.

List of SWSs and climate-smart technologies

No. 19	Rain spray tube/hose
Category	**Water saving**
Short description	An irrigation pipe with many small holes, also known as a rain spray hose, to create a fine mist of droplets sprayed onto the crop/bed.

Advantages	Disadvantages
• Saves labour, time and energy. • Easy to install. • Ensures that small drops of water are sprayed uniformly over the planting bed. • Low-cost investment compared with a drip line. • Good fit for leafy vegetables. • Works at low water pressure. • Suitable for closely spaced crops	• Lasts for only one or two crop cycles. • Weeds are a concern. • Causes plastic waste. • Relatively high atmospheric evaporation loss.

No. 20	Nethouse
Category	**Water saving**
Short description	A low-cost, tunnel-shaped nethouse creates a controlled environment for growing crops, regulating temperature, humidity and evaporation.

Advantages	Disadvantages
• Controls growing environment and protects crops from heavy rain. • Comes in a range of options, from relatively low-cost to expensive. • Can be combined with other measures, such as drip irrigation, mini sprinklers, soil compost/ biochar and mulch.	• Considerable investment cost. • Not suitable for large-scale field crops like cereals. • The farmer needs to manage heat and humidity build-up inside the nethouse.

List of SWSs and climate-smart technologies

No. 21	PVE pipe
Category	**Water saving**
Short description	PVE pipes convey water from the source to distant areas of the farm.

Advantages	Disadvantages
• No water loss compared to a canal. • Can cross unlevelled fields. • More resistant to sun exposure then PVC, less likely to break or leak.	• Can be costly. • PVE is recommended as it lasts longer than PVC, but it is costlier.

No. 22	Lay-flat hose
Category	**Water saving**
Short description	Polyethylene pipes convey water from a pump through a hose which fills when water pressure is applied.

Advantages	Disadvantages
• Easy to use and transport to other parts of the field.	• Depending on quality, it may need to be replaced every 1–3 years.

List of SWSs and climate-smart technologies

No. 23	Moisture sensor
Category	**Water saving**
Short description	Moisture sensors are placed in the soil and measure soil moisture content along the planting bed. They transmit a signal to a computer or phone and indicate when irrigation is required. About 4 on a ha are used.

Advantages	Disadvantages
• Can be combined with an automated irrigation system.	• Needs proper calibration to ensure right moisture for each crop.

No. 24	Communal reservoir
Category	**Collective water resource management**
Short description	Large, excavated reservoir on communal land which stores rainwater and runoff water for community use. Usually between 4-6 m deep and measuring from 50x100 m to several hectares.

Advantages	Disadvantages
• Large storage pond used for irrigation and livestock in the dry season. • Supports water infiltration into the groundwater allowing the aquifer to replenish.	• Maintenance is required to prevent the reservoir from filling with eroded soil. • Clear sharing agreements are needed so the facility can benefit the whole community. • Needs agreements for maintenance and user payments.

List of SWSs and climate-smart technologies

No. 25	Feeder canal with water gate
Category	**Collective water resource management**
Short description	Conveys water from a natural source to a reservoir.

Advantages	Disadvantages
• Enables transport of large volumes of water.	• High establishment cost. • Maintenance is required. • Clear agreements for water use and payments need to be in place.

ANNEX 3

Example of district dialogue programme

Duration	Activity	Objective/output	Who
	Registration	List of attendees	Project team
10 min	Welcome and opening remarks		District governor or his/her representative
20 min	Presentation about agricultural development in the province	Short presentation on agricultural development	Director of PDAFF or his/her representative
5 min	Group photo		All
20 min	Presentation about the project & findings of assessment	Present findings of rapid assessment	Technical adviser
30 min	Brainstorming session on most important issues	Confirm main climate issues by writing them on cards	Facilitator
40 min	Small group discussions (5 groups) • Public sector • Traders/input, suppliers/MFIs/ service providers • Development partners • Producers/farmers	Use small cards with challenges written down. Let participants rank them in order of priority and let them identify feasible solutions.	
15 min	Coffee break		All
25 min	Group presentations	To share the outcome of the small group discussions	Group representatives
15 min	Plenary discussion with Q & A	Overview of main findings	Facilitator & technical adviser
20 min	Presentation from a shop owner selling SWS technologies	Different technologies briefly explained and promoted	Shop owner
30 min	Matchmaking session between farmer groups and service providers	Discussion on interests, identifying potential demand	All
10 min	Conclusion & next steps		Facilitator
10 min	Closing remarks		Director of PDAFF or his/her representative
	Lunch		All

ANNEX 4

Questionnaire for individual farm assessment and investment plan

Name:	Age:	Sex:
Address:		
Farm size:		

1. Crop calendar: (understanding main activities and periods)

2. Why do you want to grow vegetables year-round?Crop calendar: (understanding main activities and periods)

3. Do you have a problem with waterlogging? How do you deal with it?

4. Do you have any problem with dry spells during the rainy season?

5. Water shortage on your farm normally starts when? How do you deal with it?

Well	Pond
Access to well: Yes / No	Project team
Type of well:	Type of pond: (does water come out or not?)
Depth:	Size and depth:
Depth in the dry season:	Depth in the dry season:
What would you like to do with it (e.g. re-drill)?	What would you like to do with it?
Estimated total cost:	Estimated total cost:
Amount willing to invest:	Amount willing to invest:

Water requirement

Pump:

What method do you use to irrigate your crops?

a) Drip/rain spray/sprinkler/flat hoses
b) What equipment maintenance do you do?
c) How do you store the equipment after use?
d) When do you irrigate your crops? How often? Do you check soil moisture before irrigating?

Water management:

Do you apply anything on your vegetable beds for moisture conservation?

a) Plastic mulch
b) Rice straw
c) Something else (describe: _____)

Do you own a nethouse? Y/N

Type of nethouse (e.g. plastic tunnel): _____

Size of nethouse (in square metres): _____

Interested in a new nethouse? Y/N

Type? _____ **Size?** _____

Crops to be produced and number of cycles? _____

Do you have a secured market? Y/N

SNV
IMPACT THAT MATTERS

CHAIN

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