CATALYZING SMALL-SCALE IRRIGATION DEVELOPMENT IN RWANDA:

AN ASSESSMENT OF THE SMALL-SCALE IRRIGATION TECHNOLOGY (SSIT) PROGRAM

September 2022

2030 Water Resources Group | HOSTED BY WORLD BANK GROUP

GWSP GLOBAL WATER SECURITY & SANITATION PARTNERSHIP

ABOUT 2030 WRG

This publication received the support of the 2030 Water Resources Group (2030 WRG).

2030 WRG is an innovative partnership for water security hosted at the World Bank Group. The trust fund catalyzes public-private collaboration to enable transformative impact towards water security. Please visit us at 2030wrg.org and follow us on Twitter: @2030WRG.

CATALYZING SMALL-SCALE IRRIGATION DEVELOPMENT IN RWANDA:

AN ASSESSMENT OF THE SMALL-SCALE IRRIGATION TECHNOLOGY (SSIT) PROGRAM

September 2022

2030 Water Resources Group / 2030 WRG

© 2022 2030 Water Resources Group / 2030 WRG
701 18th Street NW, Washington, DC 20433
Internet: www.2030wrg.org

This work is a product of 2030 WRG with external contributions. The findings, interpretations, and conclusions expressed in this work do not necessarily reflect the views of The World Bank, its Board of Executive Directors, or the governments they represent.

The World Bank does not guarantee the accuracy, completeness, or currency of the data included in this work and does not assume responsibility for any errors, omissions, or discrepancies in the information, or liability with respect to the use of or failure to use the information, methods, processes, or conclusions set forth. The boundaries, colors, denominations, and other information shown on any map in this work do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries. Nothing herein shall constitute or be construed or considered to be a limitation upon or waiver of the privileges and immunities of The World Bank, all of which are specifically reserved.

This report has been reviewed by Rwanda Agriculture and Animal Resources Development Board (RAB) and accepted by Ministry of Agriculture and Animal Resources (MINAGRI).

Rights and Permissions

The material in this work is subject to copyright. Because 2030 WRG encourages dissemination of its knowledge, this work may be reproduced, in whole or in part, for noncommercial purposes as long as full attribution to this work is given.

Please cite the work as follows: 2030 WRG, 2022. Catalyzing Small-Scale Irrigation Development in Rwanda: An Assessment of SSIT Program. 2030 Water Resources Group (2030 WRG) hosted by the World Bank Group.

Any queries on rights and licenses, including subsidiary rights, should be addressed to 2030wrg@worldbank.org.

Cover photo: © Resilience B.V. Used with the permission of Resilience B.V. Further permission required for reuse.
Cover design: Erika Endrődiné Benkő

All figures in this report are original to this publication.

CONTENTS

ACKNOWLEDGEMENTS

This study was prepared by a team led by Joy Busolo, Gabriella Izzi, Innocent Nzeyimana, Jonathan Denison, and Julia Agoncillo. The team appreciates the work done by Resilience BV through its daughter company Resiliência Rwanda, particularly Wouter Beekman, Hans Komakech, and Gertjan Becx. The team acknowledges the extensive support that was provided by the government of Rwanda (GoR) through the Ministry of Agriculture and Animal Resources (MINAGRI), Rwanda Agriculture and Animal Resources Development Board (RAB), including Charles Bucagu, Emile Ruzibiza, and Papias Mucyo, farmers, local financial institutions, private sector technology providers, and District Agronomists and Extension Officers. Without their assistance, this study would not have been possible.

The team would also like to thank Esdras Byiringiro and the peer reviewers, Francois Onimus, Joop Stoutjesdijk, and Asa Giertz, for the constructive comments and support provided. The team would like to express a special word of thanks to Parameswaran Iyer, Shobha Shetty, and Rolande Pryce for their encouragement, leadership, and guidance, as well as to all the members of the review meeting.

This study was supported by the World Bank with funding provided by the 2030 Water Resources Group (2030 WRG) and the Global Water Security & Sanitation Partnership (GWSP).

EXECUTIVE SUMMARY

Background

Rwanda's economy strongly depends on agriculture. The agricultural sector provides Rwanda with about 70 percent of its employment, 32.7 percent of its national gross domestic product (GDP), 91 percent of its food consumed, and 70 percent of its export revenue. Therefore, the government of Rwanda (GoR) sees agriculture as one of the main drivers of sustaining GDP growth and accelerating the reduction of poverty so that it affects less than 30 percent of the population. Rwanda's National Vision 2020 states that agricultural productivity needs to increase by 8.5 percent to realize the annual GDP growth target of 11.5 percent. The GoR recognizes that for this to happen, the area of the country's land under irrigation needs to increase. Given that most of Rwanda's farmers are smallholders, and smallholder agriculture contributes up to 25 percent of national GDP, a focus on developing smallholder irrigation (that is, small-scale irrigation or SSI) is essential.

The GoR's small-scale irrigation technology (SSIT) program helps smallholder farmers to overcome the financial and knowledge constraints associated with SSI development. The program was launched in 2015 with the goal of developing 25,000 hectares (ha) of newly irrigated land by 2024. Through the program, farmers are given a partial subsidy to acquire irrigation kits (pumps and water distribution technologies). The subsidy was developed to promote widespread use of demand-driven, affordable, and locally assembled irrigation technologies. Between 2015 and 2019, the program supported the development of 10,000 ha of small-scale irrigation, in line with its targets. The GoR is now reflecting on how to improve the program—based on the lessons learned from these first years of implementation—to design a new phase for further expansion.

Scope and methodology of the assessment

The 2030 Water Resources Group (2030 WRG) is a global public, private, civil society partnership and multi-donor trust fund hosted by the World Bank Group (Water Global Practice) that supports countries in developing national multi-stakeholder platforms that accelerate action to sustainably manage water resources. In Rwanda, 2030 WRG partnered with the GoR, through the Ministry of Agriculture and Animal Resources (MINAGRI), to engage the private sector in developing irrigation projects and establishing an agricultural water management workstream.

During its scoping mission, 2030 WRG, together with MINAGRI and the Rwanda Agriculture and Animal Resources Development Board (RAB), agreed on the need to provide technical assistance to: (1) assess the ongoing SSIT subsidy program's effectiveness, and (2) provide recommendations on policy and implementation reforms based on best practices and identify new and innovative financing models that could improve private incentives, reduce transaction costs, and manage the risks associated with investing in small-scale irrigation.

This report presents the key findings and recommendations of the comprehensive assessment of the existing SSIT program. The scope of the assignment was to: (1) conduct a comprehensive assessment of the SSIT program to evaluate what worked well and what could be improved; (2) review policies and laws to recommend necessary policy, regulatory, and structural reforms to accelerate the expansion of SSI; and (3) review how to leverage the potential of the private sector.

The assessment involved a literature review; a database analysis; telephone surveys and field visits with farmers; and interviews with key stakeholders from the GoR, the private sector, the donor community, and financial institutions. The literature review analyzed existing policies and reports regarding agriculture and irrigation in Rwanda in general, and the SSIT program specifically, including an overview of ongoing policies, laws, and strategies that have an influence on the development of small-scale irrigation. A total of 375 telephone surveys were conducted with farmers (semi-randomly selected from a beneficiary list received from RAB), of whom 53 agreed to a follow-up face-to-face interview during a field visit.

Key findings

The assessment showed the success of the program, with a high average satisfaction level of 3.99 on a scale of 1 to 5 (with 5 being high) among the sample group (375 farmers). The impact of the SSIT program on farmers' livelihoods was generally positive: 99 percent of interviewees indicated an increase in income, with an average increase of 525,000 Rwandan francs (RF 525,000) per year. Additionally, the program caused changes in food spending given the extra income available or the increase in crops grown for own consumption. Moreover, 66 percent of the farmers indicated a decrease in workload (of 14 hours per week on average). Factors that contributed to the success of the program were awareness creation (through district/sector agronomists, community meetings, and radio broadcasts) and water availability (64 percent of the sample have not experienced a water shortage since introducing irrigation).

The main constraints were found to be requirements for land tenure security and water permits; access to finance and the cost of equipment; getting the right technology and knowledge regarding irrigation agronomy and practices; the application process; and transparency (that is, monitoring and evaluating the program, and access to and availability of data from these processes). Although the program targeted women and youth specifically, only 13 percent of the sample group was female, and the average age of the farmers was 48 years, with age groups 20–30 and 30–40 clearly underrepresented. These constraints are explained further in the following section and serve as the basis for the suggested changes for the next phase of the SSIT program.

Main recommendations

Broaden the base of farmers

Broadening the eligibility criteria to include a land renting/leasing agreement would result in more farmers being eligible for the SSIT program. The current program requires that farmers provide proof of land ownership. As such, land tenure may have limited the uptake of SSIT as some farmers rent land. About 60 percent of the SSIT beneficiaries own their land, whereas about 37 percent are land renters. As some SSIT-supported technologies are mobile, land renters could have benefited from the program and moved with the equipment from one plot to the next as they rent a different piece of land in a different season.

Raising the requirement for a water permit to a threshold above 5 ha and using a water use declaration below this threshold will allow more farmers to become eligible for SSIT. Under Rwandan water law, a permit is not required to extract water for irrigation if the area is smaller than 1 ha. To acquire a water permit for areas larger than 1 ha, hydrological research and a feasibility survey are required, which is a lengthy and costly process (costing more than RF 100,000). To date, the Rwanda Water Resources Board (RWB) has not enforced the law among SSIT beneficiaries irrigating more than 1 ha. However, the RWB would like the permit requirement to be reflected in the SSIT subsidy application form, while recognizing the restrictive effect of the stringent threshold of 1 ha if enforced. A water use declaration for farmers located in low-risk areas or outside major hotspots and irrigating below this threshold would be sufficient to maintain insight on the water use in an area. The declaration could potentially be based on the expert opinion of either an RWB or RAB representative at district level regarding the cumulative water use impact of a group of irrigating farmers in a certain area.

Reduce inequity in acquiring SSIT equipment

Allowing farmers with smaller landholdings to apply for the subsidy (if funding allows) would increase the range of farmers who can transition to profitable irrigated production. The SSIT land size criteria of 0.5 ha to 10 ha is likely to have limited participation in the subsidy program as most small-scale farmers in Rwanda own less than 0.5 ha and renting land is common. In practice, many SSIT farmers were practicing irrigated production on less than 0.5 ha, even though they owned more land (median of land owned was 1 ha). This means that they could still apply for the subsidy on the basis of the total land owned. However, the cost-benefit analysis shows that irrigated vegetable production is already profitable with an area of 0.25 ha, even after the first season, if the equipment is subsidized, or after the second season without a subsidy. The current criteria (land ownership >0.5 ha) led to a group of relatively rich farmers benefiting from the program.

Overcome financial constraints

Raising awareness and increasing knowledge and understanding of the agricultural sector within financial institutions and working in close collaboration with financial institutions to develop fit-for-purpose financial products are recommended in the next phase, not just for the initial investment, but also to finance the running costs. Over 73 percent of interviewed farmers financed their contribution to the purchase of irrigation equipment themselves; only 22 percent needed to acquire loans from banks, cooperatives, savings and credit cooperatives (SACCOs), or informal sources. Although these farmers are willing to invest in and can contribute to SSIT equipment, most of the farmers faced operational and maintenance difficulties due to high running costs (fuel, spare parts, and skills) and loan repayments.

Generally, the private financing market is not suited to small-scale, market-oriented farmers who are part of the SSIT program, and solutions tailored to their reality do not exist. Although the SSIT program wanted financial institutions to participate to help farmers pay for the non-subsidized part of the equipment, their involvement was limited during implementation. Specifically, there were no financial and insurance products designed to target irrigation development. Financial institutions had limited involvement due to the underdeveloped private financing market, and their lack of knowledge and understanding of the agricultural sector.

Engaging SACCOs directly or indirectly through banks and/or promoting group lending will increase access to the financial services needed to invest in SSIT. About 97 percent of sampled farmers indicated that they had access to financial services, of which SACCOs were the most important source. However, these financial services were not used by farmers to finance irrigation equipment under the SSIT program as the loans were too small.

To lower the transaction burden and reduce the unit cost of the SSIT equipment to be more on a par with the market price, it is recommended to adopt the "farmers procure" model. In the current model, prices were set upfront by service providers with a large markup to cover risks. Procurement is subsequently done by an RAB representative (often the district agronomist). Under the farmers procure model, the government's role would be to facilitate access to irrigation equipment by prequalifying suppliers to guarantee quality and provide guidelines on the required quality for SSIT equipment. The farmer's role would be to select the appropriate equipment from the relevant supplier.

A differentiated subsidy approach could increase the competitiveness of solar irrigation. To align with government policies to promote more sustainable irrigation equipment types, a differentiated subsidy approach could increase the competitiveness of solar irrigation. The subsidy did help to lower the initial capital needed to access the irrigation equipment, primarily for systems with higher initial investment costs, such as solar pumps. Given the low operational costs of solar irrigation, this is also more profitable in the long term.

Get fit-for-purpose technologies

To ensure that fit-for-purpose technology is installed, it is recommended to separate the modality of private irrigation technology provision in two: (1) private technology providers will be active at national level, with the sole goal of sourcing and selling; and (2) private irrigation extension providers will be active at district level. Initially, irrigation service providers were expected to conduct field visits and design, install, and train farmers in the operation and maintenance of equipment. However, in practice, most farmers received a standard equipment package (diesel/petrol pump and 50-meter hose) without a field visit, tailored design, or training from the service provider. This often resulted in unsuitable irrigation technologies and practices, which—in combination with insufficient maintenance—led to irrigation equipment having lower lifespans.

Due to low turnover, it was too costly for the service providers to operate offices at district level as had been expected in the program concept. To reduce their input costs, most of the service providers decided to operate from Kigali. With the subsidy, the service providers are helped to scale their business until it becomes profitable. In the proposed set-up, the private irrigation extension provider has two separate tasks: (1) supporting farmers in the (pre)design and technology choice and training them to operate and maintain the equipment; and (2) providing training in irrigation agronomy. The role of this private irrigation extension provider can be covered by a local private operator or youth groups that can offer technical (pre)design, installations, or irrigation as a (private) service, focusing on specific technical services. This model would allow for private sector engagement to complement the GoR's extension service delivery.

Providing direct hands-on irrigation agronomy knowledge would strengthen the existing extension model. Using private irrigation extension providers active at district level could be linked to the current national extension model. The extension model is the main source of agronomic information and knowledge (seeds, pests, fertilizer use, and so on); however, no training is being given to farmers on irrigation agronomy and technology operation and maintenance. This has led to a lack of irrigation agronomy knowledge (for example, how to prepare fields for irrigation, or when and how much to irrigate fields), contributing to below-optimal yields from the SSIT-irrigated fields. Partnering with technical and vocational education and training schools could be an option to start educating people about irrigation agronomy and practices.

Make the process faster

Adopting a hybrid digital and paper-based application system would allow for a more inclusive and clear-cut application process for farmers. Although the SSIT program's paper-based application process might be considered fast (taking up to three months to complete), the amount of documentation involved could be discouraging many farmers from applying. A complementary digital application process would reduce the turnaround time, while allowing for better record-keeping and process monitoring. This hybrid system could be modeled on the Smart Nkunganire digital program, which is being used for a seeds and fertilizers subsidy, or it could be linked to the Irembo portal, which is already providing digital services to the GoR.

Make the process more transparent

To strengthen the monitoring and reporting process, make the process more transparent, and better guide the implementation of the program, evaluating more parameters (such as type of technology adopted and profitability of production) in the management information system is recommended. Monitoring the program involves reporting the areas of irrigation developed through SSIT to MINAGRI through a management information system. Initially, RAB evaluated and approved subsidy applications; this responsibility was later decentralized to the districts in 2018. This has complicated the reporting of the SSIT results, as it has proven difficult to collect all the documents needed to conduct the evaluation. Additionally, reporting is limited to the area irrigated using SSIT, resulting in limited insight into other impact indicators (such as the type of technology adopted, profitability of production, crop types, and farmer profiles), and therefore weak insight into the actual implementation and impact of the SSIT program.

ACRONYMS

2030 WRG	2030 Water Resources Group
BDF	Business Development Fund
DFID	Department for International Development
EIA	Environmental Impact Assessment
FCDO	Foreign, Commonwealth & Development Office
FFS	Farmers' Field Schools
FLID	Farmer-Led Irrigation Development
FPs	Farmer Promoters
GDP	Gross Domestic Product
GoR	Government of Rwanda
ha	Hectare
ICCO	Interchurch Organization for Development Cooperation
ICT	Information and Communication Technology
ICT4RAg	ICT for the Rwandan Agriculture
IFAD	International Fund for Agricultural Development
IPRC	Integrated Polytechnic Regional College
MINAGRI	Ministry of Agriculture and Animal Resources
MoU	Memorandum of Uunderstanding
NGO	Non-Governmental Organizations
O&M	Operation and Maintenance
RAB	Rwanda Agriculture and Animal Resources Development Board
REMA	Rwanda Environment Management Authority
RF	Rwandan Franc
RLA	Rwanda Land Authority
RWB	Rwanda Water Resources Board
SACCO	Savings and Credit Cooperative
SIR	Solar Irrigation Rwanda
SPIU	Single Project Implementation Unit
SSI	Small-Scale Irrigation
SSIT	Small-Scale Irrigation Technology
TVET	Technical and Vocational Education and Training
US$	United States Dollar
USAID	United States Agency for International Development

1 INTRODUCTION

1.1 Background

Rwanda is a country in transition, and one of the fastest-growing economies in East and Central Africa. The government of Rwanda (GoR) has put significant effort into producing more food for the country's growing population. The need for increased agricultural production per unit of land is described in the GoR's policies and programs. There is a general recognition that adapting to—and mitigating—climate change impacts are critical for the country's socioeconomic development. The GoR aims to increase agricultural productivity in the face of a changing climate, and hence support the strategies for poverty reduction, through investing in irrigation.

The GoR, in its draft Irrigation Master Plan 2020,[1] proposed a goal of 102,284 hectares (ha) of irrigated land by 2024. Given that most of Rwanda's farmers are smallholders, and smallholder agriculture makes up 25 percent of GDP,[2] a focus on smallholder irrigation is essential.

The GoR's small-scale irrigation technology (SSIT) program is one of many strategies aimed at reaching 24,574 ha of land equipped for farmer-led irrigation by 2024.[3] The GoR's target—set in 2014—to reach 10,000 ha by financial year 2017/18 was reported by the Ministry of Agriculture and Animal Resources (MINAGRI) to have been achieved in 2019 (10,249 ha).[4] The main component of the SSIT program is providing a partial subsidy for smallholder farmers to purchase irrigation kits (pumps and water distribution technologies). The theory of change of the SSIT program is that the GoR's subsidized access to affordable irrigation technologies will alleviate the impacts of climate-change-induced droughts and increase the agricultural productivity of smallholder farmers in Rwanda. The key stakeholders involved in this program are the Rwanda Agriculture and Animal Resources Development Board (RAB), districts, private sector service providers, and farmers.

The SSIT program has had apparent success in terms of the hectares of land equipped for farmer-led irrigation. However, it has faced some challenges—for example, limited uptake by commercial or smallholder farmers; high costs of irrigation technologies and equipment despite the GoR's partial subsidy, thereby excluding some smallholder farmers; and the diversity in the range of donor-funded irrigation financing models, which has created conflicts and overlaps between beneficiaries.

1.2 Aim of the assignment

The aim of this assignment was to assess the effectiveness of the SSIT program and to recommend changes to the program (based on best practices and innovative financing models) that can incentivize private investments, reduce transaction costs, and manage risks associated with investing in small-scale, farmer-led irrigation. The recommended methods and policies will support the future scale-up of the program (in support of MINAGRI/RAB) and provide policy recommendations for phase 2 of the program, as well as farmer-led irrigation development (FLID) in Rwanda and Sub-Saharan Africa (in support of the work of the 2030 Water Resources Group (2030 WRG)). This assignment also assesses whether there is a need for (re)designing an appropriate subsidy structure and formulating financial models that address the challenges identified during the scoping mission.

Through the assignment, we explored improved modes of engagement with FLID processes. We understand FLID as a process found extensively in Sub-Saharan Africa, where farmers drive irrigation development in response to market opportunities. FLID is expressed in many forms, adapting its character depending on where, how, and why farmers take up irrigation. Importantly, **it is not the technology that drives the change, but the solution it brings for the local context and the problems farmers face**. Therefore, it is not an individual or stand-alone process, but a setting where the farmer engages with different players to find a solution to his/her production limitations. Because of this characteristic, FLID is considered the most sustainable process for irrigation development, as it is the farmers who initiate the adoption of new practices.

[1] RAB. 2020. "Rwanda Irrigation Master Plan." Draft version.
[2] National Institute of Statistics of Rwanda. 2017. *Gross Domestic Product.*
[3] MINAGRI. 2018. *Strategic Plan for Agriculture Transformation 4 (PSTA-4).*
[4] MINAGRI. 2020. *Report of Q2 of Fiscal Year (FY) 2019–2020.*

The 2030 WRG scoping mission identified the need to investigate how to:

- Turn the irrigation sector into a demand-driven sector to facilitate FLID.
- Define policies and subsidy schemes that reduce the initial costs for investment in irrigation.
- Restructure the efforts of projects and programs to align with the policies that catalyze FLID, to improve the enabling environment in which farmers operate.

This assignment aims to support the future scale-up and to increase the potential impact of the SSIT program, as well as to define lessons learned and recommend actions to MINAGRI/RAB. These recommendations could also function as an example for the region and support the role of 2030 WRG and the World Bank in helping governments improve how policies and strategies align to facilitate the further development of the irrigation sector for all stakeholders.

Specifically, the study was designed to:

- Conduct a rapid review of existing literature related to the SSIT subsidy program to understand what has worked well (or not) and use this information to recommend new financing options to improve how the program is managed.
- Assess how the program is implemented at RAB and district levels, including farmers' and private sector stakeholders' perceptions of the program's implementation, by analyzing field data collected through household/farmer surveys, focus group discussions, and interviews with key stakeholders.
- Take stock of ongoing programs and projects in Rwanda that promote or involve engaging the private sector in SSI development and their financing mechanisms and identify potential opportunities for and barriers to engaging this sector.
- Based on the above findings, provide a set of lessons (including regional best practices) and recommend best practices and options to reform policies, leverage private services (and goods or incentives), and supplement how government incentivizes existing and future programs and project designs relating to SSI development. Recommend how to align government subsidy models for SSI, including by targeting public resources for SSI more efficiently through improved coordination among the different players providing these resources.
- Recommend options for new financing models that offer potential opportunities to improve private incentives, reduce transaction costs, and manage the risks associated with investing in SSI. The models identified will be developed as follow-on work to this assignment.

1.3 Scope of the assessment

The scope of the assessment covers:

- Policies and subsidy structures that will facilitate the scale-up of FLID in Rwanda.
- The existing SSIT program, to understand what worked well and what could be improved when scaled up.
- The opportunities, barriers, and challenges of the private sector to engage with FLID, to be able to recommend policies and strategies to leverage the potential of private sector engagement to catalyze FLID.

2 METHODOLOGY

2.1 Literature review

A literature review was conducted to understand what has worked well and what could be improved in the SSIT program. The team reviewed existing documentation on the SSIT program, policies, and reports; performed an initial stock-take of ongoing policies and strategies that promote or involve private sector engagement in SSI development; and analyzed agricultural support policies. The results of the diagnostic literature review are integrated into this report.

2.2 Assessment methodology

We used both quantitative and qualitative methods to collect and analyze data.

2.2.1 Quantitative survey method

RAB[5] shared a list of the 4,450 SSIT beneficiaries across the country over the five years (from 2015 to 2020) that the program has been running for the purpose of sampling SSIT beneficiaries to participate in the survey. The list from RAB had contact details of the listed beneficiaries, their location, and the size of their land in hectares (with a total of 11,128 ha for all the beneficiaries). As the only relevant information to stratify across was land size, we divided the beneficiaries into four subgroups (<0.50 ha, 0.5 to <1.0 ha, 1.0 to <3.0 ha, and >3 ha).

The objective of the sampling was to ensure that farmers from each land size category were equally represented in the survey. This was achieved by creating random samples of 160 beneficiaries (40 from each category) for each of the five years, listing them randomly per year, and dividing each of the five random samples per year between the five hired Kinyarwanda-speaking enumerators, who called and surveyed the listed farmers. In total, 375 farmers[6] were interviewed with a short survey over the phone.

In addition to the telephone survey, 53 long survey interviews were conducted with farmers in person.[7] The main sampling mechanism for the farmers in these long survey interviews involved contacting people who had already been surveyed over the telephone, reintroducing ourselves, and asking to conduct a field visit to their farms. This selection method was especially guided by the districts selected for visiting, the availability of farmers, and their proximity to each other. In addition to the farmers sampled from the pool of SSIT beneficiaries who had answered the short telephone survey, non-SSIT farmers were interviewed in the districts visited to collect their perspectives on the program.

In total, 53 field visits were conducted in the following nine districts: Rwamagana (11), Bugesera (10), Gatsibo (9), Nyagatare (9), Nyanza (6), Kamonyi (5), Huye (1), Gisagara (1), and Karongi (1). Assessment of the Eastern Province indicated that it is the most promising area for irrigation in Rwanda. This was reflected in the random sample of SSIT beneficiaries and thus in the availability of farmers with whom field visits could be conducted. Accordingly, the SSIT program largely targeted districts in this province.

Figure 1: Interviews per province

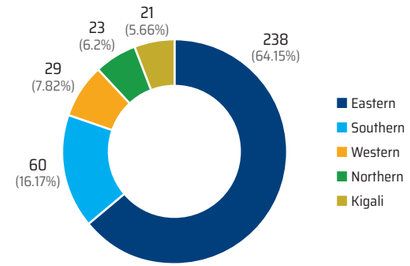
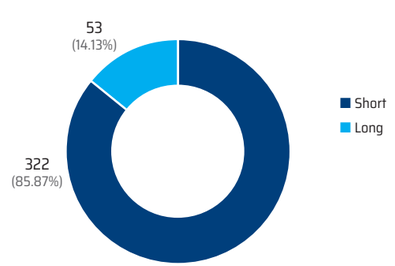


Figure 2: Type of interviews



[5] A detailed analysis of the full database of beneficiaries can be found in section 4.1.3.

[6] Determined with a power rule test, we concluded that to derive statistically significant results from a total population of 4,450 beneficiaries, a sample of 354 would be required.

[7] Twelve long interviews that were carried out in July 2021 were conducted by telephone due to restrictions in force during the third wave of the COVID-19 pandemic.

2.2.2 Qualitative survey method

In-depth semi-structured interviews were conducted with GoR officials (from MINAGRI, the Ministry of Finance, RAB, the Rwanda Water Resources Board (RWB), and the districts); key private stakeholders (exporters, irrigation equipment suppliers and irrigation service providers); farmers' cooperatives; financial institutions (for example, AB Bank, SACCO Rwabicuma in Nyanza district, the International Fund for Agricultural Development (IFAD), Banque Populaire du Rwanda, Urwego Opportunity Bank, and Business Development Fund); donors (Hinga Weze/United States Agency for International Development (USAID); the Food and Agriculture Organization; and the Foreign, Commonwealth & Development Office (FCDO); and beneficiaries selected for field visits, as outlined above.

The objective of these interviews was to investigate relevant stakeholders' perceptions of the SSIT program, to evaluate the key issues and challenges relevant to the program, and to understand how the program could be improved. The results of these interviews are integrated into this report and the annexes.

3 READING GUIDE TO THE ASSESSMENT REPORT

This assessment report presents the results of the diagnostic survey and the field assessment. The main report has been structured to reflect the main questions as outlined in the terms of reference.

The recently published FLID Guide[8] provides a well-structured diagnostic method to assess programs such as SSIT. The FLID Guide captures the complexity of the system by describing seven factors:

- Resource potential. This includes land suitability, how much surface water and groundwater are available, and water quality.
- Farmer benefits. This includes crop profitability, the whole farming system (all farm operations), and the environment in which a farmer operates.
- Policy and legal. This includes policies and laws on land and water, subsidies/incentives, and accountability.
- Knowledge. This includes research/advice on the benefits of irrigation, irrigation farming skills, operation and maintenance (O&M), and labor aspects.
- Finance. This includes the affordability of irrigation equipment and finance responses.
- Markets. This includes agricultural input/output markets, financial and technical aspects, local and export markets, and physical access to markets.
- Technology. This includes the types of technology, servicing and support, and socio-technological aspects available.

The FLID Guide was used to structure this report's annexes and relate them to each individual theme. The results of these annexes are integrated into this assessment report. The scoring results of each factor are included in section 5: Lessons learned and recommendations.

[8] Izzi, G, Denison, J, and Veldwisch, G J, eds. 2021. *The Farmer-Led Irrigation Development Guide: A What, Why and How-to for Intervention Design.* Washington, DC: World Bank. https://pubdocs.worldbank.org/en/751751616427201865/FLID-Guide-March-2021-Final.pdf.

4 ASSESSMENT OF THE SSIT PROGRAM

4.1 Overview of the SSIT program design

The SSIT program is a subsidy scheme developed by the GoR to promote the widespread use of demand-driven, affordable, and locally assembled irrigation technologies. This technology-driven intervention enables farmers to acquire irrigation kits, for example, portable diesel/petrol pumps and hose pipes, solar-driven irrigation units, treadle pumps, or dam sheets. Farmers can use the SSIT kits to irrigate from 0.5 ha to 10 ha of their land. Cooperative or consolidated farms can be given a subsidy for land sizes ranging from 10 ha to 20 ha. At the time of the program feasibility study, it was assumed that the SSIT approach would drastically reduce the cost of irrigation development—from US$4,000–US$14,000/ha to about US$1,500/ha. Under the SSIT program, MINAGRI planned to develop 10,000 ha by 2018 of the over 100,000 ha of potential irrigation area in Rwanda that could be exploited.

4.1.1 SSIT program design

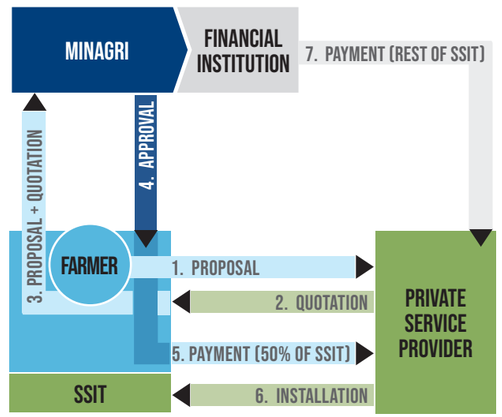
The program was designed to bring together strategic private service providers, farmers, and the GoR, to foster irrigation development. Through a memorandum of understanding (MoU) with MINAGRI, private sector service providers were expected to set up shops providing SSIT sales and services.[9] To reduce costs, most of the components were to be locally manufactured.

The program steps are as follows:

Farmers or cooperatives who want to benefit from the scheme submit their completed application letter and signed project description form through the district service provider to MINAGRI (Figure 3). At the district level, beneficiaries can be assisted by MINAGRI SSIT staff. Cooperatives are required to include their constitution, while consolidated small and medium-sized enterprises provide their board meeting minutes. Beneficiaries who want to apply for a bank loan must also provide an approved business plan and acceptance certificate from an affiliated financial institution and a bank/microfinance institution. The applications are evaluated by a MINAGRI-appointed Technical Evaluation Team. The team comprises an irrigation engineer, an agri-business expert, and a representative of the financial institutions. During evaluation, the team also relies on a site visit report compiled by SSIT staff deployed at the district level.

If the Technical Evaluation Team approves the application, the beneficiary is advised to approach a MINAGRI-registered private service provider, who checks the farm for irrigation design, including bills of quantity, and then provides a quotation. The proposal and price quotation are verified by an SSIT District Officer, then sent to MINAGRI for recommendation and notification for subsidy payment. Once recommended and notified, the farmer pays their portion of the SSIT costs and submits proof of payment to MINAGRI, which is issued with the subsidy purchase order. On successful completion of the requirements, the service provider should install the selected technology with a one-year warranty, and train farmers/cooperatives on O&M. After installation, a MINAGRI-appointed financial institution pays the private service provider the remaining share of the costs. The MINAGRI inspection team (two irrigation engineers and an internal auditor for verification) then validate and close the report on the subsidy used by the applicant.

Figure 3: SSIT subsidy acquisition process



[9] MINAGRI. 2014. *Feasibility Study on the Farmer-Led SSIT Program.*

The cost-sharing arrangement was designed so that the GoR would cover up to 40 percent for equipment costs; 5 percent for field visits, design, and bills of quantity; and 5 percent for installation and testing. Although the SSIT subsidy amount is widely reported to be 50 percent, the actual equipment cost to the farmer depends on their wealth category. The cost to the farmer varies from 25 percent to 50 percent, depending on the district (some districts added an additional 25 percent to the standard 50 percent subsidy), whereas some international NGOs (like Feed the Future Rwanda "Hinga Weze") added an additional 50 percent to the standard 50 percent subsidy.

To select beneficiaries for the SSIT program, the main criteria used to determine eligibility was the profitability of farmers' business proposals. The profitability of the proposal was determined by three sub-criteria—choice of a high-value crop (for example, bananas, onions, tomatoes); water availability; and use of low-pressure pump capacity. In addition, the consolidated land area was used for groups of farmers who applied as a cooperative.

To ensure the program was inclusive, disadvantaged farmers were to be linked to local and international nongovernmental organizations (NGOs) to support them with the remaining part of the investment costs of the SSIT package. Overall, the design of the SSIT program assumed that, by requiring farmers to pay for their irrigation equipment, O&M would be assured.

4.1.2 SSIT program implementation process

The process of SSIT program implementation varied slightly from the original plan, especially from 2018 onwards. Initially (from 2015 to 2018), RAB, which was the main implementing agency of the program, tried to follow the prescribed steps for applying and acquiring SSIT subsidies. However, in 2018, it was noted that it would be better if the role were taken up by the SSIT target districts. RAB remained responsible for budgeting, prequalification of equipment service providers, and technical oversight.

During our field visits, we observed that farmers are informed of the program through the sector agronomist, word of mouth, via neighbors and friends or the radio, or during farmers' monthly cell meetings. They submit their applications through their respective cells, who forward them to the sector agronomist and finally to the district for evaluation (Figure 4). Farmers (individuals) reported that in most cases the sector agronomist then advises them to pay their contribution to the service provider's bank account. In the design of the program, it is specified that a site visit must take place before deciding what types of equipment a farmer should receive. However, according to the sector agronomists and farmers interviewed during the study, these site visits take place rarely and, in some sectors, not at all.[10] It all depends on the proactiveness of the sector agronomist and the location. For example, one sector agronomist interviewed in Nyanza district told us that he conducts all prior site visits, and the farmers he visited confirmed that he gave them advice. Applications that fulfill all requirements are approved at the sector level and then submitted to the district level for further review.

Another observation is that once an application is approved at the sector level, it is rarely rejected at the district level. The sector plays a key role in assessing the application and the equipment for a farmer, whereas the district makes a final decision regarding the available budget. In addition, every fiscal year, districts receive earmarked funds from RAB to develop land under the SSIT program (for example, in 2021–2022 this was RF 334,500 (about US$329) per hectare). During our interviews with sector agronomists, they indicated that in some cases, the budget (earmarked funds) for the district is exhausted early in the year and that farmers cannot submit further applications.[11] This presents a challenge for farmers, especially during the dry season, when they need the equipment even more.

The duration of the application process depends on the sector and financial ability of the farmer to pay their portion of the costs. The following need to be submitted at the district level as part of the application:

- A copy of the title deed for the land (for landowners) or a copy of the lease agreement (for those renting)
- A copy of the applicant's ID
- A business plan
- A completed form signed at cell and sector levels
- An indication on the form of the type of equipment and the price.

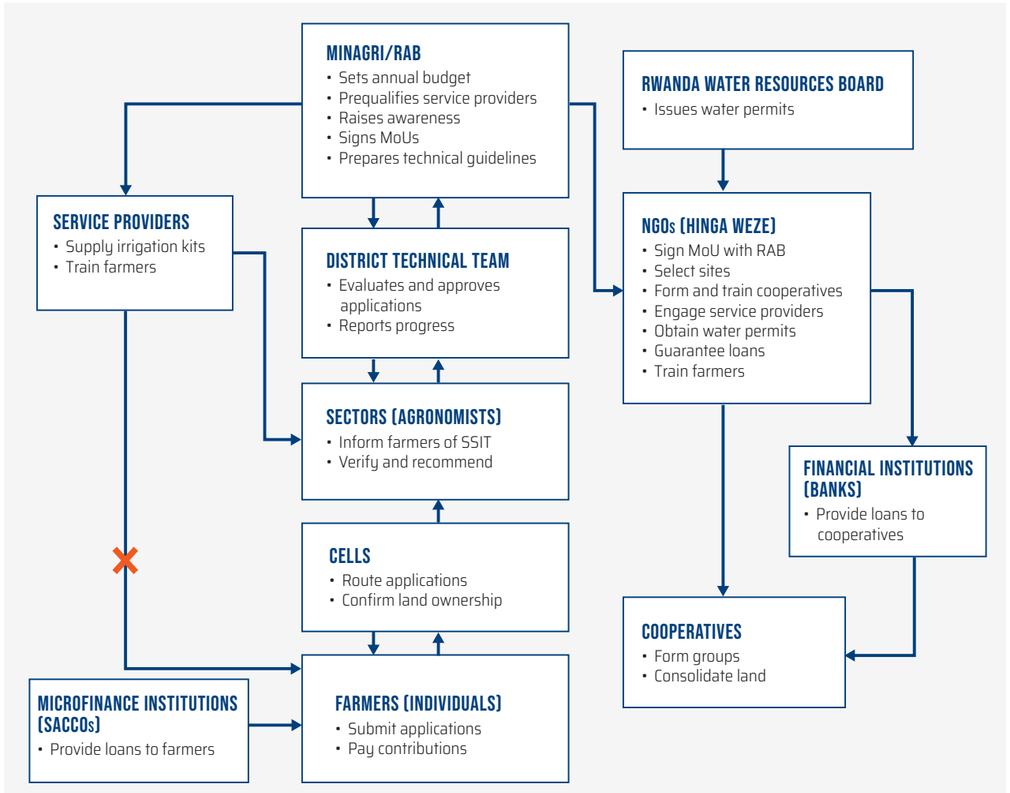
[10] Sector agronomists: Jules Gahungu, July 2021; Alfred Niyomufasha, August 2021; Josephine Dusabeyezu, September 2021.

[11] Interview with Josephine Dusabeyezu, sector agronomist, September 2021.

The subsidy given to all farmers is 50 percent, but during field visits and interviews with sector agronomists, we found that some districts added 25 percent (on top of the government subsidy) to help farmers who struggled with financing the non-subsidized part, mainly those in social categories D and E of *Ubudehe*.[12, 13] Under specific agreements that are referred to as *Imihigo*,[14] all districts set goals to be achieved every year regarding the area of irrigated land. An increased subsidy in some of the districts has helped some farmers overcome their financial impediment, and therefore allowed districts to achieve some goals as set in their *"Imihigo"* performance contracts.

After a farmer's application is sent to the district for approval, the sector agronomist is informed, and the farmer is requested to make payment into the service provider's bank account before the equipment is supplied. This process differs across the country: in some districts, sector agronomists link farmers with service providers after the approval of the district; in other districts, this is done by irrigation staff at the district level. Equipment should be delivered by the service provider to the farmer, but, in many cases, farmers picked up the items from the sector office or in the nearby center. In some cases, farmers apply for simple kits, such as hose pipes and diesel or petrol pumps, and (after submitting proof of payment) the service provider delivers the irrigation kit to a nearby center. In such cases, most farmers only get the kit, with no formal training from the service provider.

Figure 4: Actual SSIT implementation process



[12] Interview with Jules Gahungu, sector agronomist, July 2021.

[13] *Ubudehe* is a social classification program for households. Depending on the total household income, there are five categories from the highest income to the lowest, indicated by letters A to E.

[14] *Imihigo* is the practice of holding public officials accountable through performance contracts related to certain goals.

The SSIT program design states that irrigation service providers are responsible for training farmers on the O&M of the equipment and must provide a one-year guarantee for equipment repair. A precondition in the design of the program was that service providers would set up shop locally; however, this proved to be economically unviable. Many of the service providers are based in Kigali, except for a few based in Nyagatare, Rwamagana, and Gatsibo districts. From the interviews, it was clear that some providers do not go to the field to train farmers. In addition, many farmers had problems sourcing spare parts, as most service providers operate in Kigali. Spare parts are expensive, and it takes time to get them to those who can afford them. In the first year, the service providers are required (as per their contract) to provide technical assistance in case of equipment malfunction, but service provision becomes a big issue after that year. It would be helpful if local technicians could be trained so that farmers can more easily access repair services.

The non-subsidized part of the irrigation equipment is expected to be paid by the farmer in one installment. However, it was observed that there is no flexibility (for example, being able to pay in multiple installments or share the costs and equipment with others) or concrete support (for example, provision of external loans, support in getting collateral, or facilitation of group lending) for farmers to be able to do so. In the survey, most of the farmers indicated that they bought equipment using their own savings, followed by a few farmers who used a savings and credit cooperative (SACCO) loan to finance the equipment. Although SACCOs are not necessarily the easiest or cheapest option for farmers, they are often the only option available for farmers in rural areas.

Alongside SACCOs, there is limited uptake of external financing by farmers and limited capacity and experience on the part of financial institutions to provide financing solutions for SSIT farmers. Many of the financial institutions are not involved in financing agricultural activities, let alone irrigation development. Although the program design mentioned the involvement of financial service providers such as banks, none of the interviewed banks were formally contacted or were involved in creating specific financial instruments that fit the needs of farmers in an SSI development context.

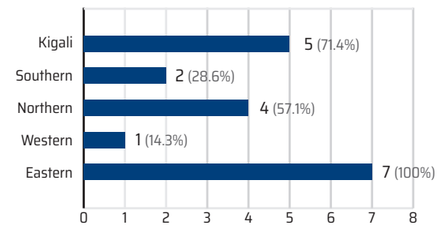
More than 66 percent of our random sample of SSIT farmers indicated that the main barrier to improving irrigation in their situation was related to the availability and price of the irrigation equipment. As we conducted field visits, many farmers further disclosed that they did not receive help to set up and run the irrigation systems; that service providers are often not present in the districts where they supplied the equipment; and that, overall, the lack of good technicians and spare parts shops is a key challenge.

In the MoU between MINAGRI and any given service provider, the service provider is responsible for procuring and supplying small-scale irrigation equipment, and commits to:[15]

- Providing the final design, bills of quantity, and costing for selected farm plots in various districts based on the criteria used by MINAGRI, the agreed unit rates for the equipment, and the farmer's preferences.
- Training the farmer beneficiary in the O&M of the supplied small-scale irrigation system.
- Providing a one-year maintenance guarantee for the equipment.
- Having in stock spare parts and qualified personnel to assist the farmer with the SSIT program.

A survey was conducted with seven service providers[16] to see how they view the services they provide. As shown in Figure 5, all seven service providers are present in the Eastern Province; many are in the Northern Province and Kigali; and a few are found in the Western and Southern Provinces. Of the seven surveyed service providers, four have service shops located outside of Kigali, all of which are in the districts of Rwamagana and Bugesera in the Eastern Province. Furthermore, six of the seven service providers said they assisted the farmers in designing and installing the irrigation equipment, mostly through field visits, and based on the crops, water source, and season.

Figure 5: Presence of service providers in provinces across Rwanda



There is clearly an information gap between the farmers' knowledge of irrigation equipment usage and the optimal way to use the equipment in their situation. This information gap becomes a market-related issue, as running costs remain high when farmers need to frequently repair equipment or replace their parts, especially in districts that are poorly served by service providers and where lack of both help and spare parts create scarcity in the irrigation equipment market.

[15] MINAGRI. 2014. *Feasibility Study on Farmer-Led SSIT Program*.

[16] The survey, conducted in August 2021, was sent to 12 service providers, of whom seven responded.

The service providers want to have more engagement with the implementing organs in the ministries and agencies throughout the program. They also seek clearer guidelines, standards, and a common understanding of the program, expressing concerns over differing implementation strategies across different districts and provinces. They were concerned that the price lists had not been updated and that the costs incurred by the service providers are not uniform across districts, even though the processes are the same. Moreover, repayment to service providers has been slow (in some cases taking up to three years).

Considering the concerns of both the farmers and the service providers in terms of supplying equipment, we suggest that the next phase of the program should **prioritize** uniform implementation guidelines across the country, clear requirements for providing follow-up services, and guidance for farmers after installation of equipment; and **consider** the possibility of subsidizing spare parts, as the running costs are quite high, as well as offering general advice and regular communication with service providers to ensure their service to farmers remains of a high quality after installation.

RAB engineers at the district level monitor the program process and progress, with one engineer responsible for two or three districts. RAB engineers are involved in the process of hiring service providers to ensure that the farmers are ordering the right equipment and that the right product is delivered to farmers. According to RAB, the engineers also conduct regular field visits, provide training to cooperatives, and give advice on maintenance. However, reporting from the district level is very limited: most of the reporting to MINAGRI's management information system is about irrigation and equipment. According to the RAB technical team, decentralizing the evaluation and approval of subsidy applications to the districts has complicated the reporting of the SSIT results.

4.1.3 Analysis of total database of SSIT beneficiaries

The total database of SSIT beneficiaries, as provided by RAB for the years 2015 to 2020, consisted of 4,450 farmers and a total of 11,128 ha. However, several farmers were included in the database in more than one year (that is, they applied more than once for the subsidy with the same land size, so it was assumed they did not increase their irrigated area). If this duplication is compensated for, this represents a total of 4,321 farmers who received the SSIT subsidy, and a total land area of 10,719 ha. In terms of land area irrigated by individual farmers, there are significant differences across the districts. For example, farmers in Karongi have, on average, 1.11 ha, whereas farmers in Nyaruguru have 15.22 ha. This can be explained by the fact that, in Nyaruguru, groups of farmers were the primary recipients of the subsidy (53 percent of beneficiaries were groups).

Of the individual applicants, 18 percent were assumed to be female (based on the first names of the beneficiaries). For the districts as a whole, on average 11 percent of applicants were groups. In several districts, groups of beneficiaries account for the major share of SSIT area: in Gakenke, Huye, Muhanga, Nyamagabe, Nyarugenge, Nyaruguru, and Rubavu, groups have over 50 percent of the SSIT area. The average area for groups was 6.04 ha, while for individuals it was 2.07 ha—considerably larger than the average landholding in Rwanda (0.3 ha).[17] Regarding land area categories, in some districts only a small number of farmers account for the major share of the reported area. In Burera, for example, there were five farmers with an area larger than 10 ha; however, together they accounted for 417 ha.

It remains unclear whether the database reports reflect the size of the landholding or of the area to be irrigated, which in many instances are different, as farmers rent plots to irrigate seasonally or irrigate only a fraction of their total owned land. To further investigate this, the reported irrigated area in the farmer survey was compared to the reported area in the database. Of the 375 farmers included in the farmer survey, 303 could be identified in the database. In 123 cases, the database had a larger land size than the indicated irrigated area In the survey; in 101 cases, this was the other way around (survey area larger than database area); in 79 cases, the areas were equal. For these farmers, the total difference between the survey and database areas was 6.61 ha. Registration and data management could thus be improved, but over- and under-estimation cancel each other out, so there is no reason to reject the reported number of hectares of irrigation development under the SSIT program. The full analysis of the RAB database regarding application year, gender, and area can be found on the "Total database" tabs at www.resiliencebv.com/ssit (password: 2030WRG).

4.1.4 Overview of the general characteristics of the beneficiary sample

The list of beneficiaries was not stratified according to gender. From our sample group, only 13 percent of the interviewees were female (Figure 6), which is comparable to the relative share of females in the total beneficiary group, in which 18 percent of the individual applicants were female.

[17] USAID. 2014. *Assessment of the Economic, Social, and Environmental Impacts of the Land Use Consolidation Component of the Crop Intensification Program in Rwanda*. Final Report.

Figure 6: Gender distribution of interviewees

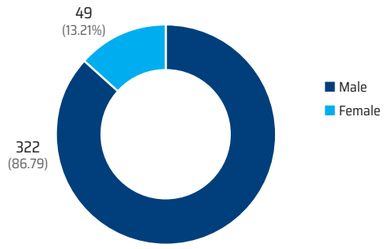
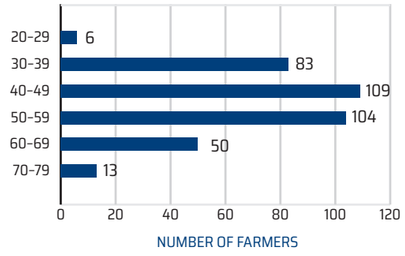


Figure 7: Age distribution of interviewees



The average age of the interviewees was 48 years—Figure 7 shows the stratification of beneficiaries per age group, where young farmers (age groups 20–29 and 30–39) are clearly underrepresented.

Interviewees' educational levels were only asked for in the long interviews (53 total). Together, the "none finished" and "primary" educational level represent 70 percent of the interviewees (Figure 8). Although the number of interviewees in the field is not sufficiently high to be able to extrapolate these characteristics to the whole beneficiary group, such a large representation of low education is probably indicative of the whole.

4.1.5 Key stakeholders' perceptions of the program implementation and impact

Beneficiaries' level of satisfaction with the SSIT program's implementation was generally high. On a scale of 1 to 5 (with 5 being high), the average satisfaction of sampled SSIT beneficiary farmers was 3.99, which indicates the program's positive achievements (Figure 9).

The survey further assessed the impact the SSIT program had on income, food expenditure, and workload. Ninety-nine percent of interviewees indicated an increase in income after SSIT, with an average increase of RF 525,000 per year. The extra income was mostly spent on health and food, with education, savings, and assets as the second-most important spending items. The survey results also indicated that changes in food spending varied (38 percent increase, 34 percent decrease, 28 percent remained the same). A decrease could indicate that more crops were grown for own consumption, whereas an increase could indicate higher food intake overall. Regarding workload, 66 percent of interviewees indicated a decrease in workload, with on average 14 hours less work per week (indicating less laborious irrigation methods). Increased work could indicate more land area or more intense farming methods, meaning increased farm income as well. Farmers indicated that the saved time was mostly spent on paid labor and education.

Although the impact of the SSIT program differs for each individual case, these results point at the generally positive impact it had on farmers' livelihoods.

Figure 8: Educational level of interviewees

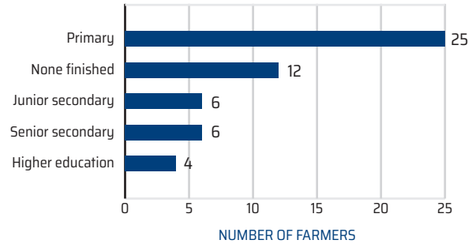
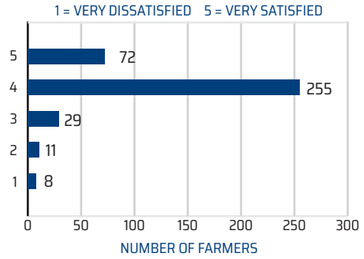


Figure 9: SSIT beneficiary farmers' satisfaction level on a scale of 1 (low) to 5 (high)



4.1.6 Key driving forces behind the results of the program

The SSIT program achieved its target of developing 10,000 ha, as shown in Figure 10. In most parts of the country, farmers were able to access the irrigation subsidy; however, the beneficiaries are not evenly distributed across the country. This unequal division could be expected, considering the resources and markets available. Rwanda's water resource potential for the development of small-scale irrigation is considerable, given the abundance of relatively easily accessible surface water resources throughout the year. Moreover, shallow groundwater presents a relatively untapped resource with great potential for SSIT development, especially near lakes. Although land is hilly in many parts of Rwanda, the abundant presence of terraces and other land-levelling practices proves that these lands can still be used for SSI development, if appropriate irrigation methods are used. A more detailed analysis of the resource potential is presented in Annex 1.

There are several driving forces behind the SSIT program's success, the first being widespread awareness creation. The approach used to promote the SSIT program (for example, through community meetings and radio advertisements) created considerable awareness among farmers. Most farmers interviewed during the study had first learned about the SSIT program from the district agronomist, other farmers, sector agronomists, or on the radio (Figure 11).

Another important driver was land tenure security. Although about 60 percent of the beneficiaries owned their land, about 37 percent rented it (Figure 12). The SSIT guidelines state that a land title deed is necessary for obtaining support. In some districts, it was acceptable for a renter to show a copy of the land title deed (from the owner) or a copy of the lease agreement, but they might have been difficult to obtain. Although this requirement for the proof of land ownership allowed more land renters to be eligible in some cases, it may have prevented other potential renting farmers without access to title deeds from investing in irrigation equipment. Moreover, this requirement may have created some doubts as to the intention of the SSIT program (for example, some farmers were initially suspicious that the subsidy was a trick by the GoR to dispossess them of their land).

Figure 10: Number of SSIT subsidy beneficiaries per district and total area (ha)

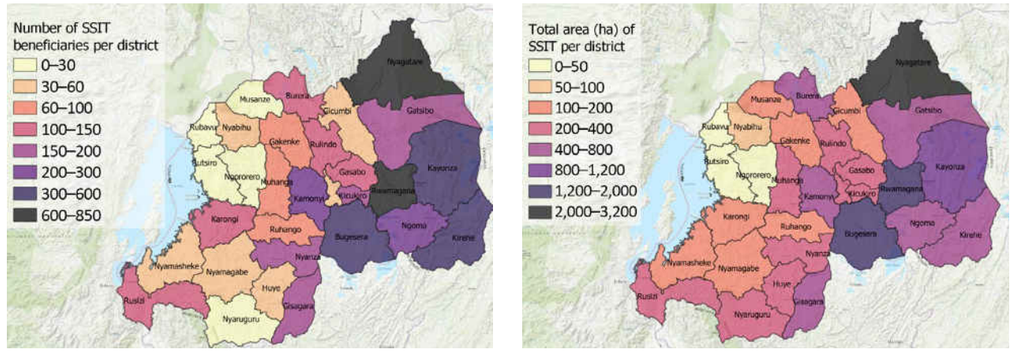


Figure 11: How farmers first learned about the SSIT program

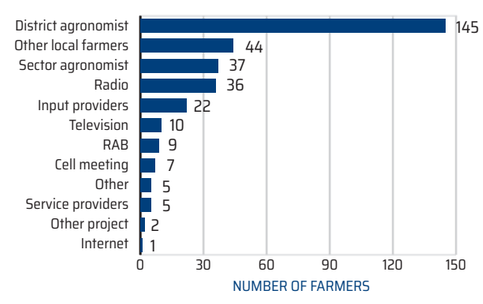
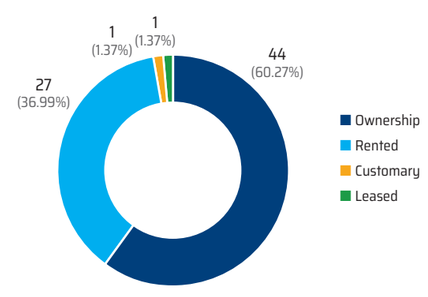


Figure 12: Land tenure and ownership



Some districts approved applications from land renters who were able to provide proof of their lease agreements.[18]

Our survey shows that about 73 percent of the SSIT farmers financed the non-subsidized part of the SSIT equipment from their own savings (Figure 13). Only 22 percent acquired financial support from banks, SACCOs, or other sources. The high portion of payments with own savings suggests that the SSIT farmers in our sample were, in general, able to pay for irrigation equipment. However, it also reflects a limited uptake of external financing (such as loans) and involvement of the financial sector.

We recognize that a down payment for the irrigation equipment is only one part of the puzzle. In terms of affordability, there is often a focus on the price of the non-subsidized part of the irrigation equipment. However, we found (through a combination of desk research and fieldwork) that financial difficulties often occur after receiving the equipment, for example because of high costs for O&M and a lack of access to markets (that is, not being able to sell irrigated produce).

Lastly, water availability positively contributed to the success of the program. **Only about 6.7 percent of the farmers interviewed reported having insufficient water for irrigation, while 64 percent had never experienced a water shortage** (Figure 14). This was also observed in the field, where the impression was obtained that many water sources were not used yet (such as shallow groundwater) or underdeveloped.

4.1.7 Challenges faced during the program's implementation

The SSIT paper-based application has many requirements, and the process often takes too long. To apply for the subsidy, a farmer must submit the following documents to the sector agronomist for verification:

- A letter of application written by the farmer
- A summary of the business idea
- A detailed business plan for three seasons
- A copy of the title deed for the land
- In the case of rented land, a copy of the title deed for the rented land and a contract signed by the landowner.

Some of these requirements may have discouraged many farmers from applying for the subsidy, by presenting challenges as follows.

First, many of the farmers needed help with developing business plans, which can be costly. For example, in Nyanza district, developing a business plan can cost between RF 100,000 and RF 150,000 (about US$100 and US$150).[19]

The second challenge is the requirement for proof of land ownership, as it might be difficult for informal renters to secure a contract with landowners. Although land renters were eligible in some districts, this may have prevented other tenant farmers from investing in irrigation equipment.

Figure 13: Source of funds for contribution to SSIT equipment

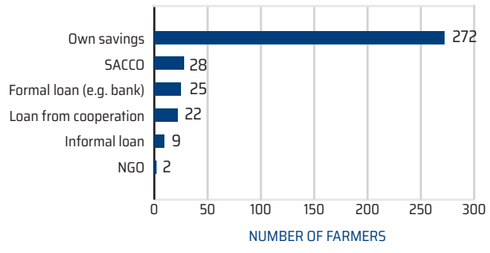
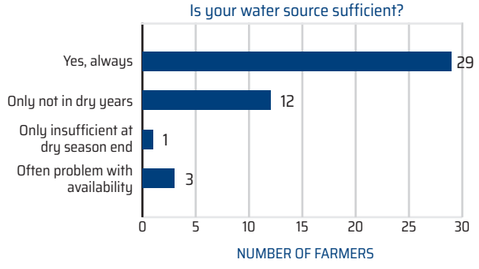


Figure 14: Access and irrigation water shortage



[18] Based on interviews with sector agronomists from Gashari sector in Karongi district and Rukomo sector in Nyagatare district.

[19] August 2022: US$1=RF 1,000

Third, the SSIT land size criteria of 0.5 ha to 10 ha is likely to have limited participation in the subsidy program. Most of the small-scale farmers in Rwanda own less than 0.5 ha. (In practice, many SSIT farmers were irrigating produce on less than 0.5 ha, with the median for the surveyed farmers being 0.4 ha. However, they owned more, with the median of land owned being 1 ha, so they could still apply for the subsidy.) However, the cost-benefit analysis shows that irrigated vegetable production is profitable even with an area of 0.25 ha, and even after just the first season, if the equipment is subsidized.[20] This size requirement has enabled a group of relatively wealthy farmers (who own more land than the average Rwandan farmer) to benefit from the program. Allowing farmers with smaller landholdings to apply for the subsidy would increase the range of farmers who can start with profitable irrigated production.

Fourth, frequent changes in SSIT modes of implementation are likely to have negatively affected progress and the reporting of achievement. Up until the end of 2017, the SSIT program was implemented directly by MINAGRI through RAB. However, from 2018, the program was decentralized to the district level, with MINAGRI providing a technical oversight role. From 2018 to 2021, district authorities were responsible for working directly with the farmers and reporting progress through MINAGRI's agricultural management information system. In 2021, it was reported that the SSIT program implementation process had changed again. As depicted in Figure 15, the process is now controlled by the Single Project Implementation Unit (SPIU) of RAB.

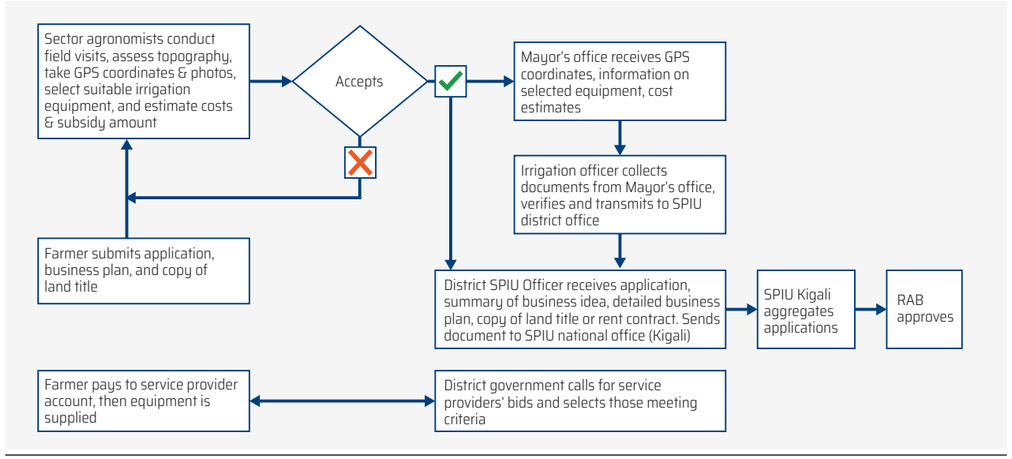
This new layer via the Single Project Implementation Unit is leading to further delays in the time taken to process applications. Although it has been reported that applications taken to higher levels are never rejected, the whole process takes three weeks to three months to complete, partly because of the rather lengthy paper-based process. This situation could be improved by introducing digital tools in one or more steps of the application process and by keeping the district as the focal point for the SSIT program.

Finally, limited training offered to technical staff (for example, sector agronomists) involved in implementing SSIT may have contributed to selecting the wrong equipment or the inadvertent rejection of applications, and in turn, limiting progress in the rollout of the program. (For example, a sector agronomist in Nyanza revealed that the absence of training means that most agronomists don't know how to use a GPS device.)

4.2 Farmer typologies

Based on the survey data and field observations, we have tried to identify farmer typologies that reflect those using SSIT. The defined typologies help in assessing the effect of the SSIT program on common types of farming systems in Rwanda in general and their profitability in particular. We have also included two cases of rice typologies, because of the prevalence of rice in the Eastern Province and our observation of several farmer-developed rice irrigation schemes.

Figure 15: SSIT implementation process in 2021



Source: Interview sector agronomist in Nyanza district

[20] The cost-benefit analysis (section 4.3) analyzes the profitability of irrigated agriculture with regard to different land sizes.

A clear description of the different farmer typologies as identified from the field research can be found in Annex 2, a summary of which is presented in Table 1.

Typologies 1 and 2 are the main target group for SSIT: small-scale irrigating farmers producing vegetables in the dry season, where manual irrigation is seen as a first step for learning about irrigation application, agronomy of horticulture, and market relations before upgrading to larger pump and hose systems. Typology 3 relates to smallholder horticulture farmers who have shifted to solar-powered irrigation. Typologies 4 and 5 relate to different irrigated maize production systems, with variations in market relation and scale. Typology 6 relates to another solar solution to understand the implications of investing in solar systems for larger production systems. Typologies 7 and 8 are included to analyze the different types of irrigated rice production: cooperative versus individual.

These typologies can be condensed further, as shown in Table 2.

Table 1: Farmer typologies

#	Characteristics/ Type	Technology	Crops	Size	Access	Organizational style	Market linkages
1	Small/ Informal	Bucket/ Watering can	Vegetables	<0.5 ha	Land rented; tech owned; no water fee	Individual	Informal traders
2	Medium/ Informal/ Commercial	Pump/Hose	Vegetables	0.5–1 ha	Land owned; tech owned; no water fee	Individual	Informal traders
3	Small/ Innovator/ Commercial	Solar/Mobile	Vegetables	<1 ha	Land owned; tech owned; no water fee	Individual	Informal traders
4	Medium/ Informal/ Mixed subsistence-commercial	Pump/Hose	Maize	0.5–1 ha	Land owned; tech owned; no water fee	Individual	Informal traders
5	Large/ Formal/ Contract	Pump/Hose	Maize seeds	>3 ha	Land owned; tech owned; water fee	Individual	Contract farming
6	Large/ Innovator/ Commercial	Solar/Fixed	Macadamia	>3 ha	Land owned; tech owned; water fee	Individual	Contract farming
7	Small/ Rice/ Cooperative	Canal/ Marshland	Rice	<0.5 ha	Land rented; tech rented; water fee	Cooperative	Cooperative
8	Small/ Rice/ Private	Canal/ Marshland	Rice	<1 ha	Land owned; tech owned; no water fee	Individual	Informal traders

Table 2: Categorized farmer typologies

#	Characteristics/ Type	Technology	Crops	Size	Access	Organizational style	Market linkages
1, 7	Small/ Informal/ Cooperative	Bucket/ Watering can Canal/ Marshland	Vegetables Rice	<0.5 ha	Land rented; tech owned; no water fee	Individual Cooperative	Informal traders Cooperative
2, 3, 5, 8	Medium/ Informal/ Commercial	Pump/Hose Solar/Mobile Canal/ Marshland	Vegetables Maize Rice	0.5–3 ha	Land owned; tech owned; no water fee	Individual	Informal traders
4, 6	Large/ Formal/ Contract	Pump/Hose Solar/Fixed	Maize Perennials Vegetables	>3 ha	Land owned; tech owned; water fee	Individual	Contract farming Export

These typologies are mostly based on distinctions made by the FLID Guide (i-BOX 2.1, page 132), where the **first** row is similar to peasant farming systems, limited by options and cash; the **second** similar to entrepreneurial farming systems, whose primary purpose is to generate profit; and the **third** similar to corporate farming systems, which are large scale and capital-intensive, and where the owner/company acts as an investor.

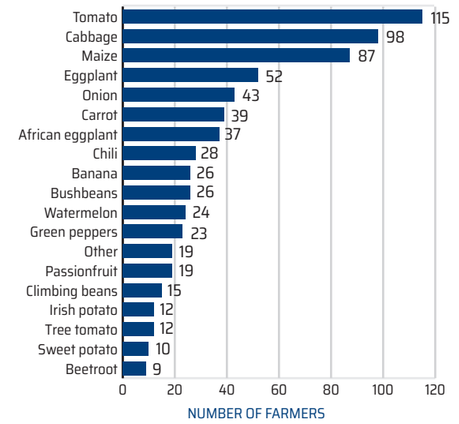
4.3 Cost-benefit analysis

The draft Rwanda Irrigation Master Plan[21] describes the most common crops produced in Rwanda in relation to irrigation. It states that "Rwanda is endowed with comparatively good and well-distributed rainfall over season A (Sept–Dec) and season B (Jan–May)." To justify crop irrigation at this time, there must be a sufficient increase in yield from an additional water supply to cover the cost of developing and operating irrigation systems.

Production seasons in Rwanda	Season A	Season B	Season C
Period	Sept–Dec	Jan–May	Jun–Aug

Irrigation in Rwanda is primarily applied to high-value fruit and vegetables in season C (June to August), such as tomatoes, onions, (African) eggplants, cabbages, carrots, watermelons, and chilies. Besides these, irrigation is applied year-round to perennials, such as avocados, citrus, passionfruit, and macadamia, and sometimes during the rainy season to prevent harvest reduction due to dry spells (mostly for maize). The irrigated crops indicated by field survey respondents are shown in Figure 16.

Figure 16: Main irrigated crop types



The area distribution data shows that land rental is common among SSIT farmers. The land rental price was found to range from RF 50,000 to RF 500,000 (about US$50—US$500) per hectare per year, with an average of RF 205,000 (about US$205).

For each of the typologies, a cost-benefit analysis was performed. The production data on input use and costs, labor, and yield was obtained from the farmer field surveys. Equipment costs were divided over the lifespan of the equipment. A detailed example for the vegetable/ pump hose system (typology 2) is given in Figure 17. The calculations for the other typologies can be found in Annex 2.

Figure 17: Cost-benefit calculations for typology 2: Vegetables; pump & hose system (technology owned)

1. COSTS

Input	Unit	Quantity	Unit cost	Total costs
Seeds	RF/ha	1	25,000	25,000
Fertilizer	RF/ha	1	100,000	100,000
Pesticide	RF/ha	1	200,000	200,000
Fuel	RF/ha	1	200,000	200,000
Subtotal				**525,000**

Labor	Worker days/ha	Quantity	Wage rate (RF/day)	Total costs
Family	150	1	1,200	180,000
Hired	100	1	1,200	120,000
Subtotal				**300,000**

Land renting	ha	RF/ha	Total costs
0	0	240,000	0
Total costs			**825,000**

2. BENEFIT

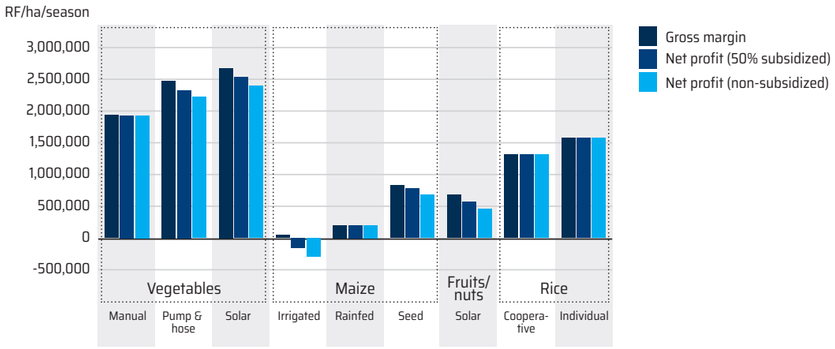
Crop	Yield (kg/ha)	Price (RF/kg)	Revenue
Tomato	11,000	300	3,300,000
		per season:	**per ha:**
Gross margin RF		**2,475,000**	**2,475,000**

3. INVESTMENT COSTS

Item	Costs (RF)	Farmer costs (RF)	Lifespan (seasons)	Cost/ season
Pump	500,000	250,000	5	50,000
Hose	200,000	100,000	2	50,000
Maintenance				50,000
Subsidy			**50%**	**150,000**
			per season:	**per ha:**
4. TOTAL PROFIT RF			**2,325,000**	2,325,000
US$			2,397	2,397

[21] RAB. 2020. "Rwanda Irrigation Master Plan." Draft version.

Figure 18: Summary of results of cost-benefit analyses for several irrigated farming typologies



The overall results of the cost-benefit analyses are presented in Figure 18. Both the net profit with and without irrigation equipment subsidy are included. For comparison purposes, all values are in Rwandan francs per hectare per season.

Several observations can be made based on the cost-benefit analyses.

First, irrigated production is generally profitable in Rwanda, except for irrigated maize production. This could be because many farmers irrigate maize for food security purposes, and the monetary loss is accepted in exchange for increased food security. **The profitability of rainfed maize is also considerably higher (RF 201,500 (about US$201) per hectare per season**—see Figure 4b in the appendix of Annex 2).

Second, **the net profit does not increase significantly with a 50 percent subsidy on irrigation equipment**. For small-scale vegetable production, the increase is 4 percent; for pump and hose and solar systems, the increase is 5 percent; for irrigated seed maize, it is 15 percent; and for the large-scale solar system, it is 23 percent. **This indicates that such a subsidy has little influence on the annual profitability of smallholder irrigated agriculture.** However, the subsidy helps to significantly lower the initial capital needed to start irrigation, primarily for more expensive systems such as solar pumps. Given the lower operational costs of solar irrigation, this is also more profitable in the long term.

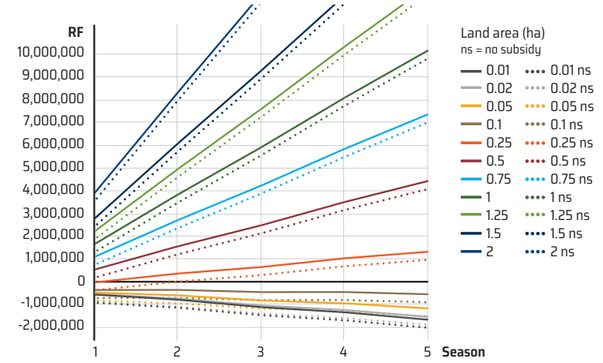
Third, it was found from the field survey that the lifetime of fuel pump and hose systems was considerably shorter than expected: generally, about two to three years for pumps and only one year for hoses. The reasons for this could be a lack of training on the O&M of pumps and low-quality hose material. The relatively low lifespan results in low net profits per season, a situation that could be improved with training and better maintenance options. The laborious water application techniques found in the field could also be improved by capacity building. Farmers' field schools and farmer promoters could play a key role in raising farmers' knowledge of technology.

Another observation from the field survey is that yields are rather low, both for rainfed and irrigated production. Although the analysis is based on a limited number of farmer surveys and yields were not directly measured, this does raise the issue that, for food security reasons, other aspects of farming besides irrigation need to be improved.

Figure 18 presents a rather simplified picture of irrigated farming in Rwanda. To investigate farming production systems and their profitability in more detail, we performed a more in-depth analysis of the production costs and profits for smallholder tomato farming with the SSIT subsidy for different land sizes. Figure 19 shows the profitability for different landholding sizes, with and without the subsidy, including all costs (for own labor and land renting). The results show that long-term profitability is not significantly impacted by the subsidy, but it does make smallholder irrigated tomato farming profitable from a landholding size of 0.25 ha after the first season, instead of from 0.4 ha without the subsidy.

For farmers with smaller land sizes, forming a group to collectively apply for SSIT equipment could be considered, given that the investment burden can then be shared between several farmers, as well as the depreciation costs and costs for equipment maintenance. Another strategy would be to promote the renting of equipment and provide irrigation as a service, where farmers would pay only for renting the equipment (and fuel). As presented in Figure 2b in the appendix of Annex 2, this would be profitable for all land sizes, as there are no fixed costs involved (that is, investment costs for equipment, irrespective of land size).

Figure 19: Profitability of different areas of smallholder tomato farming with and without SSIT subsidy



The cost-benefit analyses performed for several farmer typologies indicate considerable potential profits from irrigated agriculture in Rwanda, except for small-scale irrigated maize. Survey data reveals that (irrigated) production in Rwanda still has relatively low yields, and it could benefit from improved input use and capacity building. **The SSIT equipment subsidy increases net profit by about 4 percent to 23 percent over the lifespan of the subsidized system.** Considering the range of profits made by smallholder irrigators using (fuel) pump and hose systems, we can assume that offering a subsidy on this type of equipment has little influence on farmers' willingness and capacity to pay. However, as a higher initial investment is needed for solar pumps, the subsidy could be an effective way to promote their use.

4.4 Existing public goods and services

There are several key public goods and services that are relevant for the success of facilitating investments in smallholder irrigation. These include:

- Shared water infrastructure (marshlands and large irrigation schemes)
- Rural roads
- Extension and advisory services
- Existing agricultural education institutions (for example, technical and vocational education and training (TVET) colleges)
- Subsidy schemes.

Access to government programs that contribute to shared infrastructure promoted SSIT and/or irrigation development in general (see Annex 3). For instance, the SSIT program was implemented at the same time as the government program for marshland development that facilitated access to irrigation water. In the fiscal year 2018/19 alone, MINAGRI reported that marshland development totaled 37,093 ha, with about 8,780 ha of hillside irrigation and 16,071 ha of small-scale irrigation.[22] The following fiscal year (2019/20), the total area under irrigation was reported at 63,742 ha, including 37,273 ha of marshlands, 8,780 ha of hillsides, and 17,689 ha of small-scale irrigation.[23] Marshland development goes hand in hand with small-scale irrigation.

By developing these marshlands, the GoR brought water closer to farmers' plots, and they were then able to apply for small-scale kits such as pumps and pipes for water application to crops. Maps developed by RAB of areas suitable for SSIT[24] show that most of these plots were in marshlands, making marshland development a strong candidate for increasing the adoption of small-scale irrigation. In addition, in areas where the GoR has invested in large-scale irrigation, it has triggered the adoption of irrigation among small-scale farmers. These projects helped farmers to not only learn about the benefits of irrigation but also to connect small kits to the large-scale irrigation water access points.

Rural roads are another enabling driver of adoption of irrigation by farmers. In 2011, the GoR, through MINAGRI, started the Rwanda Feeder Roads Development Program.[25] This program is being implemented by the Rwanda Transport Development Authority.

[22] MINAGRI. 2019. *Report of Fiscal Year (FY) 2018-2019.*

[23] MINAGRI. 2020. *Report of Fiscal Year (FY) 2019-2020.*

[24] RAB. 2018. *Feasibility Study for the Identification of Potential Small-Scale Irrigation Areas in Rwanda.*

[25] Ministry of Infrastructure. 2017. *National Feeder Roads Policy.*

The program's development objectives are enhanced market access and reduced transport costs for people and goods, overcoming the constraints that limited connectivity places on trade and economic growth. This program contributed to the development of irrigation areas that are accessible to markets.

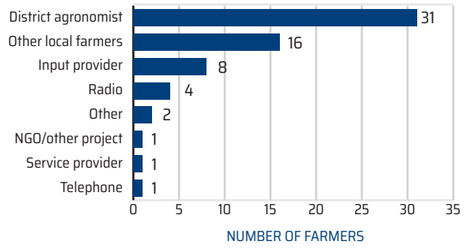
Access to better extension and advisory services is another public good that supports irrigation development in Rwanda. Since 2014, MINAGRI and the Ministry of Local Government have been delivering extension services under the new model named "Twigire Muhinzi" (for crop farmers) and "Twigire Mworozi" (for livestock producers). The Twigire Muhinzi model combines the farmers' field school approach and the farmer promoter approach. This model promotes peer learning among farmers and the demonstration of technologies on plots established in the farming community. Thus, different technologies, including the judicious use of fertilizers and chemicals, as well as irrigation, can be demonstrated, and farmer promoters help in mobilizing neighboring farmers to adopt modern technologies for production.

This model has been extensively used to show the use of different irrigation kits and differences in yields and profitability between irrigated and non-irrigated land. It has also supported the adoption of SSIT and demonstrated how to use other agricultural inputs to maximize profits where irrigation is applied. The model has reduced the gap between extension agents and farmers, improving their access to research findings. Farmers interviewed for the SSIT assessment stated that the district agronomist and other local farmers (or farmer facilitators) are their main source of agronomic information (Figure 20). The farmer facilitator is reported as the knowledge broker of SSIT and other agronomic practices.

The TVET system aims to increase the number of extension officers. Currently, the Integrated Polytechnic Regional Colleges (IPRCs) that train graduates in agriculture are IPRC East (Gishari), IPRC North (Musanze), and IPRC South (Huye). IPRC Huye and IPRC Gishari also offer courses on irrigation. Thus, there is capacity to provide irrigation knowledge, training, and skills in Rwanda, and it can be leveraged within the existing system of extension services (Twigire Muhinzi). For instance, it is critical to revisit the partnership agreements signed between RAB and some TVET schools like "Gisgari" TVET and "Huye" TVET to educate people on irrigation agronomy and practices, and thus improve irrigation-specific extension services to farmers.

Finally, there are many subsidy programs that complement the SSIT program. Since 2007, the GoR has been implementing its program of crop intensification, which promotes access to and the use of modern inputs

Figure 20: Small-scale farmers' sources of agronomic information



(seeds, fertilizers, irrigation technology, improved post-harvest technology, and better storage facilities) through several innovative public incentives, including subsidies on seeds and fertilizers. Another program is the Smart Nkunganire System, which is used by RAB to digitalize the end-to-end value chain of the Agro-Input Subsidy program.[26]

4.5 Existing agricultural support policies

This section presents a summarized analysis of land and water policies and laws that support agricultural development in Rwanda. A more detailed analysis of existing agricultural support policies can be found in Annex 3.

4.5.1 Land policy and tenure

4.5.1.1 Overview of land administration structure

The Ministry of Environment is responsible for developing and implementing land policies and laws. Land use planning and administration is carried out by the Rwanda Land Authority. At the local level, districts define land use and development plans that have a direct impact on agricultural productivity and irrigation areas. Land administration and use is regulated at the district level by the district land bureau, which is responsible for ensuring that land use plans are followed and implemented. Among other things, the bureau is responsible for issuing occupancy permits and supporting land transfers. These services have further been decentralized to the sector level, where the land officer and notary support the transfer of land use rights for those who buy land. However, it is the Ministry of Local Government, through the Local Administrative Entities Development Agency, that provides budget support to districts. The agency's activities often include irrigation targets that are funded by the Ministry of Finance through earmarked funds.

[26] Smart Nkunganire System: https://smartnkunganire.rw/.

Finally, MINAGRI is responsible for initiating and managing programs designed to transform and modernize the sector to ensure food security and contribute to the national economy. These programs include irrigation development and crop productivity improvements, such as land use consolidation and the management of supporting subsidy schemes on seeds and fertilizers, SSIT, and crop insurance.

4.5.1.2 Overview of land policies and laws

The Land Law (N°43/2013 of 16/06/2013) in Rwanda classifies land as either individual land or state land. Individual (that is, private) land can be obtained under principles of customary law or under formal law. State land includes: (1) state land in the public domain (for example, lake shores, national parks, roads, and tourist sites), which generally cannot be alienated; (2) state land in the private domain of the state (for example, vacant land, swamps, plantations, and expropriated land), which can be alienated; and (3) land in the public domain of local government, for example, district, town, and municipality land), which is controlled by local governments.

The formal law recognizes the following tenure types, some of which were issued prior to the promulgation of the Land Law, yet continue to be in effect:

- **Right to emphyteutic lease.** According to the Land Law, every person possessing land acquired through customary means or purchase is the recognized proprietor. The formal law recognizes individual rights to land through the right to emphyteutic lease.
- **Freehold right to land.** These rights apply to developed land with infrastructure, reserved for residential, industrial, commercial, social, cultural, or scientific services.
- **Public land.** Public land is in the domain of the state and includes land belonging to public institutions or local authorities.

Most of the land in Rwanda was titled during the land regularization program, where every private plot was registered considering family ownership, where the husband and wife own an equal share of the land on the title deed. The management of land titles is the responsibility of the Rwanda Land Authority.

Secure land tenure encourages people to invest in the land and enables access to public services and finance. However, while the Land Law has established the basis for land tenure security, it has also created problems. For instance, the land use consolidation programs led to the confiscation of unused and abandoned properties and restrictions on the use of other land types, among other issues.[27]

Rwanda land tenure security may have limited the program's success over the past five years because of the requirement to submit proof of land ownership and the limitations on renters. The SSIT application form does not allow a farmer to be granted the government subsidy if the land is not owned by the applicant or the applicant cannot produce a lease contract signed by the landowner. However, this was not always required during the program's implementation, as the assessment team met farmers who benefited from the program using leased land. The requirement for leased land was a lease contract signed by the landowner.

4.5.1.3 Land access

Access to agricultural land in Rwanda is severely limited, so most farmers cultivate small rainfed plots. The average landholding in Rwanda is about 0.3 ha per household.[28] To address the problem of land scarcity and low agricultural productivity, the GoR instituted comprehensive land tenure reforms and a systematic land registration program, along with its Crop Intensification Program. Participation in the Crop Intensification Program requires community agreement to land consolidation and resettlement. The GoR's accomplishment of recording and registering rights to all land in Rwanda is a commitment to improving tenure security. The National Land Policy of 2004 provides that: (1) all Rwandans will enjoy the same rights of access to land; (2) all land shall be registered, and land shall be alienable; (3) consolidation of household plots is encouraged; and (4) land administration shall be based on a title deeds registration system.[29]

4.5.2 Water policies and tenure

4.5.2.1 Overview of water administration structure

The Ministry of Environment is responsible for developing water resources management policies and laws. Implementing these policies and laws is the responsibility of the RWB, which issues water use permits and has developed an online system to apply for them. Issues related to water use are under the responsibility of the district watershed committees at district level, and the catchment committees at catchment level.

[27] USAID. 2015. *An Assessment and Plan for a Comprehensive Review of Rwanda's 2004 National Land Policy.* http://pdf.usaid.gov/pdf_docs/PA00M1FM.pdf.

[28] USAID. 2014. *Assessment of the Economic, Social, and Environmental Impacts of the Land Use Consolidation Component of the Crop Intensification Program in Rwanda.* Final Report.

[29] Ministry of Lands, Environment, Forests, Water and Mines. 2004. *National Land Policy.*

No water management structures are operational at district level to support the implementation of water permits, while all RWB activities are centralized at the RWB's headquarters. The responsibilities of environmental management and the control of economic activities, including irrigation, are under the Rwanda Environment Management Authority.

4.5.2.2 Overview of water policies and laws

The Rwanda National Water Resources Management Policy of 2011[30] sets the direction on how water resources will be conserved, protected, and managed to secure and enhance its availability for, and utility to, present and future generations. The policy identifies key challenges related to water resources management in Rwanda, including:

- Uncertainty related to climate change effects
- Competition and conflict over water resources
- Poor land use practices, including deforestation and conversion of wetlands
- Limited infrastructure and limited supply of safe water
- Limited financial, technical, and administrative capacity to effectively manage water resources
- Limited functional framework to support decentralized water users and managers
- Limited data on water resources.

To implement the Water Resources Management Policy, the Water Law (N°49/2018 of 13/08/2018) determines the use and management of water resources in the country. This law provides the legal back-up to meet the challenges highlighted by the Water Policy. It recognizes principles such as protecting water resources from pollution, requiring water users and water polluters to pay, using water users' associations, and providing for the public distribution of water. The priorities set forth in this law for water distribution are domestic use; environmental protection; and economic activities, including agriculture/irrigation.

4.5.2.3 Water permits

The Water Law includes regulations regarding water permits and prioritizes smallholder farmers in water permit requirements: the land area threshold for needing a water permit is set at 1 ha, which exempts smallholder farmers irrigating land of less than 1 ha. The law also does not require smallholder farmers to conduct an environmental impact assessment for small irrigation projects of less than 1 ha. However, this assessment is required for large projects or projects that include large water storage structures (such as dams greater than 15 m²). To date, the RWB has not required water permits for SSIT beneficiaries who irrigate 1 ha or more. These exemptions on thresholds were apparently given to help farmers in drought-prone areas of the Eastern Province so they could irrigate without needing permits. However, the RWB intends to register, and issue permits to all such water users. It would also like to see the requirement for water permits being integrated into the application process for the SSIT subsidy. Collective water permits are only granted to farmers supported by the USAID-funded Hinga Weze project in Bugesera district.

To acquire a water permit for areas larger than 1 ha, hydrological research and a feasibility survey are required, which is a lengthy and costly process (more than RF 100,000 (about US$100). If water permits are enforced for SSIT farmers with more than 1 ha, this poses an additional burden for them to start with irrigated production. **We recommend raising the requirement for a water permit to a threshold above 5 ha and using a water use declaration for farmers located in low-risk areas or outside major hotspots and irrigating below this threshold.** This declaration should be sufficient to monitor water use while not unnecessarily restricting irrigation activities.

4.6 Farmers' financing mechanisms and market opportunities

Within farmer-led irrigation processes, farmers take the initiative, make decisions, and lead the process of developing irrigation—and therefore also pay for and own the irrigation equipment. However, the affordability of irrigation equipment is often a major constraint that limits the uptake of small-scale irrigation. Although subsidy schemes such as the SSIT program are important tools to bridge existing affordability gaps, challenges remain on the financing side.

As part of this research, three different aspects related to financing were investigated. The first aspect is farmer financing, that is, the ability of the farmer to finance the non-subsidized part of the SSIT equipment through their savings, formal or informal loans, microcredit, and so on. The second aspect is private financing, that is, the capacity and experience of financial institutions to provide financing solutions to farmers who want to purchase irrigation equipment. The third aspect considers government and donor-funded projects and assesses the extent to which donor-funded projects can help farmers to access irrigation equipment and other agricultural inputs and disbursement methods (either individually or in groups).

[30] Ministry of Natural Resources. 2011. *National Policy for Water Resources Management.*

In terms of farmer financing, one of the key takeaways is that the ability to pay for irrigation equipment moves beyond the procurement of the actual equipment. The procurement costs are often the focus of discussions about the affordability of irrigation because irrigation is costly. It requires maintenance and is often associated with increased use of complementary inputs and costs to handle the increase in produce. Farmers who have paid the down payment with their savings might, as a result, have issues paying for their daily household expenses. There are financial institutions that provide financial products for O&M costs, but the uptake of these kinds of products seems to be low in an SSI context. Shifting the focus of the SSIT program, by moving away from an exclusive emphasis on purchasing equipment to include supporting farmers with additional costs that come with irrigation, might lift a major barrier for farmers.

Our survey data shows that 76 percent of SSIT farmers financed the non-subsidized part of the SSIT equipment fully or partially from their own savings. This indicates a limited uptake of external financing. Our data also shows that if external financing is used to pay for the non-subsidized part, it is most often by means of a SACCO loan. The reasons for limited uptake of external financing include a mismatch between the financial institution's requirements and what a farmer can offer, and limited promotion of group lending (to groups such as cooperatives). Group lending has contributed to a higher uptake of financial services in other countries. **However, our survey data indicates that only 8 percent of our total sample financed the SSI equipment through a cooperative. The remaining 92 percent financed it individually.** This indicates that although some farmers are part of cooperatives, these do not seem to be able to support them with financing.

In terms of private financing, four observations were made on the limited role played by financial institutions within the SSIT program. The first observation was that the Rwandan market does not seem suited to small-scale, market-oriented farmers who are part of the SSIT program. Farmers indicate that, in general, the financial environment in Rwanda is not favorable for them to obtain loans due to high interest rates and limited availability. **Therefore, the financial sector has limited experience of providing loans and other financial products to the agricultural sector. The survey data shows that SACCOs play an important role in gaining access to financial services.** However, SACCOs are not necessarily the cheapest option for farmers (as interest rates typically range from 20 percent to 30 percent) and often they are not used for irrigation practices, but for personal and household expenses.

Second, the financial sector lacks knowledge and understanding of the agricultural sector. Agribusinesses and agricultural lending are perceived as risky endeavors due to the seasonality and uncertainty of farmers' incomes, which lead to even higher interest rates and more extensive application requirements. Moreover, in our limited experience with the sector, we uncovered inappropriate lending policies and products, high transaction costs being charged to reach remote rural populations, and a lack of expertise to manage agricultural loan portfolios.

It is important to encourage financial institutions to gain confidence in, and a deeper understanding of, the sector so that financiers will take more risks, and create finance policies and products for agriculture, and irrigation specifically. This leads to our next point.

The third observation was that the sector lacks financial products that meet the needs of the agricultural sector. It is unrealistic to expect that the existing (lending) products of commercial banks will automatically fit within the context of SSI development. **Financial institutions should design products that fit the needs and farming cycles of SSIT farmers.** Specific features such as the repayment terms, the type of loan (short, medium, or long term), collateral requirements (for example, the ability to use SSIT equipment as part of collateral), and pricing should be designed to fit the context of farmers who start irrigation practices using the government subsidy. Based on desk research and interviews with local banks, we have not come across specific irrigation products that are designed to meet the needs of farmers who irrigate their produce.

Lastly, the fourth observation was a limited uptake of insurance in private financing. Insurance is a way to protect businesses from financial losses and is promoted to reduce the negative impacts of crop failure and livestock illness. It can therefore help farmers to access credit, which would increase their willingness and ability to invest in labor and inputs. Different types of agriculture-related insurance include weather index, area yield, livestock mortality, and price insurance. The FLID Guide stresses that insurance limits risks and is therefore part of an integrated financing response to increase the uptake of irrigation. While irrigation itself is "insurance" against water scarcity risks, the use of financial insurance products bundled within loan products could help to mitigate these hazards.

Our data showed that 92.5 percent of our sample did not insure their crops. When we asked farmers in the field about insurance, they had limited knowledge about how it works and what the benefits are. Although there are ongoing initiatives to mobilize more insurance for farmers (for example, the national insurance scheme or initiatives at the sector level, as seen in the Busoro sector), a clear link with the SSI development context is missing. The national insurance scheme, for example, targets cooperatives only (whereas the SSIT program targets individuals) and is limited to eight crops: maize, rice, Irish potatoes, cassava, French beans, beans,

soybeans, and chilies. Except for French/green beans, most vegetables are not part of this scheme, but most SSIT farmers irrigate and grow vegetables.

Based on this assessment of private financing, we recommend working with the financial sector to create financial products that fit the needs of farmers in a FLID/SSI development context. Recent research looks at new financing models with the potential to bridge existing affordability gaps by, for example, reducing transaction costs, managing risks, or providing other incentives for financial institutions to become more active in the agricultural sector.

For instance, agricultural value chain finance products are financing provided to a player or actor in the value chain to increase value-chain growth and competitiveness. This approach helps to identify where the financing needs and gaps are; which partner can provide financing; and ways to improve access to finance throughout the value chain. This can lead to comparative advantages for financial institutions who have in-depth knowledge of the agricultural value chain and have market-based risk management mechanisms. Closer to the farmer are direct smallholder lending models in which farmers receive a full range of financial services such as group lending and cash during lean periods to mitigate risks.

A third possibility is indirect lending, where a financial institution lends indirectly to smallholders through a bigger aggregator organization, such as a farmer-based organization or a cooperative, whereby all group members become borrowers, thereby becoming guarantors for each other.

Lastly, the pay-as-you-go model is increasingly used as a solution where farmers make a down payment and pay off the balance in installments, which are often facilitated by mobile payments. In Rwanda, the Solar Irrigation Rwanda market development program tested this approach within its solar irrigation subsidy model. However, the results were not entirely fruitful, and further research is needed to gain a better understanding of the local context and the conditions that meet the needs of farmers.

Although these new models inspire other programs, we note that there must be sufficient time for trial and error, and to adapt such models to the local context for FLID in Rwanda.

The third aspect of our financial assessment considers government and donor-funded projects. There are different government and donor-funded projects, subsidies, and initiatives, and we recommend aligning the SSIT program with such efforts to enable even lower payment costs for farmers and a higher uptake of irrigation. We noted that donor and government-funded projects tend to work in silos, which hinders each program from tapping into the successes of other irrigation-related programs and larger schemes. Each program determines when, where, and what kind of system is implemented. For example, IFAD is financing major irrigation schemes throughout the country, but it is not formally linked to the SSIT program. It could be beneficial if such schemes promoted the SSIT program and helped farmers near the irrigation schemes to tap into large-scale infrastructure for their smaller-scale solutions.

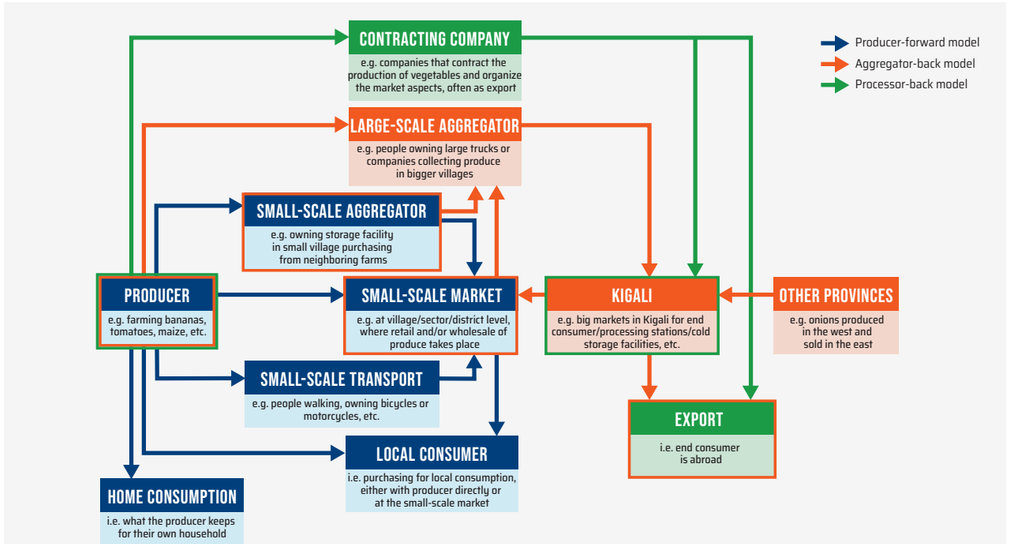
Examples of GoR activities that might facilitate the greater involvement of private financial institutions include new initiatives to lower the (perceived) risks by lenders (for example, through insurance schemes, credit guarantees, and promoting group lending), activities to lower transaction costs (for example, through closer collaboration with SACCOs), and supporting farmers' abilities to repay loans (for example, by facilitating access to markets and promoting contract farming). Donors can provide support here by offering access to additional financing (such as through top-up grants), building capacity and enabling access to knowledge (such as increasing financial literacy to help farmers reach out to financial institutions), and facilitating access to support functions, such as collateral or access to new technologies.

4.7 Markets

The ability of farmers to expand, intensify, and increase profits from irrigated produce depends on their access to markets. Enabling efficient access to, and effective engagement with, markets is a key aspect to facilitating farmers' business success. Our analysis shows that this aspect is underdeveloped within the SSIT program.

The FLID Guide identifies four market access models: (1) producer-forward model; (2) aggregator-back model; (3) processor-back model; and (4) vertically integrated model. Based on our fieldwork and desk research, we created an updated overview of observed market linkages within the SSIT context and along the lines of the models as presented in the FLID Guide (Figure 21). We did not observe any examples of SSIT farmers engaging in the fourth (vertically integrated) model, so we limited our analysis to the first three models. The linkages are seen from a producer's point of view and are linked to the three market access models presented in the FLID Guide. The purpose of Figure 21 is to describe the identified market linkages, to be able to identify and locate the market-related bottlenecks and challenges for SSIT farmers. Many of the SSIT farmers we consulted in the field expressed that they had various difficulties linking up with the markets, especially when they relied on small-scale aggregators and local consumers to purchase directly from the farms.

Figure 21: Identified market linkages following crops upstream



Note: The arrows indicate the direction of the crops along the value chain (created for the purpose of this research. See also Annex 6: Markets).

Based on the analysis of the market access models and the role of government and donors, we recommend adding a component to the program design to target the productivity and market gap that some SSIT farmers face, where they produce more (because they start to irrigate) but are not able to sell the additional produce for a reasonable price, or at all.

We also suggest working closely with an implementing partner to integrate potential add-ons into the program set-up or into other existing programs that aim to improve market linkages for farmers. We suggest:

- Actively connecting traders to farmers—for example, by leveraging digital platforms such as the e-SOKO platform of the GoR.
- Emphasizing access to markets alongside increasing productivity, for example, building capacity for marketing produce and increasing access to information about buyers and prices.
- Facilitating market access for irrigated goods by focusing on developing supporting functions, such as digital tools, improved infrastructure, and improved input and equipment supply.
- Supporting farmers as they organize into associations or cooperatives to increase their bargaining power.
- Advocating for the development of infrastructure that increases market access for farmers, such as feeder roads and storage facilities.

In terms of private sector development in an SSI context, our analysis points toward opportunities within the supporting market functions related to input and equipment supply to farmers; infrastructure; and digitalization and market information.

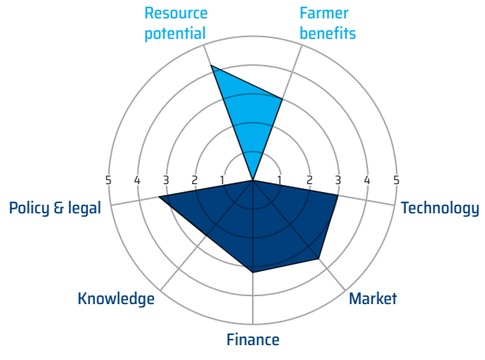
In terms of input and equipment supply to farmers, the local private sector could tap into opportunities related to providing and maintaining inputs and equipment, establishing local shops and repair centers, and local manufacturing of irrigation equipment. In terms of infrastructure, private sector parties could be engaged to design, build, operate, maintain, and finance feeder roads; provide (cold) storage facilities and transportation; and develop other infrastructure such as expanded mechanization, access to affordable sources of electricity (which is needed for processing, cold storage, and drying), and agro-processing. The private sector could play an important role in digitalization and increasing access to market information. The design of the SSIT program does not have a formal link or modality to engage the private sector alongside these opportunities, and we advise further research on ways to do so.

Lastly, through our desk research, we came across various projects that aim to improve market development and market linkages for farmers in the country. The Improving Market Systems for Agriculture in Rwanda project, funded by the Department For International Development (DFID) (currently under the FCDO), helps to commercialize agriculture by improving the way agricultural market systems function, making them more effective, participatory (by including poor farmers and other disadvantaged groups), and more competitive.[31] The Great Lakes Trade Facilitation project,[32] funded by Rwanda's Ministry of Trade and Industry, tries to facilitate cross-border trade by increasing the capacity for commerce and reducing the costs faced by traders, especially small-scale and women traders, at targeted locations near the border. These programs provide a promising avenue to collaborate with, yet irrigation is not necessarily part of these programs. We advise linking up with existing projects that already aim to strengthen market systems in Rwanda and looking at ways to link farmers within the SSIT program to these programs, to support them with increased market access.

4.8 Scoring of FLID factors in Rwanda

Based on the assessment, all seven factors related to the rationale and enabling conditions for FLID in Rwanda were scored. The overall scores for each factor are presented in Figure 22. More detailed descriptions of each scoring aspect related to the factors can be found in the respective annexes.

Figure 22: Scoring of the FLID factors for Rwanda



4.9 Recommendations for program implementation

Based on the review of the SSIT program design and the implementation process, we recommend improving the following five key aspects of the program implementation:

Invest in digital technology to improve the subsidy application process. The SSIT process has been restricted to a paper application and has been passing through multiple layers of administrative structures. This was done to help authorities confirm land ownership but created delays of up to three months. The use of a mobile- or tablet-based digital application (in a hybrid form with some paper-based steps) could reduce the turnaround time and allow key stakeholders to better document and monitor the process. More importantly, it would improve the selection of the most appropriate irrigation equipment. **This could be modeled on the Smart Nkunganire digital program being used for a seeds and fertilizers subsidy, or it could be linked to the Irembo portal providing digital services to the GoR.**

Improve the monitoring and evaluation framework of the program. Although all the involved parties at RAB, the district level, and the sector level state that program details are being submitted to a management information system at MINAGRI, it is still unclear how this information is being used to support the program's implementation. In addition, it is reported that only limited information is being collected, for example, farmers' contact details, land area, and technology. **Combined with a hybrid mobile-based digital application, developing a robust monitoring and evaluation framework would support the program with tracking the process and ensuring that valuable information is collected, processed, stored, and used for decision-making.**

Develop technical guidelines for the small-scale irrigation technologies being promoted. The SSIT program has mostly focused on supplying equipment to farmers, with the assumption that knowledge would be acquired in the process. During the field visits, we noted that in many cases the irrigation equipment was either oversized or being used inappropriately, leading to excessive operational costs and frequent failure. **We also recommend developing technical guidelines that combine the different aspects of irrigated agriculture, market assessment, and land and water tenure assessment, among others.**

[31] Read more about this program at https://www.swisscontact.org/_Resources/Persistent/3/d/d/6/3dd65baab788b62ec19acf79ac615c1e92401984/IMSAR_Factsheet_-_Rwanda.pdf.

[32] Read more about this project at http://gltfp.mtic.go.ug.

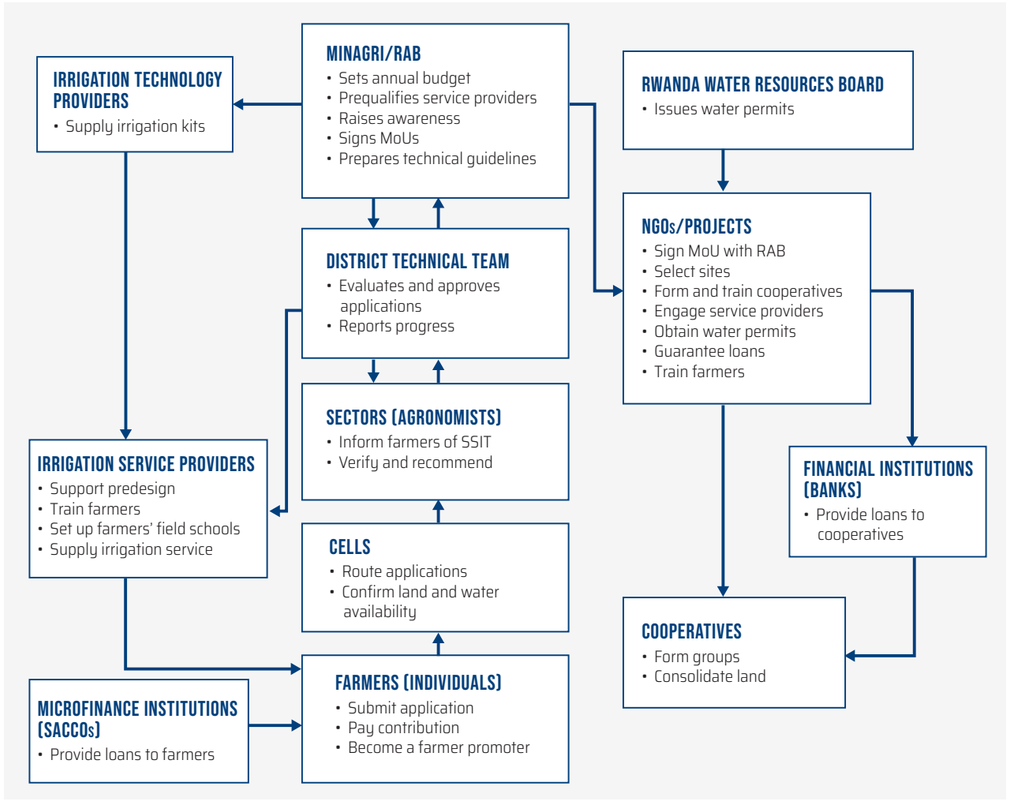
Promote groundwater development and use to potentially reduce farmers' costs. Despite groundwater being available in many places, most farmers were either not aware of its suitability or preferred to extend their pipe to a distant marshland. For most hillside irrigation systems where the water source is a marshland, the cost of lifting water can be reduced by investing in shallow wells on the boundary or at the right elevation.

Apply a differentiated subsidy approach to increase the competitiveness of solar irrigation. Solar irrigation has higher initial investment costs but lower operational costs, and therefore increased long-term profitability.

4.10 Framework for better targeting public resources in SSIT

Besides the overall recommendations stated in section 4.9, we propose some adjustments to the roles of different stakeholders in a second phase of the SSIT program. In Figure 23, we have provided an outline framework to better target public funds in SSIT. It is not fundamentally different from the framework discussed above, but there are some key changes, which we discuss below.

Figure 23: Design of a framework to target public funds in SSIT



4.10.1 Central process

In general, the central processes between farmer, cell, sector, district, and national level were working well. An effort could be made to smooth the application process to reduce the application time by clarifying responsibilities and delegating decision-making power. Observations in the field were that irrigated land was often rented.

The biggest change we propose is at the cell level—**to take away the requirement of land ownership and replace it with a confirmation that farmers have secure access to land (rented or owned) and nearby water that is sufficient to make the investment plausible.** This requirement would also allow farmers with little or no land, but with the financial capacity to hire and buy irrigation equipment, to apply for SSIT. Moreover, many of the SSIT-supported technologies are mobile, so land renters can benefit and move with the equipment from one plot to the next if they rent a different piece of land in a different season.

Another suggested change to the process is to shift the procurement of the equipment from the GoR to the farmer, thereby reducing the GoR's role to prequalifying suppliers, to guarantee quality and provide guidelines for SSIT equipment. This would lower the transaction burden on the GoR, reduce the unit cost of the SSIT equipment, and increase the probability of getting fit-for-purpose technology for each farmer.

4.10.2 Irrigation technology providers

The biggest change is in separating the role of the SSIT service providers into irrigation **technology** providers and irrigation **extension** providers. Under the group of irrigation technology providers, all current contracted service providers are included. They would continue engaging in what they do well: importing and selling irrigation materials. As the irrigation market is not yet big enough in Rwanda, there is no economic incentive for them to be in the districts together with subsidiaries. Thus (as we observed), they do not engage directly with the farmers, as the individual approach of SSIT would make this too costly, and they only indirectly engaged through the sector agronomist in determining the appropriate technology. Similarly, they did not provide training to farmers on their use.

4.10.3 Irrigation extension providers

We propose that a new role, that of irrigation extension providers, be introduced at the district level. Such providers would be graduates of a vocational training facility, trained in:

- Predesign (determining land and water suitability, making rough cost-benefit calculations of irrigated production, and determining appropriate technologies for farmers).
- Pump O&M.
- Field application techniques (such as furrows, basins, sprinklers, spray tubes, and drips).
- Irrigation agronomy (recognizing water stress, stress from water abundance, and water plant diseases).

If these irrigation extension providers are helped to set up shop at the district level, on an individual or group basis, they can then be engaged by the district officer to perform the role of predesign and training originally given to the service providers. The 10 percent of the SSIT costs that was originally budgeted for project set-up could be used to pay for these services, which can be further supported with subsidies from the scale-up of the SSIT program. **The irrigation extension providers would be the link between farmers and the irrigation technology providers in acquiring the irrigation equipment for the farmers and installing the equipment with the appropriate training.**

Irrigation extension providers could also be engaged within the "Twigire Muhinzi" extension model, setting up farmers' field schools at the cell level, and supporting farmers to become farmer promoters, so that knowledge spreads further at the cell level. The farmer promoter and farmers' field school initiatives are working well, but they have no focus on irrigation. Partnering with TVET schools could be an option to start educating people about irrigation agronomy and practices.

These same individuals or groups could be further encouraged to start providing their own irrigation services, going to farms with their own equipment to irrigate the field on a contract basis (modeled on the youth groups already performing this service in Rwanda). This would take away the requirement for farmers to buy the equipment and pay for the service instead.

4.10.4 NGOs/Projects

The "NGOs/Projects" approach is on the right side of the framework in Figure 23. This has not changed, although efforts could be made to better integrate the NGO projects in facilitating some of the processes of the SSIT program to promote the FLID and market-led approaches. **We recommend that RAB catalyze and facilitate these processes by focusing on training, access to finance, supporting the extension service system, facilitating access to markets, or engaging with smallholder farmers to consolidate into production groups big enough to apply to the SSIT program.** As mentioned in section 4.1.1, there are ongoing NGO/donor projects that target, for example, financial literacy for or access to markets by smallholder farmers. It would be interesting to see if and how SSIT farmers could be included in such programs, to address some of the challenges they face.

4.10.5 Financial institutions

For a potential follow-up program, we advise conducting a formal outreach to financial institutions and jointly designing financial products that can be used by farmers who are part of the SSIT program.

Assessing the role of financial institutions in the SSIT program is not only covered by the uptake of external loans by farmers. Private financing also relates to the capacity and experience of financial institutions to provide finance for farmers who are interested in purchasing equipment with an SSIT subsidy. A new design would focus on enabling financiers to gain confidence and create a deeper understanding of the SSI development sector, making them more willing to take risks and to create financial policies and products that fit the needs and context of SSIT farmers.

There is a mismatch between the farmers' financial requirements and lenders' requirements from farmers. Financial institutions should be part of the SSI development context to be able to design financial products that fit the needs and farming cycles of SSIT farmers. Specific features, such as the repayment terms, the type of loan (short, medium, or long term), collateral requirements (for example, the ability to use SSIT equipment as part of collateral), and pricing should be designed to fit the context of farmers who start irrigation using the government subsidy. **We recommend closer collaboration between the GoR and financial institutions on this topic.**

4.11 Suggestions to support each farmer typology

In Table 3, we combine the seven scoring factors related to the FLID environment in Rwanda with the recommendations and the farmer typologies (from Table 1) to suggest ways of supporting each typology specifically for each factor.

Table 3: Suggested support for different farmer typologies based on FLID factors

#	Character-istics/Type	Technology	Knowledge	Policy	Resource base	Farm benefit	Market	Finance
1	Small/ Informal	Has access to cheap irrigation technologies. Provide subsidies to help overcome the initial invest-ment hurdle.	Provide training on irrigation agronomy.	Allowing for choice on when, what, and how to pro-duce can have a significant impact on FLID facilitation.	Water and land are often easy to rent/get ac-cess to at this scale.	Despite the small land size, if marketed well, benefits can be sig-nificant for the household.	Market price awareness systems might help in better negotiation at the farmgate.	Crop produc-tion history registration might be a promising set-up to ac-cess finance for scale-up.
2	Medium/ Informal/ Commercial	Allows for scaling to larger produc-tion areas. On-farm technol-ogy advice is es-sential to ensure best fit. Spare parts/O&M is a constraining factor.	Provide training on field irrigation application practices. Training in the O&M of pumps is essential to improve lifespan of technology.	Subsidy is a clear push behind the uptake of this type of production system. Land ownership requirement might be a constraining factor in uptake.	Many farmers rent or own land in different locations. Access to water was limited to size of production system. Shallow ground-water options should be researched.	Produc-tion is more risk-prone. Higher input investment is required. Lim-ited (irrigation) knowledge results in suboptimal production levels.	Market satura-tion and price fluctuations might be prob-lematic. Support for informal trad-ing networks might result in better price regulation and spread of produce.	Farmers often mention finance as a limiting factor. Informal trading networks can bridge the gap between farmers who are too small for formal banking.
3	Medium/ Informal/ Mixed subsistence-commercial	Irrigation is often used to supple-ment rainfed production. On-farm technol-ogy advice is es-sential to ensure best fit. Spare parts/ O&M is a con-straining factor	Provide training on field irrigation application practices. Training in the O&M of pumps is essential to improve lifespan of technology.	There is a push for irrigated produc-tion of subsistence crops (such as maize) but using a pump and hose system has a neg-ative cost-benefit ratio. More focus on improving agronomic produc-tion might have a better impact.	Farmers often own the land, with access to water. Scale is impor-tant to reach economic viability for sub-sistence crops.	The farm ben-efit of irrigated subsistence crops is often negative. Sub-sidy on these systems might aim at increas-ing food crop production to ensure food se-curity, instead of commercial viability.	Subsistence crops often compete with imported goods, and prices are linked to world market prices. Price subsidies might increase production without pushing up the price.	Finance could support broader subsidy goals: seeds, fertil-izers, mecha-nization.

#	Characteristics/Type	Technology	Knowledge	Policy	Resource base	Farm benefit	Market	Finance
4	Large/ Formal/ Contract	This group is similar to typology #3 but is focused on seeds production under contract. Irrigation is essential to secure and guarantee high-quality production.	Provide training on field irrigation application practices. Training in the O&M of pumps is essential to improve lifespan of technology.	Planning of production areas is essential, as seed production has a detrimental effect on neighboring farms, as it excludes them from producing "normal" seeds.	Land and water seem less problematic with this scale of farmers.	Production is more risk-prone. Higher input investment. Limited (irrigation) knowledge results in suboptimal production levels.	Markets are relatively guaranteed, and state-controlled.	Use finance to stimulate mechanization and include neighboring (smallholder) farmers in producing seeds.
5	Small/ Innovator/ Commercial	Small-scale solar irrigation technology has beneficial O&M characteristics but is limited in the area it can cover.	Provide training on field irrigation application practices. Training in the O&M of pumps is essential to improve lifespan of technology.	Differentiated subsidy (higher for solar) might help to stimulate and mature the solar market and improve uptake.	Water and land are often easy to rent/get access to at this scale.	Apart from the initial investment costs, the O&M costs are relatively low, reducing the production risk.	Market price awareness systems might help in better negotiation at the farmgate.	Finance is a limiting factor. Informal trading networks can bridge the gap between these types of farmers, who are too small for formal banking arrangements.
6	Large/ Innovator/ Commercial	Location-specific solar solutions are required for application at this scale.	Provide training on field irrigation application practices. Training in the O&M of pumps is essential to improve lifespan of technology.	Policies geared toward financial instruments for large commercial farmers would support these farmers.	Land and water seem less problematic with this scale of farmers. Ownership often guaranteed.	Production is often geared toward niche markets, such as macadamia, with high profitability.	Often have access to either niche products or markets, such as hotels.	See policy suggestions.
7	Small/ Rice/ Cooperative	Irrigation is often used to supplement rainfed production but is based on gravity canal systems.	Knowledge of irrigation agronomy is widespread. Exchange visits and farmer-to-farmer learning could promote further spread.	Rice is a subsistence crop with important links to food security and import substitution. Large-scale irrigation infrastructure is part of GoR policy.	Land is often rented from the cooperative or very small plots are owned by individual members of the cooperative. Land consolidation seems prevalent in this sector.	In theory, the farm benefit is positive, but the production area might be too small for it to be significant, particularly as production arrangements with the cooperatives can be restrictive.	The cooperatives play an important role in facilitating the markets.	Finance is facilitated through the cooperative, for example, for seeds.
8	Small/ Rice/ Private	Irrigation is often used to supplement rainfed production, but it is based on gravity canal systems.	Knowledge of irrigation agronomy is widespread. Exchange visits and farmer-to-farmer learning could promote further spread.	Rice is a subsistence crop with important links to food security and import substitution. Policies geared toward improved varieties are important to boost production.	Land ownership seems essential to be able to construct the permanent irrigation infrastructure for irrigated rice. Often in swampland areas.	The farm benefit is positive and through the direct (informal) market. Linkages are more beneficial than the cooperative model.	Market linkages are more informal and parallel to the cooperative rice economy.	Finance for improved seeds could support this sector.

4.12 Recommendations for SSIT2

Table 4 summarizes all the findings and recommendations from this assessment report for improving the second phase of the SSIT program, including the responsible institutions.

Table 4: Recommendations for SSIT2

Areas for improvement	Proposed change		Who?
	SSIT1	SSIT2	
Broadening the base of farmers	Only landowners are eligible	Both owners and **renters are eligible.**	Rwanda Land Authority (RLA)
	Water permits are required	**Water use declarations are** sufficient below a certain area/outside hotspots.	Rwanda Water Resources Board (RWB)
Overcoming financial constraints	Limited uptake of external financing; farmers pay for SSIT with own savings	• **In close collaboration with financial institutions, develop financial products that are fit for purpose. For example, collateral and guarantee fund** arrangements with banks to develop agricultural/irrigation financial products. • **Engage SACCOs** directly or indirectly through banks and/or promote group lending. • Increase knowledge and understanding of agricultural sector within financial institutions.	Ministry of Finance/ Ministry of Agriculture and Animal Resources (MINAGRI) National Bank of Rwanda (BNR) /Rwanda Cooperative Agency (RCA)
Increasing access to finance	Government procures	Government prequalifies suppliers; **farmer procures.**	Rwanda Agriculture and Animal Resources Development Board (RAB)
Reducing the unit cost of the equipment	Subsidy equal for all technologies	Increase competitiveness of specific technologies through **differentiated subsidies**, between petrol-/diesel-powered pumps (either decrease) and solar power (or increase subsidy).	RAB/MINAGRI
Getting fit-for-purpose technology	Blended responsibility of irrigation technology providers and irrigation extension providers	Separate responsibilities of irrigation **technology providers** (active at national level) and irrigation **extension providers** (active at district level, private sector engagement, youth groups, technical (pre) design, installations, irrigation as a service).	RAB/MINAGRI
Overcoming knowledge constraints		Strengthen the extension model/officers, focusing on hands-on knowledge of **irrigation agronomy** to strengthen the overall reach of SSIT2 program.	RAB/MINAGRI
Making the process faster	Paper-based applications	Hybrid of **digital and paper-based application** system. Faster procedures that fit the needs, timelines, and context of farmers.	RAB/RWB
Making the process more transparent	Unclear performance and use of public funds	MINAGRI to **strengthen the management information system** to increase the parameters that are evaluated.	MINAGRI

ANNEX 1: RESOURCE BASE POTENTIAL

Key findings

- Surface water is abundant in many parts of Rwanda. In general, surveyed farmers indicated that they have few problems accessing water.
- Many sub-catchments in Rwanda still have resource potential for developing small-scale irrigation, and the small-scale irrigation technology (SSIT) program can actively target these already identified areas using the Rwanda Irrigation Master Plan (2020).
- Shallow groundwater presents an added opportunity for irrigation development, especially when it occurs close to surface water sources (such as around lakes). Shallow wells can easily be installed for this relatively untapped water resource, an aspect that should be focused on in the next phase of the SSIT program.
- Although many parts of Rwanda are hilly, the abundance of terraces and other types of leveled land proves that inclines can still be suitable for small-scale irrigation development if appropriate irrigation methods are used.

1.1 Resource base and SSIT

1.1.1 Introduction

Availability and accessibility of water resources are important drivers for developing farmer-led irrigation systems and apply equally to the potential success of the SSIT program. Rivers, streams, rain, lakes, and groundwater are common water resources in Rwanda that can all be tapped for irrigation. Water resources go hand in hand with land resources. A combination of access to water and suitable land makes for an important driver for farmer-led irrigation. Answering the question "What is the natural resource potential for SSIT expansion in Rwanda?" relies on two aspects: the natural resource base itself and the viability of using that resource (that is, the water mobilization cost) in practical terms.

1.1.2 Natural resource base

The resource base is defined as the total suitable land area that could be irrigated with the available water, according to sectoral priorities and allocations. In Rwanda, studies reported considerable potential for expanding irrigation, but they also revealed a data gap on the exact size of the current area irrigated using SSIT. The *Feasibility Study for the Identification of Potential Small-Scale Irrigation Areas*, completed in September 2018 by the Rwanda Agriculture and Animal Resources Development Board (RAB),[33] identified 84,704 ha of potential irrigable land through the SSIT program. Note that some of the areas included under this category have already been identified by the Irrigation Master Plan[34] and were counted in other categories (or domains). In terms of master planning, the Master Plan recommended developing only 28,000 ha using SSIT up to 2021.

In terms of land resources, it is difficult to define the agricultural land that is managed on a small scale (and thus suitable for SSIT). Regardless of size, what matters most is whether it is cost-effective farmer-led irrigation development (FLID). Therefore, in terms of land suitability, there is no clear distinction between the total irrigation potential in Rwanda and the SSIT potential. Table 1.1 shows the total potential per category and per level 1 catchment.

It is widely accepted that Rwanda has substantial irrigation resources that can still be developed. Further, substantial opportunities exist, not just for expansion but also for intensification—that is, better use of the water available—through improving water productivity. Paying attention to aspects of storage, sectoral allocations, the seasonal effects of irrigation on basin water balance, and the actual extent of existing irrigation (including SSIT) is therefore essential to properly understanding the resource potential.

[33] RAB. 2018. *Feasibility Study for the Identification of Potential Small-Scale Irrigation Areas in Rwanda.*

[34] RAB. 2020. "Rwanda Irrigation Master Plan." Draft version.

Table 1.1: Irrigation potential per domain and per catchment[35]

Domains	CRUS	CKIV	NMUK	NNYU	NNYL	NAKN	NAKU	NAKL	NMUV	All
Runoff for small reservoirs domain	2,148	5,179	4,165	7,155	7,056	7,270	6,521	9,162	3,344	**52,000**
Dam potential	167	1,447	172	7,058	15,610	12,859	894	1,430	12,464	**52,101**
River potential	-	-	-	12,424	4,710	36,171	25,868	48,241	8,466	**135,880**
Lake potential	-	23,909	-	-	28,372	9,125	26,816	14,142	-	**102,364**
Marshland potential	3,700	4,702	6,398	9,060	8,998	26,656	33,184	22,731	7,735	**123,164**
Groundwater	3,000	5,000	5,000	7,000	4,000	5,500	2,500	3,000	1,000	**36,000**
TOTAL	**9,015**	**40,237**	**15,735**	**42,697**	**68,746**	**97,581**	**95,783**	**98,706**	**33,009**	**501,509**

Note: Abbreviations used for the catchments are the following: CRUS—Congo basin, Rusizi catchment; CKIV—Congo basin, Kivu Lake catchment; NMUK—Nile basin, Mukungwa catchment; NNYU—Nile basin, Nyabarongo Upper catchment; NNYL—Nile basin, Nyabarongo Lower catchment; NAKN—Nile basin, Akanyaru catchment; NAKU—Nile basin, Akagera Upper catchment; NAKL—Nile basin, Akagera Lower catchment; NMUV—Nile basin, Muvumba catchment.

1.1.3 Resource potential and the cost of water mobilization

Mobilization costs are based on how near water is to irrigable lands and the need for storage. In Rwanda, much of the success of the SSIT program has been attributed to the existence of environments where farmers can easily and cheaply access water for irrigation, and where they can grow high-value crops and access markets to sell produce. Where large bodies of water (such as lakes, reservoirs, or rivers) are close to irrigable land, these were accessed easily by individuals and small groups of farmers with simple technologies at relatively low costs. In contrast, where there is fluctuating seasonal water supply and irrigable lands are far from a water source, heavy and costly engineering construction is needed for both storage and transmission. For example, retention dams in Rwanda collect large volumes of water during the rainy season and supply irrigation water during the dry season.

In practical terms, situations of easy access include hillside streams that can be diverted into simple gravity canals or through cheap pipelines to the fields or locations within a few hundred meters of lakes, rivers, wetlands, ponds, or streams. Where water must be lifted, farmers often use buckets, watering cans, small petrol/diesel pumps, or treadle pumps. Energy costs, in terms of human labor, fuels, or solar panels, increase proportionally with distance and lifting height. Accordingly, the distance and pumping head (for treadle, petrol, or diesel pumps) are key parameters for resource potential.

The investment costs can vary widely within a given domain due to topography, distance from the water source to the irrigated area, and complexity of the irrigation network, among many other factors. Table 1.2 shows the progression from highly favorable resource situations, where SSIT takes place most easily, to more costly, time-consuming, and complex situations, where the probable range of investment and operating costs is expressed in US dollars per irrigated hectare.

Table 1.2: Estimated cost of various irrigation systems[36]

Domain	Investment costs ($/ha)	O&M costs ($/ha)
Marshland, diversion, gravity	1,500–4000	50–100
Marshland, dam, gravity	16,000–20,000	150–200
Hillside, dam, gravity	20,000–30,000	200–300
River/lake, pumped	6,000–10,000	300–500
Groundwater, pumped	4,000–10,000	400–600
SSIT	3,500–6,000	600–800

[35] RAB. 2020. "Rwanda Irrigation Master Plan." Draft version.

[36] RAB. 2020. "Rwanda Irrigation Master Plan." Draft version.

Where resource potential is high—reflected by proximity (being near) to a plentiful supply of water—costs and constraints to FLID are low, and farmers can adopt irrigation and expand and intensify their operations with no or minimal public support. Where resource potential is low—meaning water is distant and water supplies are stressed, and/or substantial storage is needed—financial and transactional costs and complexity are higher. The need for public funding to support FLID processes increases as resource potential decreases.

The resource potential assessment has gone beyond just physical resource availability to also consider infrastructure development costs, the potential to access and augment resources cost-effectively (such as small dams and shallow wells), the costs to be borne by farmers, and the farmers' organizational abilities.

Assessment of the resource potential factor is intended to identify the high resource potential contexts where SSIT can flourish. The suitability of small-scale irrigation systems, close to a water source with high water availability, is the key parameter.

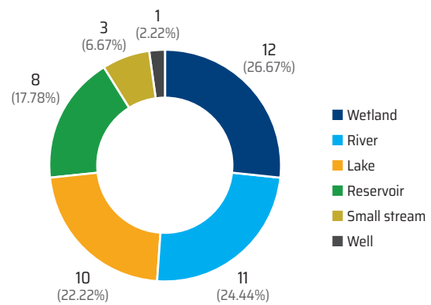
1.1.4 Increasing the potential—small dams and water-harvesting ponds

One way that the resource potential was increased in Rwanda, albeit at public cost, was through constructing small dams and ponds. Small dams are built as barriers in drainage lines or off-channel, on perennial or ephemeral streams/rivers. Water-harvesting arrangements with excavated ponds (sometimes lined with plastic dam sheets, clay, or concrete) are designed to capture overland sheet flow. These kinds of small water storage structures can trigger FLID by providing additional water resources for irrigating adjacent arable lands. Increasing these initiatives will enhance Rwanda's resource potential in terms of FLID. Rwanda's potential, based on broad geographic characteristics (including rainfall, runoff, slope, and proximity of storage sites to land) is high but needs to be assessed. No report showing existing initiatives has been produced in Rwanda.

1.1.5 Groundwater and SSIT in Rwanda

Groundwater can play an important role in SSIT in Rwanda once appropriate technology has been developed. Shallow wells have low construction costs and are associated with simple hand-lifting or pumping technology. The abundant surface water resources offer important potential for shallow wells due to the high water table. Current practices have rarely tapped into this potential. Of the 45 farmers who indicated their water source, only one was using a shallow well (Figure 1.1).

Figure 1.1: Types of water sources used



The combined use of both groundwater and surface water sources can extend the crop production season and offset the risks associated with surface water variability caused by other users sharing the same surface resource.

With shallow groundwater, Rwandan farmers can easily cover the development costs of the resource themselves, or with a little support. Sustainable groundwater use can be aided by measures referred to in other annexes of this report, especially technology.

1.2 Diagnostics and scoring of the resource potential factor

The diagnostic of resource potential was informed by the prior discussion on data uncertainty and the broader concept of "potential" that goes beyond simple physical resource availability. The resource potential factor was scored to answer the question "Why and when is SSIT favorable in Rwanda?" from a resource perspective. The answer to this question was found to be that SSIT is favorable when (1) water is abundant, accessible by farmers in a cost-effective manner, and of good quality; and (2) related land resources are suitable for irrigation development by farmers.

1.2.1 Diagnosis of resource potential

A country-level diagnostic comprises mapping, desktop reviews, and field validations of land and water resources. Building on existing assessments conducted in Rwanda, Annex 1 has considered the *Feasibility Study for the Identification of Potential Small-Scale Irrigation Areas*[37] as the most complete picture of the resource potential in Rwanda. Most of the information contained in this annex is taken from this feasibility study.

[37] RAB. 2018. *Feasibility Study for the Identification of Potential Small-Scale Irrigation Areas.*

Potential sites for SSIT

A total of 54,340 ha (gross) of potential SSI sites have been identified in the Eastern Province, covering the districts of Bugesera, Gatsibo, Kayonza, Kirehe, Ngoma, Nyagatare, and Rwamagana. In the Southern Province, a total of 30,363.8 ha (gross) have potential for the development of SSI, covering the districts of Gisagara, Huye, Kamonyi, Muhanga, Nyamagabe, Nyanza, Nyaruguru, and Ruhango. The combined potential of these two provinces covers 84,552 ha (gross),[38] about 15.5 percent of the potential irrigation area identified in the Irrigation Master Plan of 2020.[39]

Available water resource assessment

Guaranteed availability of water for irrigation is essential for transforming the potential identified SSIT sites into sustainable irrigation projects. Thus, the available water resources and water demand in each of the catchments where the potential SSI sites are located were analyzed by the same report[40] for both current and future availability and demands. The water demand scenario was restricted to the following major consumer sectors: domestic water use, livestock, industry, and irrigation.

The report provides a basis for assessing whether the catchment-generated water resources can meet future expansions of irrigation development. The identified potential SSI sites are in the sub-catchments of Mwogo, Mbirurume, mid-Nyabarongo, Mambu-Kayumbu, Nyabarongo Valley, Muhazi, Warufu, Ngoma, Upper Muvumba, Muvumba downstream, Mwogo, Rusasa, Mugesera, and Akagera complex.

Of the 17 sub-catchments that were analyzed, only Akagera and Mugesera showed a potential risk of water shortage for irrigation development. Although water resources in these catchments can meet immediate irrigation development needs, future scenarios reflect a risk, as other priority sectors such as domestic and industry water use are likely to expand. It is thus advisable that any development of irrigation in these areas should be short term.

1.2.2 Approach to scoring the resource potential factor

Within the limits of available information and based on the FLID Guide,[41] the parameters considered for scoring the resource potential include water availability (quantity), water resource type, distance to the water source, groundwater availability, and accessibility. As availability of and proximity to water are of primary importance, a score for water availability was generated from measuring the accessible surface water and groundwater. Where surface water is abundant and reliable, it is often more convenient to exploit than groundwater. Where surface water is limited and/or available only seasonally, groundwater was included in the considerations. Groundwater also has the advantage of being developed close to the point of use, thus reducing investment needs for conveyance structures and materials. The scores of these various parameters were combined to generate a single weighted score for natural resource potential. The FLID Guide suggests a summarized table (Table 1.3) that has been used in scoring resource potential in Rwanda.

Table 1.3: Scoring guidelines for the resource potential aspect

	Score				
	5 Highly suitable	4 Suitable	3 Moderately suitable	2 Moderately unsuitable	1 Unsuitable
Surface water: distance to water source (m)	<10–250	250–500	500–1,500	1,500–2,500	>2,500
Water availability:	Water is abundant nationally and widely available for irrigation.	Water is widely available for irrigation in numerous sub-regions but there is scarcity in a few sub-regions.	Water is abundant in a few sub-regions, but competition is a common factor in regard to irrigation use.	Water availability for irrigation is nominally constrained; cross-sectoral and localised competition is a feature.	Water availability is heavily constrained, competition and conflict are serious, irrigation abstraction are curtailed.
Groundwater: depth (m)	<7	7–10	10–15	15–30	>30
Groundwater: aquifer productivity (l/s)	>0.5	0.1–0.5	-	-	-
Slope (%)	0–2	2≤4	4≤6	6≤8	>8

[38] RAB. 2018. *Feasibility Study for the Identification of Potential Small-Scale Irrigation Areas.*

[39] RAB. 2020. "Rwanda Irrigation Master Plan." Draft version.

[40] RAB. 2018. *Feasibility Study for the Identification of Potential Small-Scale Irrigation Areas in Rwanda.*

[41] Izzi, G, Denison, J, and Veldwisch, G J, eds. 2021. *The Farmer-Led Irrigation Development Guide: A What, Why and How-to for Intervention Design*. Washington, DC: World Bank.

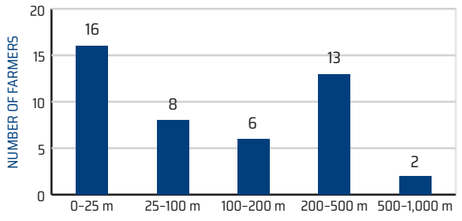
The combined weighted score for water availability and nearness to a water source ranges from highly suitable (5) to unsuitable (1). Depth to groundwater and aquifer productivity were used to score groundwater potential. When available at shallow depths and thus easily accessible, groundwater was given a high score. Where groundwater is available at depths up to 7 meters, the conditions are highly suitable for developing groundwater for FLID. With easily accessible groundwater, farmers can invest in less capital-intensive methods to access water, for example by using manual pumps, buckets, and ropes. As groundwater depth increases, farmers need motorized pumps. Such cases require more investment but will score highly when greater benefits are to be gained from irrigated production.

1.2.3 Overall scoring of resource potential in Rwanda

Distance from the water source

Up to 250 meters from the water source to the field, the resource potential is qualified as highly suitable. Two-thirds of all surveyed sources are within 200 meters and thus qualify as highly suitable (Figure 1.2). In terms of distance to water source, the suggested score is 4/5.

Figure 1.2: Distance to water source (as indicated during the farmer field survey)



Surface water availability

Rwanda has a dense hydrographic network. Lakes occupy an area of 128,190 ha; rivers cover an area of 7,260 ha; and water in wetlands and valleys covers 77,000 ha.[42] Plentiful surface water compared to only 84,000 ha of SSIT potential and perennial rivers and streams offers a promising resource base for developing SSIT. Rwanda easily scores 5/5 for surface water availability and is assumed to be highly suitable for FLID.

Groundwater availability

The groundwater availability goes hand in hand with surface water availability. With a high density of surface water, including perennial rivers, streams, and lakes, the interaction between groundwater and surface water is obvious in many parts of Rwanda. The abundance of surface water resources has resulted in high potential for shallow wells due to the high water table. Near perennial surface water bodies, the groundwater table was found to be high, above the 7 meters suggested in the FLID Guide. The proposed score is thus 5/5. We recommend promoting the use of this relatively untapped water source in Rwanda.

Aquifer productivity

Aquifer productivity in Rwanda was not considered as part of this assessment, given the scarcity of information available.

Land suitability (slope)

In terms of land suitability, the FLID Guide proposes slopes ranging from 0 percent to 5 percent, with greater than 8 percent regarded as unsuitable, but this criterion does not make allowances for local conditions. Given the general topography of Rwanda, a slope up to 16 percent is considered suitable for SSIT. The Ministry of Agriculture (MINAGRI)/RAB has identified potential land area of 84,000 ha for SSIT, all with a slope below 16 percent and therefore suitable for SSIT irrigation. Land consolidation (which is well understood by the farmers) is also an important driver for SSIT development. The land suitability can be scored at 3/5.

Conclusion on resource suitability

The overall score for resource suitability is calculated as 4.25 out of 5 (the average of the abovementioned scores), highlighting the vast potential for SSIT development in Rwanda in terms of natural resource availability and accessibility.

[42] RAB. 2020. "Rwanda Irrigation Master Plan." Draft version.

ANNEX 2: FARMER BENEFITS OF IRRIGATION

Key findings

- On average, the financial benefit of irrigation to farmers in Rwanda is rated as "medium" when using the FLID Guide:[43] there is a relatively short dry season in many areas, and established market linkages for irrigated production during these times are often rather weak. However, considerable profits can be made from increasing vegetable production in the dry season, and there is potential for increased yields in irrigated crops during the rainy season.
- Cost-benefit analyses that were performed for several farmer typologies indicated considerable profits from irrigated agriculture in Rwanda, except for small-scale irrigated maize. However, survey data reveals that (irrigated) production in Rwanda still has rather low yields and can benefit further from improved input use and capacity building, specifically around the operation and maintenance of irrigation systems.
- The lifespan of diesel/petrol pumps and pipes is relatively short (two to three years). Training and better maintenance services can increase lifespan and net seasonal benefits for all irrigated production systems. Moreover, building capacity of irrigation agronomy and techniques could further lower production costs, given the inefficient irrigation techniques being applied by many farmers.
- The small-scale irrigation technology (SSIT) equipment subsidy increases net profit in a range from 10 to 20 percent. Considering the range of profits made by smallholder irrigators using (fuel) pump and hose systems, it is assumed that the subsidy on this type of equipment has little influence on farmers' willingness and capacity to pay. However, given the higher initial investment needed for solar pumps, the subsidy could be an effective way to promote the use of these specific systems.

2.1 Introduction

This annex presents cost-benefit analyses of different irrigated production systems based on available SSIT equipment and cropping patterns in Rwanda. The analyses were performed to better understand the options available and the impacts on livelihood and capability (cash flow) and farmers' willingness to pay, based on the profitability of the various options. This annex presents the findings of both the diagnostic literature review and the field survey of the SSIT assessment.

2.2 Methodology

First, a literature review was performed, focusing on several recent cost-benefit analyses previously conducted for (irrigated) agriculture in Rwanda, some specific to the SSIT program. From this review, several potential combinations of SSIT equipment and cropping patterns were selected based on data on SSIT equipment sales and actual cropping patterns. (Cropping patterns such as H1 and M1 are numbered according to location and type; H means hillside and M means marshland, with numbers added to indicate types of crops.) The appropriateness of this selection was cross-checked with farmer typologies encountered during the field surveys and with collected production data. Cost-benefit analyses were then performed for all typologies, from which conclusions and recommendations for the SSIT program can be drawn.

2.3 Results

2.3.1 Climate analysis in relation to risk of crop failure

Using data on Rwandan farmers who received the SSIT subsidy between 2016 and 2020, we derived the distribution and concentration of SSIT beneficiaries across the districts (Figures 2.1 and 2.2).

[43] Izzi, G, Denison, J, and Veldwisch, G J, eds. 2021. *The Farmer-Led Irrigation Development Guide: A What, Why and How-to for Intervention Design*. Washington, DC: World Bank.

Figure 2.1: Number of SSIT beneficiaries per district

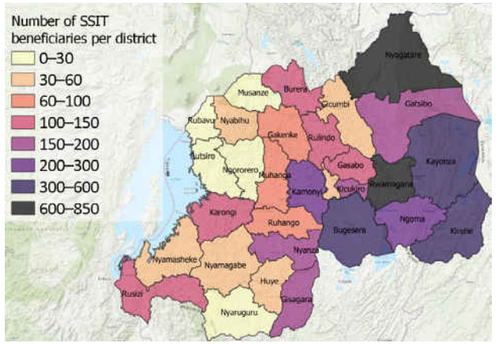


Figure 2.2: Total area (ha) of SSIT farmers per district

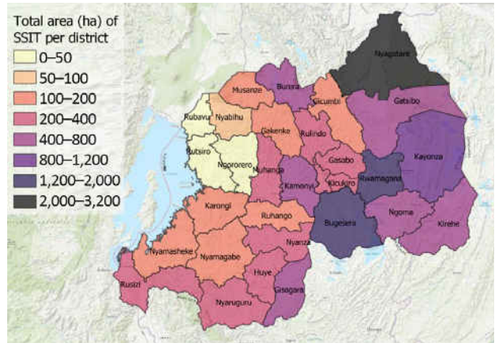
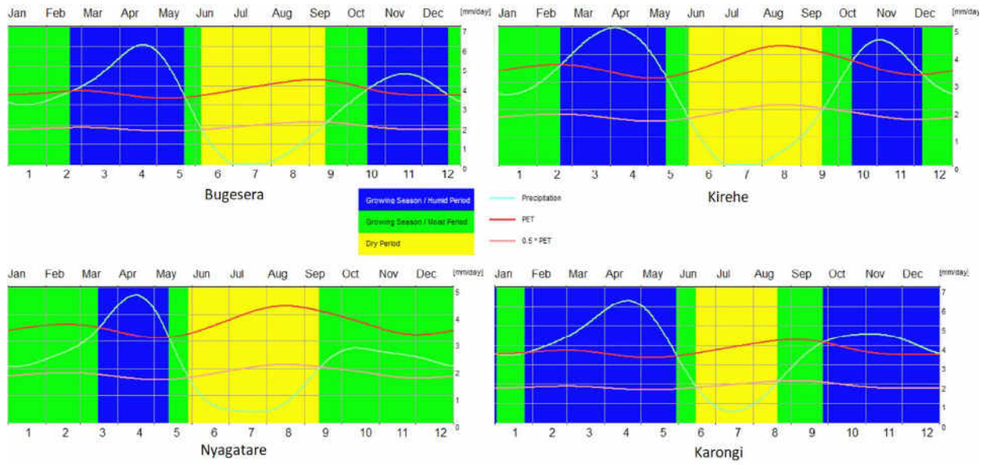


Figure 2.3: Average monthly precipitation and evapotranspiration for indicative locations in Rwanda



Given this distribution of SSIT farmers, a climate analysis for the districts of Nyagatare, Kirehe, Bugesera, and Karongi was performed to cover the spatial distribution of irrigated agriculture in Rwanda (Figure 2.3).

Seasonal precipitation and evapotranspiration patterns are very similar throughout Rwanda. There is a dry season roughly between June and August; a first rainy season between September and December; and a second rainy season between January and May. In all analyzed districts, the rains in the second season were more substantial than in the first season. In most areas, both the first and the second rainy season provided a sufficient level of precipitation (higher than potential evapotranspiration) for a sufficient period of time for crop production. In the north-eastern part of Rwanda (Nyagatare and Gatsibo), the climate is significantly drier than in the rest of the country.

Irrigation can be applied for multiple reasons in relation to the local climate:[44]

- Additional cropping seasons
- Early/late planting in the rainy seasons for better market prices
- Crop protection against dry spells during the rainy season.

[44] Izzi, G, Denison, J, and Veldwisch, G J, eds. 2021. *The Farmer-Led Irrigation Development Guide: A What, Why and How-to for Intervention Design.* Washington, DC: World Bank.

When looking at climatic variation in Rwanda, the most logical reason for irrigation is to have an additional cropping season in the drier months. In some areas (for example in Nyagatare), irrigation may also be necessary for higher production during the rainy seasons (especially the first). This was also evident in the farmer survey, which found that most farmers (89 percent) irrigate to produce crops in the dry season; 25 percent for better market timing of crop cycles; and 16 percent to secure production during dry spells (dry periods during the rainy season that can have negative impact on production because of water scarcity).

With regard to the use of irrigation to secure production during dry spells, the climate change projections for Rwanda (Figures 2.4 and 2.5)[45] indicate that dry spells are not projected to last longer in the future, and even shorten during the dry season (June to September) towards the end of this century (2080–2099). During the rainy seasons, the ensemble median projections are close to 0, so there is no significant change in the length of dry spells projected during the rainy season (RCP 8.5 scenario selected). So, regarding climate change, there is no reason to assume that rainy season dry spells will become a greater problem in the future.

Climate change projections indicate a slight increase in average monthly precipitation during the rainy season, so irrigation is unlikely to become more important for rainy season productivity in the future (Figure 2.6).

Figure 2.4: Projected change in consecutive dry spell days for Rwanda for 2020–2039

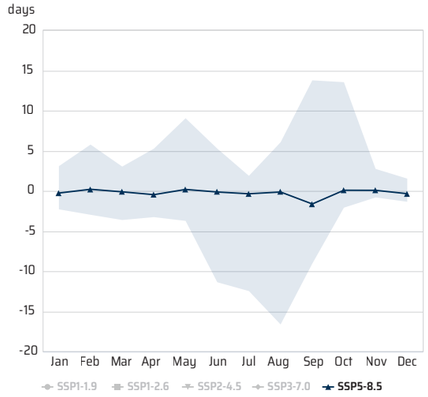


Figure 2.5: Projected change in consecutive dry spell days for Rwanda for 2080–2099

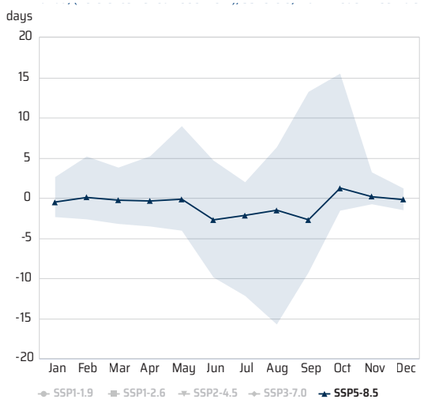
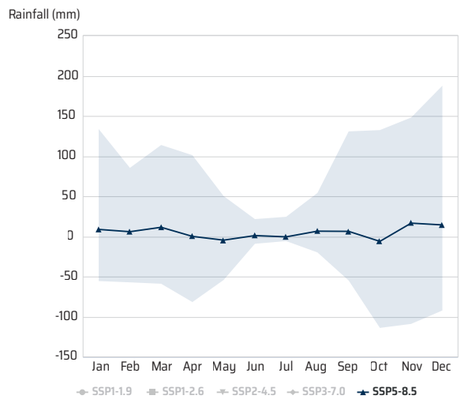


Figure 2.6: Projected change in monthly precipitation for Rwanda for 2020–2039



[45] World Bank. 2021. *Climate Change Knowledge Portal* (accessed September 7, 2021), https://climateknowledgeportal.worldbank.org/country/rwanda/climate-data-projections.

2.3.2 Assessment of farmer typologies, crops and cropping patterns

To adequately assess the potential for irrigation and the added value of subsidizing SSIT equipment, several farmer typologies are defined based on both literature data and the field surveys. The features of the typologies include cropping patterns, irrigation technologies used, land size and access, organizational style, and market linkages.

Crops (and cropping patterns)

Production seasons in Rwanda	Season A	Season B	Season C
Period	Sept-Dec	Jan-May	Jun-Aug

The draft Rwanda Irrigation Master Plan[46] describes the most common crops produced in Rwanda in relation to irrigation. It states that "Rwanda is endowed with comparatively good and well-distributed rainfall over season A (Sept-Dec) and season B (Jan-May)." To justify crop irrigation at this time, there must be a sufficient increase in yield from an additional water supply to cover the cost of developing and operating irrigation systems. Common staple crops such as maize, sorghum, bush beans, and Irish potatoes are not usually irrigated, but they can increase their yields under good management and high-input irrigation regimes. In the marshlands, rice is an important staple crop. When looking at the field data, most interviewed farmers cultivated maize and bush beans as rainfed crops in seasons A and B, as well as sorghum and (sweet or Irish) potato. Vegetables such as tomato, carrot, cabbage, and (African) eggplant are produced without irrigation in these seasons.

As stated above, irrigation in Rwanda is mostly for crop production in season C (June to August), when it is primarily applied to high-value vegetables such as tomato, onion, (African) eggplant, cabbage, carrots, watermelon, and chilies. Besides these, irrigation is applied year-round to perennials such as avocado, citrus, passionfruit, and macadamia, and sometimes during the rainy season to prevent harvest reduction because of dry spells (mostly for maize). The rainfed and irrigated crops indicated by field survey respondents are presented in Figures 2.7 and 2.8.

The draft Rwanda Irrigation Master Plan of 2020 also describes the main cropping patterns of these crops (Table 2.1), which correspond with the field survey's findings. The most common cropping pattern was M2 in the marshlands and H1 on the hillsides.

Figure 2.7: Main irrigated crop types

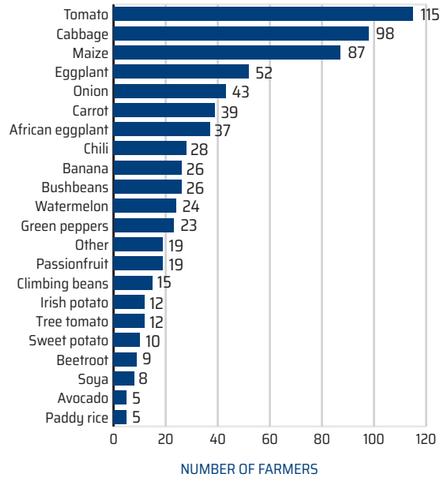
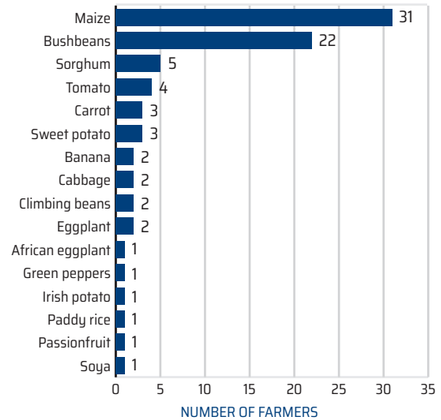


Figure 2.8: Rainfed crop types



[46] RAB. 2020. "Rwanda Irrigation Master Plan." Draft version.

Table 2.1: Different cropping patterns in marshland and hillside irrigation systems[47]

Stratum	Crop pattern	Season A	Season B	Season C
Marshland	**M1** Paddy rice	Paddy rice, 100%	Paddy rice, 100%	Nil
	M2 Food + horticulture	Maize, 50%; soya, 30%; vegetables, 20%	Maize, 50%; bush beans, 30%; vegetables, 20%	Vegetables, 50%
	M3 Sugarcane	Sugarcane, 100%	Sugarcane, 100%	Sugarcane, 100%
Hillside	**H1** Food + horticulture	Maize, 50%; soya, 30%; vegetables, 20%	Maize, 50%; bush beans, 30%; vegetables, 20%	Vegetables, 50%
	H2 Fruit trees + food + horticulture	Fruit 55%; maize 20%; soya 10%; vegetables 5%	Fruit 55%; maize 20%; bush beans 10%, veg 5%	Fruit 55%; vegetables, 15%
	H3 Irish potatoes + food + horticulture	Potato, 25%; maize, 25%; bush beans, 25%; vegetables, 25%	Potato, 25%; maize, 25%; bush beans, 25%; vegetables, 25%	Vegetables, 50%

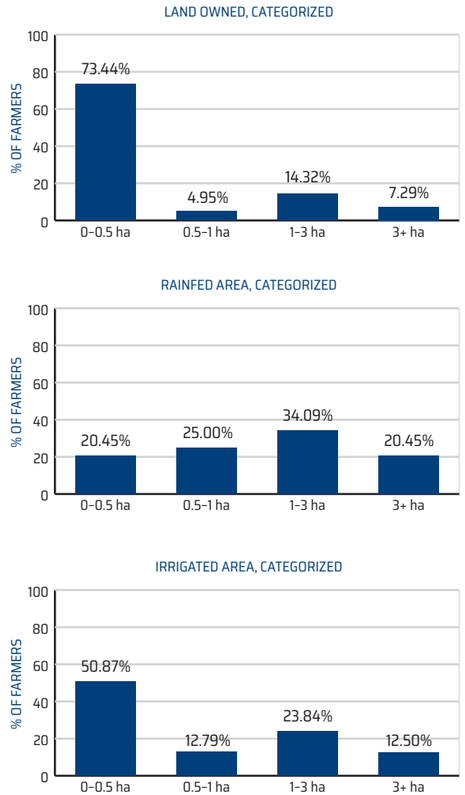
Technology

The most widely used irrigation technologies are simple pump and hose systems, with solar pumps becoming increasingly common. Farmers who start irrigation mostly use buckets or watering cans. Gravitational irrigation using furrows from small streams is less common, as most SSIT farmers use lakes, wetlands, and rivers as sources of irrigation. The most used application technique is with hose pipes, whereas rainguns, sprinklers, and driplines are seldom used. More details regarding the technology of the SSIT program can be found in Annex 7. For the cost-benefit analysis, it is necessary to note that the renting of irrigation equipment is also a common practice in Rwanda, with farmers paying a fee based on the amount of fuel used.

Land size and access

Land is a scarce resource in Rwanda, with an average and median farm size in the irrigated marshlands of 0.16 ha and 0.10 ha, respectively, compared with 0.41 ha and 0.40 ha in the hillside irrigation areas.[48] In the field survey data, the average and median sizes of land owned are 6.88 ha and 1.00 ha, respectively; for rainfed areas, 4.33 ha and 1.00 ha; and for irrigated areas, 3.37 ha and 0.40 ha. The rainfed and irrigated areas are areas used so they include rented land as well. The data indicates that several farmers have relatively large land holdings (>10 ha) in the SSIT program. The distribution of land holdings from the survey data is depicted in Figure 2.9.

Figure 2.9: Distribution of land holdings and rainfed and irrigated areas (n=375)



[47] RAB. 2020. "Rwanda Irrigation Master Plan." Draft version.

[48] RAB. 2020. "Rwanda Irrigation Master Plan." Draft version.

The area distribution data shows that land rental is a common practice among SSIT farmers, as cultivated areas are often larger than land owned. This finding was corroborated in the field interviews (Figure 2.10). The land rental price was found to range from RF 50,000 to RF 500,000 (about US$49–US$490) per hectare per year, with an average of RF 205,000 (about US$202).

Organizational style and market linkages

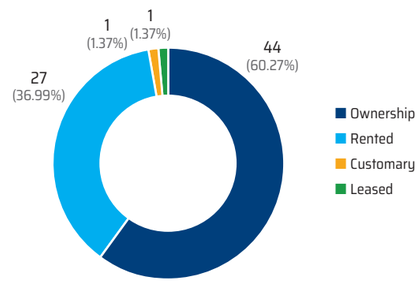
The government of Rwanda (GoR) is encouraging small-scale farmers to organize themselves in cooperatives, as reflected in the Land Use Consolidation (LUC) program and other initiatives. Cooperatives are found in government-initiated marshland irrigation schemes (for paddy rice) and in some large-scale hill irrigation systems powered by solar pumps. However, most of the farmers included in the survey irrigate on an individual basis.

Different forms of market linkages exist, but most of the farmers sell their produce to informal traders or directly at a local market. A more elaborate analysis of this aspect is provided in Annex 6 (Markets).

Farmer typologies

The characteristics of farmers in Rwanda in general, and SSIT beneficiaries specifically (as described above), results in eight farmer typologies, outlined in Table 2.2.

Figure 2.10: Tenure type distribution (n=53)



Typologies #1 and #2 are the main target group for SSIT: small-scale irrigating farmers producing vegetables in the dry season, where manual irrigation is seen as a first step (learning about irrigation application, agronomy of horticulture, and market relations) before upgrading to larger (pump and hose) systems. Typology #3 relates to smallholder horticulture farmers who have shifted to solar-powered irrigation. Typologies #4 and #5 relate to different irrigated maize production systems, with variations in market relation and scale. Typology #6 relates to another solar solution to understand the implications of investing in solar systems for larger production systems. Typologies #7 and #8 are included to analyze the different types of irrigated rice production: cooperative vs. individual.

Table 2.2: Farmer typologies

#	Characteristics/ Type	Irrigation technology	Crops	Size	Access	Organizational style	Market linkages
1	Small/ Informal	Bucket/Watering can	Eggplant	<0.5 ha	Land rented; tech owned; no water fee	Individual	Informal traders
2	Medium/Informal/ Commercial	Pump/Hose	Tomato	0.5–1 ha	Land owned; tech owned; no water fee	Individual	Informal traders
3	Small/Innovator/ Commercial	Solar/Mobile	Tomato	<1 ha	Land owned; tech owned; no water fee	Individual	Informal traders
4	Medium/Informal/ Mixed subsistence/ Commercial	Pump/Hose	Maize	0.5–1 ha	Land owned; tech owned; no water fee	Individual	Informal traders
5	Large/Formal/ Contract	Pump/Hose	Maize seeds	>3 ha	Land owned; tech owned; water fee	Individual	Contract farming
6	Large/Innovator/ Commercial	Solar/Fixed	Macadamia	>3 ha	Land owned; tech owned; water fee	Individual	Contract farming
7	Small/Rice/ Cooperative	Canal/Marshland	Rice	<0.5 ha	Land rented; tech rented; water fee	Cooperative	Cooperative
8	Small/Rice/Private	Canal/Marshland	Rice	<1 ha	Land owned; tech owned; no water fee	Individual	Informal traders

2.3.3 Assessment of SSIT costs and subsidy rates

The costs of different SSIT equipment types included in the cost-benefit analysis are based on the price list of SSIT equipment provided by the Rwanda Agriculture and Animal Resources Development Board (RAB). More information on equipment costs and financing arrangements can be found in Annex 7 (Technology) and Annex 5 (Finance).

As per a feasibility study by the Ministry of Agriculture and Animal Resources (MINAGRI), SSIT equipment is subsidized up to 40 percent.[49] Additionally, up to 5 percent of the field visit, design, and bill of quantity (BOQ) costs are subsidized, as well as 5 percent of the costs for installation and training. This amounts to up to 50 percent of the SSIT equipment (installation) costs being subsidized (Table 2.3).

The actual rate of subsidy for the equipment depends on the area of consolidated land and the profitability of the proposed production system, as indicated in Table 2.4.

Profitability was categorized as low, medium, or high, based on the content of the business proposal. The business proposal was assessed using three criteria:

- The choice of a high-value crop (for example banana, onions, or tomato)
- Water availability at less than 20 meters
- Use of a low-pressure pump capacity, pumping, and maintenance costs of the proposed type of SSIT.

In practice, however, it was found that the land consolidation and profitability criteria were either not assessed or were reflected in the price paid: 85 percent of the interviewed farmers paid between 45 and 55 percent of the total equipment price. For the cost-benefit analyses, a subsidy of 50 percent is thus assumed as the standard rate.

2.3.4 Cost-benefit analyses

A cost-benefit analysis was performed for each of the typologies. The production data on input use and costs, labor, and yields was obtained from the farmer field surveys. Equipment costs were divided over the lifespan of the equipment. The results of the analyses are presented here and are compared to similar analyses for Rwandan smallholder production systems from literature. The detailed analyses can be found in the Appendix.

The overall results of the cost-benefit analyses are presented in Figure 2.11. Net profit, both with and without an irrigation equipment subsidy, were included. For comparison purposes, all values are in Rwandan francs (RF) per hectare per season.

Table 2.3: Subsidy breakdown and cost sharing

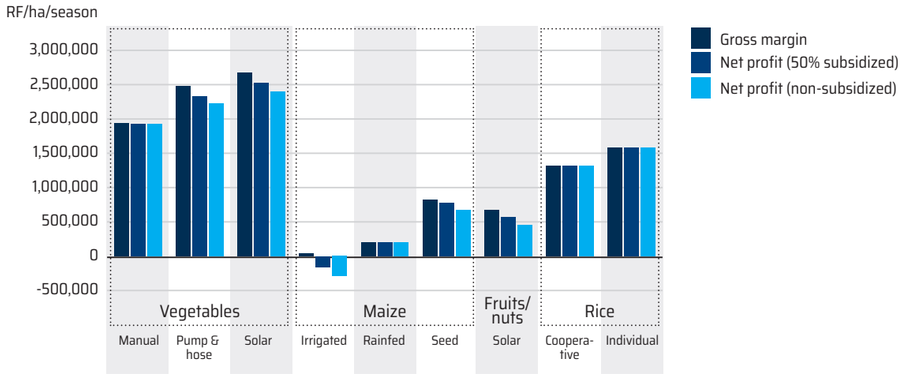
Cost item	Government subsidy	Beneficiary cost	Comment
SSIT equipment	Up to 40%	Remaining part	Not more than 40% of project cost
Field visit, design, and BOQ	Up to 5%	95%	Not more than 5% of project cost
Installation and training	Up to 5%	95%	Not more than 5% of project cost
Operation and maintenance	0%	100%	Warranty for six months

Table 2.4: Subsidy allocated per criteria

Land consolidation	Subsidy rate (%)		
	Low	Medium	High
7.5–10 ha	50	37.5	25
5.0–7.0 ha	37.5	25	20
1.5–4.5 ha	25	20	15
0.5–1.0 ha	20	10	10

[49] MINAGRI. 2014. *Feasibility Study on Farmer-Led SSIT Program.*

Figure 2.11: Summary of results of cost-benefit analyses for several irrigated farming typologies



Several observations can be made based on the analyses.

First, irrigated production is generally profitable in Rwanda, except for irrigated maize production. This might be because many farmers irrigate maize for food security purposes, and the monetary loss is accepted in exchange for increased food security. The profitability of rainfed maize is also considerably higher (RF 201,500 per hectare per season—see Table A2.4b in the Appendix).

Second, the net profit does not increase significantly with a 50 percent subsidy on irrigation equipment. For small-scale vegetable production, the increase is 4 percent; for pump and hose and solar systems, the increase is 5 percent; for irrigated seed maize it is 15 percent; and for the large-scale solar system it is 23 percent. This indicates that such a subsidy has little influence on the annual profitability of smallholder-irrigated agriculture. However, the subsidy helps to significantly lower the initial capital needed to start irrigation, primarily for more expensive systems such as solar pumps. Given the lower operational costs of solar irrigation, this is also more profitable in the long term.

Third, it was found from the field survey that the lifetime of fuel pump and hose systems was considerably shorter than expected—generally, about two to three years for pumps and only one year for hoses, possibly because of a lack of training about the operation and maintenance of pumps, as well as low-quality hose material. The relatively low lifespan results in low net profits per season, a situation that could be improved with training and better maintenance options.

This analysis also shows that individual rice production could be more profitable than rice production linked to a cooperative. This is mainly as a result of the lower production costs related to land rentals and water fees, but also because farmers in cooperatives are required to sell all of their rice output and may not take any of it for their own consumption, which increases opportunity costs. However, this conclusion is preliminary, and a more elaborate analysis of both production systems is needed for any recommendations on this topic.

Another observation from the field survey is that yields are rather low, both for rainfed and irrigated production. Although the analysis is based on a limited number of farmer surveys and yield was not directly measured, this raises the issue that, for food security reasons, other aspects of farming besides irrigation need to be improved. In Table 2.5, irrigated yields of selected crops are presented alongside indicative attainable yields for sub-Saharan Africa.[50]

Figure 2.12 compares the net financial benefit of different production systems over time. The rainfed production system consists of one harvest of maize and one of rainfed vegetables per year; the irrigated system consists of two maize harvests and one harvest of irrigated vegetables per year using pump and hose systems, the same as the solar production system. The results indicate that given the high profits, both the irrigated and solar production systems are quickly more profitable than rainfed farming, and that the payback time is rather short, even for solar systems.

[50] KZNDARD (KwaZulu-Natal Department of Agriculture and Rural Development). 2019. *Vegetable Production in KwaZulu-Natal: Expected Yields* (accessed September 7, 2021), https://www.kzndard.gov.za/images/Documents/Horticulture/Veg_prod/expected_yields.pdf. (Note that "conservative" expected yields are used.)

Table 2.5: Average, median, and attainable yields of selected irrigated crops

Crop	Average yield (kg/ha)	Median yield (kg/ha)	Attainable yield (kg/ha)
Beetroot	500	500	14,000
Bush beans	500	500	3,500
Cabbage	3,967	4,000	30,000
Carrot	4,875	4,500	20,000
Chili	2,000	2,000	7,000
Eggplant	19,500	19,500	20,000
Eggplant (African)	7,000	6,500	13,500
Green peppers	2,500	2,500	7,000
Macadamia	600	600	3,750[51]
Maize	3,681	3,300	7,000[52]
Onion	3,007	2,700	17,500
Tomato	12,351	12,500	30,000

Figure 2.11 presents a rather simplified picture of irrigated farming in Rwanda. To investigate farming production systems and their profitability in more detail, a more in-depth analysis of production costs and profit for smallholder tomato farming with SSIT subsidy for different land sizes was performed.

Figure 2.13 shows the total profit for the first season only, when the investment in irrigation equipment must be paid. Data regarding input costs and revenue can be found in Table A2.2a in the Appendix. Results are calculated for the situation with/without monetized family labor, and with/without land rental. Additionally, a comparison is made to the situation without SSIT subsidy, including all other costs (monetized family labor and land rent). The results show that with the subsidy, smallholder tomato farming is profitable with a land size of about 0.25 ha, even after the first season. Without a subsidy, the land size must be at least 0.4 ha to be profitable.

After the first season, the costs decrease significantly, as the investment has already been made. However, depreciation costs for the equipment must still be included, given that money must be set aside to buy new equipment (without a subsidy) when its lifespan has passed.

Figure 2.12: Net profit of different production systems over time

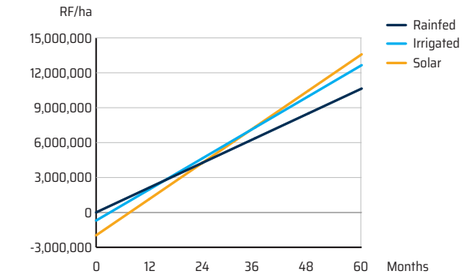


Figure 2.13: Total profit of smallholder tomato farming for different land sizes

[51] AgMRC (Agricultural Marketing Resource Center). 2021. *Macadamia Nuts* (accessed September 7, 2021), https://www.agmrc.org/commodities-products/nuts/macadamia-nuts.

[52] AGRA (Alliance for a Green Revolution in Africa). 2020. *Rwanda on Course to Become Self-Sufficient in Seed Supply* (accessed September 7, 2021), https://agra.org/rwanda-on-course-to-become-self-sufficient-in-seed-supply-2/.

Figure 2.14: Profitability of different areas of smallholder tomato farming with subsidy (unbroken lines) and without SSIT subsidy (dotted lines)

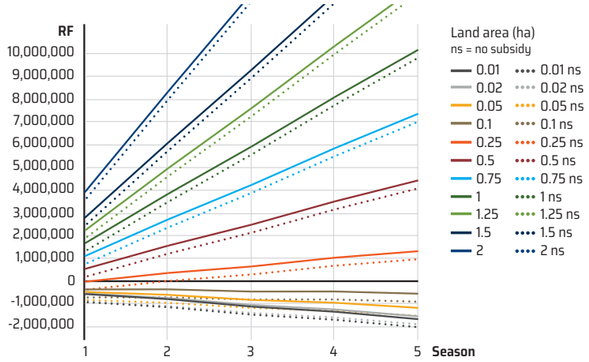


Figure 2.14 presents the profitability of different landholding sizes, with and without subsidy, including all costs (own labor and land renting). The results show that long-term profitability is not significantly impacted by the subsidy, but it does make smallholder irrigated tomato farming profitable from a landholding size of 0.25 ha after the first season, instead of from 0.4 ha without the subsidy.

Given that most Rwandan farmers have plots in this category, the subsidy would have succeeded in accelerating the uptake of irrigated farming. For farmers with smaller land sizes, grouping together and applying collectively for SSIT equipment could be considered, given that the investment burden can then be shared between several farmers, as well as the depreciation costs and costs of equipment maintenance.

Another strategy would be to promote the renting of equipment and provide irrigation as a service, where farmers would pay only for renting the equipment (and fuel). As presented in Table A2.2b in the Appendix to Annex 2, this would be profitable for all land sizes, as there are no fixed costs involved (that is, no investment costs for equipment, irrespective of land size).

Literature comparison

The draft Irrigation Master Plan[53] presents an extensive table on estimated gross margins for irrigated crops on page 36. In general, vegetables have the highest margins for irrigated production, especially tomato and garlic, with over RF 4 million/ha (about US$3,920) of gross margin. All other vegetables included have a gross margin of about RF 2 million/ha (about US$1,960), similar to the results of the cost-benefit analyses presented in this annex. Other food crops, such as maize and soya beans, have considerably lower gross margins (RF 748,812/ha and RF 471,610/ha (about US$734 and US$462, respectively)), which is also comparable to the results of the presented assessment.

In the 2014 feasibility study performed by MINAGRI (Table 2.6), cost-benefit analyses were performed with different subsidy levels for onion, tomato, and maize. These also indicated considerable possible profits for smallholder farmers using SSIT equipment; however, yields are overestimated in comparison to the data from the field survey. Similar net profit amounts indicate that production costs are also estimated to be higher in MINAGRI's analyses.

Table 2.6: Cost-benefit analyses for several crops and subsidy rates

Subsidy rate (%)	Net profit on banana (RF) with 50 T Ha^{-1}	Net profit on onion (RF) with 20 T Ha^{-1}	Net profit on tomato (RF) with 20 T Ha^{-1}	Net profit on maize (RF) with 4 T Ha^{-1}
0	1,591,095	1,543,483	716,728	–291,465
25	1,628,396	1,580,784	747,598	–254,164
50	1,665,698	1,618,085	778,468	–216,863

[53] RAB. 2020. "Rwanda Irrigation Master Plan." Draft version.

Labor

For the cost-benefit analyses, two important notes must be made regarding the labor component.

First, according to the field survey data, the amount of labor days per crop cycle for one hectare does not differ significantly between pump and hose systems and manual irrigation. For example, the average amount of labor for tomato is 370 days/ha for manual irrigation, compared to 360 days/ha for pump and hose systems, where a greater difference (lower labor for pump and hose) might be expected. Irrigation techniques encountered in the field could be an explanation for this: with pump and hose systems, the hoses are often carried around by multiple people, and water is applied directly to the crops. Less laborious short-furrow irrigation methods were not seen in the fields, and automated sprinkler/raingun systems were infrequently seen, indicating that irrigation is still a rather new practice in many parts of Rwanda and that there is little experience with different (less laborious) application methods. More information on this observation is discussed in Annex 4 (Knowledge).

Second, the amount by which family labor is valued (known as the shadow wage) is crucial. A recent research paper[54] examined constraints on the adoption of irrigation in the context of hillside irrigation schemes in Rwanda. The research found that, although irrigation enables dry season horticultural production, boosting on-farm cash profits by 44–71 percent, technology adoption was still rather low; four years after the canals became operational, only 30 percent of plots were irrigated. The most significant reason for this low adoption is the increased labor costs involved: if the household's labor increase is included in the analysis (with household wages valued at market rates), then the 44–71 percent gain becomes a 12–38 percent loss in profits. The conclusion is that the profitability of the transition to dry season horticulture enabled by irrigation depends crucially on the shadow wage at which household labor is valued.

The cost-benefit analyses performed for this assessment indicated little loss in profits when including family labor: gross margins decrease on average by 7.6 percent and net profits by 8.7 percent. Labor was also not identified by farmers as one of the main constraints on adopting irrigation during the field survey. However, increased labor still needs attention when promoting irrigation, especially with regard to water application techniques. Most water application techniques used in the field were unnecessarily labor-intensive because farmers have limited irrigation knowledge and expertise, a problem that can be tackled by training.

Other benefits of irrigation

In addition to dry-season production, irrigation can have other significant benefits, as discussed in the following sections.

Market timing (crop price fluctuation)

The field survey data indicates a considerable price fluctuation throughout the year for several crops.

Table 2.7: Price fluctuation of several crops

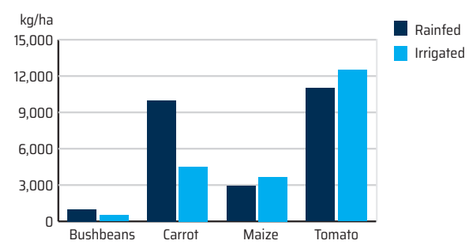
Crop	Low price	Normal price	High price
Maize	80–100 RF/kg	150–180 RF/kg	200 RF/kg
Tomato	50 RF/kg	300 RF/kg	500 RF/kg
Eggplant	90 RF/kg	350 RF/kg	550 RF/kg
Cabbage	50 RF/pc	150 RF/pc	200 RF/pc

These results show that profits can vary significantly throughout the year. Irrigation can be used to time production such that higher prices can be obtained, a strategy that has considerable potential in Rwanda given this data. However, only 25 percent of interviewed farmers were doing this.

Increased rainfed production

When applied correctly, irrigation could also increase rainy season yields. When comparing the yields of several crops for rainfed and irrigated production (Figure 2.15), the yield of irrigated crops is, however, not much greater (tomato and maize) or is even lower (bush beans and carrot) for irrigated production. This indicates that agronomic aspects other than irrigation need to be improved simultaneously—also given the attainable yields presented in Table 2.5.

Figure 2.15: Average rainfed and irrigated yields of selected crops



[54] Jones, M R, Kondylis, F, Loeser, J A, and Magruder, J. 2019. *Factor Market Failures and the Adoption of Irrigation in Rwanda.* Washington, DC: The World Bank.

2.4 Conclusion

The financial benefit of irrigation to farmers in Rwanda is medium: there is a relatively short dry season in many areas, and the market linkages for irrigated produce are often rather weak. However, considerable profits can be made with vegetable production in the dry season, and there is a potential increase in the yields of irrigated crops during the rainy season.

The cost-benefit analyses performed for several farmer typologies also indicate considerable profits from irrigated agriculture in Rwanda, except for small-scale irrigated maize. Survey data reveals, however, that (irrigated) production in Rwanda still has rather low yields and could benefit from improved input use and capacity building.

The SSIT equipment subsidy increases net profit by about 10 to 20 percent during the lifecycle of the subsidized system. Considering the range of profits made by smallholder irrigators using (fuel) pump and hose systems, it is assumed that the subsidy on this type of equipment has little influence on farmers' willingness and capacity to pay. However, given the higher initial investment needed for solar pumps, the subsidy can be an effective way to promote the use of these specific systems.

2.4.1 Recommendations

Given these findings, we recommend two main changes for the SSIT program.

First, the lifespan of diesel/petrol pumps and pipes is relatively short (two to three years). Training and better maintenance services can increase this lifespan and increase net seasonal benefits for all irrigated production systems. Moreover, building capacity of irrigation agronomy and techniques could lower production costs, given that the survey indicates that many farmers applied inefficient irrigation techniques. Second, given the assumed minor influence on farmers' willingness and capacity to pay the subsidy for (fuel) pump and hose systems, it might be better to put more focus on systems with higher initial investment costs (solar, for example), for which a subsidy could have more impact.

2.5 Diagnostics and scoring

To score the farmer benefit aspect of irrigation in Rwanda, account for the fact that the dry season is relatively short. Moreover, drought-related crop failure is not (yet) a major issue, but it could become increasingly problematic given climate change effects. Survey data shows the potential yield increase for irrigated crops compared to non-irrigated crops during the rainy season. Considerable profits can be made from irrigated production during the (short) dry season, although market linkages for selling irrigated produce are rather weak in some areas. Given these aspects, the overall farmer benefit of irrigation in Rwanda scores 3 out of 5 (medium).

2.6 Appendix: Detailed cost-benefit analyses

Table A2.1: Vegetables; manual

COSTS

Input	Unit	Quantity	Unit cost	Total costs
Seeds	RF/ha	0.25	12,500	3,125
Fertilizer	RF/ha	0.25	50,000	12,500
Pesticide	RF/ha	0.25	150,000	37,500
Subtotal				**53,125**

Labour	Worker days/ha	Quantity	Wage rate (RF/day)	Total costs
Family	150	0.25	1,200	45,000
Hired	100	0.25	1,200	30,000
Subtotal				**75,000**
Total costs				**128,125**

BENEFIT

Crop	Yield (kg/ha)	Price (RF/kg)	Revenue
Eggplant (African)	7,000	350	612,500
			per ha:
Gross margin	RF/season	**484,375**	**1,937,500**

INVESTMENT COSTS

Item	Costs (RF)	Lifespan (seasons)	Cost/ season
Bucket/can	10,000	4	2,500
			per ha:
TOTAL PROFIT	RF/season	**481,875**	**1,927,500**
	US$/season	497	1,987

Table A2.2a: Vegetables; pump and hose system (technology owned)

COSTS

Input	Unit	Quantity	Unit cost	Total costs
Seeds	RF/ha	1	25,000	25,000
Fertilizer	RF/ha	1	100,000	100,000
Pesticide	RF/ha	1	200,000	200,000
Fuel	RF/ha	1	200,000	200,000
Subtotal				**525,000**

Labour	Worker days/ha	Quantity	Wage rate (RF/day)	Total costs
Family	150	1	1,200	180,000
Hired	100	1	1,200	120,000
Subtotal				**300,000**

Land renting	ha	RF/ha	Total costs
0	0	240,000	0
Total costs			**825,000**

BENEFIT

Crop	Yield (kg/ha)	Price (RF/kg)	Revenue
Tomato	11,000	300	3,300,000
			per ha:
Gross margin	RF/season	**2,475,000**	**2,475,000**

INVESTMENT COSTS

Item	Costs (RF)	Farmer costs (RF)	Lifespan (seasons)	Cost/ season
Pump	500,000	250,000	5	50,000
Hose	200,000	100,000	2	50,000
Maintenance				50,000
Subsidy	*50%*			150,000
				per ha:
TOTAL PROFIT	RF/season	**2,325,000**		**2,325,000**
	US$/season	2,397		2,397

Table A2.2b: Vegetables; pump and hose system (technology rented)

COSTS

Input	Unit	Quantity	Unit cost	Total costs
Seeds	RF/ha	1	25,000	25,000
Fertilizer	RF/ha	1	100,000	100,000
Pesticide	RF/ha	1	200,000	200,000
Fuel	RF/ha	1	400,000	400,000
Subtotal				**725,000**

Labour	Worker days/ha	Quantity	Wage rate (RF/day)	Total costs
Family	150	1	1,200	180,000
Hired	100	1	1,200	120,000
Subtotal				**300,000**

Land renting	ha	RF/ha	Total costs
0	0	240,000	0
Total costs			**1,025,000**

BENEFIT

Crop	Yield (kg/ha)	Price (RF/kg)	Revenue
Tomato	11,000	300	3,300,000
			per ha:
Gross margin	RF/season	**2,275,000**	**3,033,333**
			per ha:
TOTAL PROFIT	RF/season	**2,275,000**	**3,033,333**
	US$/season	2,345	3,127

Table A2.3: Vegetables; solar pump system

COSTS				
Input	**Unit**	**Quantity**	**Unit cost**	**Total costs**
Seeds	RF/ha	0.75	25,000	18,750
Fertilizer	RF/ha	0.75	100,000	75,000
Pesticide	RF/ha	0.75	200,000	150,000
Subtotal				**243,750**

Labour	**Worker days/ha**	**Quantity**	**Wage rate (RF/day)**	**Total costs**
Family	150	0.75	1,200	135,000
Hired	100	0.75	1,200	90,000
Subtotal				**225,000**

Land renting	**ha**	**RF/ha**	**Total costs**
0	0	240,000	0
Total costs			**468,750**

BENEFIT			
Crop	**Yield (kg/ha)**	**Price (RF/kg)**	**Revenue**
Tomato	11,000	300	2,475,000
			per ha:
Gross margin RF/season		**2,006,250**	**2,675,000**

INVESTMENT COSTS				
Item	**Costs (RF)**	**Farmer costs (RF)**	**Lifespan (seasons)**	**Cost/ season**
Solarpump + hose	1,970,000	985,000	10	98,500
Maintenance				10,000
Subsidy 50%				108,500
				per ha:
TOTAL PROFIT RF/season			**1,897,750**	**2,530,333**
US$/season			1,956	2,609

Table A2.4a: Maize, small-scale irrigated

COSTS				
Input	**Unit**	**Quantity**	**Unit cost**	**Total costs**
Seeds	RF/ha	0.75	25,000	18,750
Fertilizer	RF/ha	0.75	100,000	75,000
Pesticide	RF/ha	0.75	20,000	15,000
Fuel	RF/ha	0.75	200,000	150,000
Subtotal				**258,750**

Labour	**Worker days/ha**	**Quantity**	**Wage rate (RF/day)**	**Total costs**
Family	100	0.75	1,200	90,000
Hired	70	0.75	1,200	63,000
Subtotal				**153,000**

Land renting	**ha**	**RF/ha**	**Total costs**
0	0	240,000	0
Total costs			**411,750**

BENEFIT			
Crop	**Yield (kg/ha)**	**Price (RF/kg)**	**Revenue**
Maize	3,600	165	445,500
			per ha:
Gross margin RF/season		**33,750**	**45,000**

INVESTMENT COSTS				
Item	**Costs (RF)**	**Farmer costs (RF)**	**Lifespan (seasons)**	**Cost/ season**
Pump	500,000	250,000	5	50,000
Hose	200,000	100,000	2	50,000
Maintenance				50,000
Subsidy 50%				150,000
				per ha:
TOTAL PROFIT RF/season			**–116,250**	**–155,000**
US$/season			–120	–160

Table A2.4b: Maize, small-scale rainfed

COSTS				
Input	**Unit**	**Quantity**	**Unit cost**	**Total costs**
Seeds	RF/ha	0.75	25,000	18,750
Fertilizer	RF/ha	0.75	100,000	75,000
Pesticide	RF/ha	0.75	200,000	15,000
Subtotal				**108,750**

Labour	**Worker days/ha**	**Quantity**	**Wage rate (RF/day)**	**Total costs**
Family	70	0.75	1,200	63,000
Hired	40	0.75	1,200	36,000
Subtotal				**99,000**

Land renting	**ha**	**RF/ha**	**Total costs**
0	0	240,000	0
Total costs			**207,750**

BENEFIT			
Crop	**Yield (kg/ha)**	**Price (RF/kg)**	**Revenue**
Maize	2,900	165	358,875
			per ha:
Gross margin RF/season		**151,125**	**201,500**
			per ha:
TOTAL PROFIT RF/season		**151,125**	**201,500**
US$/season		156	208

Table A2.5: Maize; medium-scale contract farming (seed production)

COSTS				
Input	**Unit**	**Quantity**	**Unit cost**	**Total costs**
Seeds	RF/ha	3	100,000	300,000
Fertilizer	RF/ha	3	200,000	600,000
Pesticide	RF/ha	3	40,000	120,000
Fuel	RF/ha	3	200,000	600,000
Subtotal				**1,620,000**

Labour	**Worker days/ha**	**Quantity**	**Wage rate (RF/day)**	**Total costs**
Family	70	3	1,200	252,000
Hired	40	3	1,200	144,000
Subtotal				**396,000**

Land renting	**ha**	**RF/ha**	**Total costs**
0	0	240,000	0
Water fee	3	20,000	60,000
Total costs			**2,016,000**

BENEFIT			
Crop	**Yield (kg/ha)**	**Price (RF/kg)**	**Revenue**
Maize	5,000	300	4,500,000
			per ha:
Gross margin RF/season		**2,484,000**	**828,000**

INVESTMENT COSTS				
Item	**Costs (RF)**	**Farmer costs (RF)**	**Lifespan (seasons)**	**Cost/ season**
Pump	500,000	250,000	5	50,000
Hose	200,000	100,000	2	50,000
Maintenance				50,000
Subsidy 50%				150,000
				per ha:
TOTAL PROFIT RF/season			**2,334,000**	**778,000**
US$/season			2,406	802

Table A2.6: Perennials; solar large scale

COSTS				
Input	**Unit**	**Quantity**	**Unit cost**	**Total costs**
Seeds	RF/ha	40	250,000	10,000,000
Fertilizer	RF/ha	40	400,000	16,000,000
Pesticide	RF/ha	40	200,000	8,000,000
Subtotal				**34,000,000**

Labour	**Worker days/ha**	**Quantity**	**Wage rate (RF/day)**	**Total costs**
Family	2	262	1,200	628,800
Permanent	15	262	1,500	5,895,000
Seasonal	60	40	1,500	3,600,000
Subtotal				**10,123,800**

Land renting	**ha**	**RF/ha**	**Total costs**
0	0	240,000	0
Water fee	40	20,000	800,000
Total costs			**44,923,800**

BENEFIT			
Crop	**Yield (kg/ha)**	**Price (RF/kg)**	**Revenue**
Macadamia	600	3,000	72,000,000
			per ha:
Gross margin RF/season		**27,076,200**	**676,905**

INVESTMENT COSTS				
Item	**Costs (RF)**	**Farmer costs (RF)**	**Lifespan (seasons)**	**Cost/ season**
Total installation	85,000,000	42,500,000	10	4,250,000
Maintenance				200,000
Subsidy 50%				4,450,000
				per ha:
TOTAL PROFIT RF/season			**22,626,200**	**565,655**
US$/season			23,326	583

Table A2.7: Rice; cooperative

COSTS				
Input	**Unit**	**Quantity**	**Unit cost**	**Total costs**
Seeds	RF/ha	0.2	30,000	6,000
Fertilizer	RF/ha	0.2	250,000	50,000
Pesticide	RF/ha	0.2	15,000	3,000
Subtotal				**59,000**

Labour	**Worker days/ha**	**Quantity**	**Wage rate (RF/day)**	**Total costs**
Family	40	0.2	1,200	9,600
Hired	150	0.2	1,200	36,000
Subtotal				**45,600**

Land renting	**ha**	**RF/ha**	**Total costs**
1	0.2	240,000	48,000
Water fee	0.2	20,000	4,000
Total costs			**156,600**

BENEFIT			
Crop	**Yield (kg/ha)**	**Price (RF/kg)**	**Revenue**
Rice	7,000	300	420,000
			per ha:
Gross margin	RF/season	**263,400**	**1,317,000**
			per ha:
TOTAL PROFIT	RF/season	**263,400**	**1,317,000**
	US$/season	272	1,358

Table A2.8: Rice; individual

COSTS				
Input	**Unit**	**Quantity**	**Unit cost**	**Total costs**
Seeds	RF/ha	0.2	30,000	6,000
Fertilizer	RF/ha	0.2	250,000	50,000
Pesticide	RF/ha	0.2	15,000	3,000
Subtotal				**59,000**

Labour	**Worker days/ha**	**Quantity**	**Wage rate (RF/day)**	**Total costs**
Family	40	0.2	1,200	9,600
Hired	150	0.2	1,200	36,000
Subtotal				**45,600**

Land renting	**ha**	**RF/ha**	**Total costs**
0	0	240,000	0
Water fee	0	20,000	0
Total costs			**104,600**

BENEFIT			
Crop	**Yield (kg/ha)**	**Price (RF/kg)**	**Revenue**
Rice	7,000	300	420,000
			per ha:
Gross margin	RF/season	**315,400**	**1,577,000**
			per ha:
TOTAL PROFIT	RF/season	**315,400**	**1,577,000**
	US$/season	325	1,626

ANNEX 3: POLICY AND LEGAL FRAMEWORK

Key findings

Policies and a regulatory framework for water and land security are essential to developing farmer-led irrigation. This annex assesses policies and laws, mainly focusing on water and land, with a particular emphasis on tenure, governance, and regulations. Policies relating to knowledge, access to finance, and access to markets are covered in other annexes.

On water tenure type and governance, this annex describes how the small-scale irrigation technology (SSIT) program has benefited from the characteristics of water and land use rights, helping SSIT beneficiaries to benefit from access to these key elements in developing irrigation. The Water Law defines modalities for sustainably managing water resources and modalities for accessing water use permits and application procedures. These, in part, set a good regulatory framework for managing water resources and facilitating access to permits by setting up processes for applying water permits and an institutional framework for water management.

However, enforcing the Water Law is still challenging, and there are constraints on applying the requirements of the law to small farmers scattered across the country. In addition, the Rwanda Water Resources Board (RWB)—mandated to implement water resources management policies—is still nascent and has no subnational structures to inspect all smallholder water users. These constraints create a governance gap in terms of managing water resources and enforcing water use permits. Policies and guidelines, such as the Water Resources Master Plan, the Irrigation Master Plan, and the Land Use Master Plan, are clear on how water resources should be managed to support current and future generations. Environmental policies and laws also support regulations for water resources management and environmental safeguards.

On land tenure, security, and regulations, Rwanda has made good progress on the registration and regulation of ownership and rights transfers, setting the basis for secure investment in land. It has been made mandatory for SSIT applicants to be landowners (as per subsidy application forms). Land security has encouraged the farmers to adopt small-scale irrigation, but reports indicate that irrigation has increased land market value, thus increasing the possibility of getting the land leased or the selling price of the land if irrigation infrastructures are installed. The Land Use Consolidation Ministerial Order partly supports investment in irrigated land by regulating different forms of land use on agricultural land, including cooperative farming. This has helped groups of farmers access irrigation equipment and to raise their contributions, which was difficult for some farmers as individuals. During the assessment, we saw shared water permits, which allow grouped farmers to use water legally; most farmers who irrigate on an individual basis use water without proper permits.

The institutional set-up relating to water and land is quite complex, with many institutions involved, but dividing labor clearly makes it easy for farmers to be supported to access government facilities and incentives. However, institutions must coordinate regularly to ensure better service delivery to small farmers.

The policy and legal framework for water and land in Rwanda has created an enabling environment where policies and institutions to help citizens access support services, and to access rights and security of tenure, have produced conditions conducive to developing and adopting small-scale irrigation.

The policy, legal, and institutional framework is scored as “satisfactory,” as it sets the basis on which irrigated agriculture and private sector involvement in irrigation can start, develop, and be sustainable in the long run.

3.1 Introduction

Developing irrigation among smallholders depends on several issues relating to land tenure rights and water rights. Appropriate policies and a sound regulatory framework help farmers access water and land for expanding investments. In Rwanda, the government of Rwanda (GoR) sees agriculture as one of the main drivers to sustain GDP growth and accelerate poverty reduction so that it affects less than 30 percent of the population. The GoR recognizes that for this to happen, the area of land under irrigated agriculture needs to increase, and that the cheapest option for this is through farmer-led irrigation development (FLID). There is a strong national vision and political will to improve Rwanda's agricultural sector, as observed through a number of laws and policies that address issues of land and water rights, land use planning, and environmental safeguards. This contributes to the success of the SSIT program.

Irrigation is one of the main drivers of agriculture development in the country. Our assessment of laws and policies relating to land and water rights and tenure revealed that the legal instruments are well structured and that administrative structures to implement them are functional. Manuals and guidelines have been drafted to guide the implementation of some legal documents. During this assessment, we found that there is enough legal and regulatory back-up to support the development of irrigation in Rwanda. Different policies have also been drafted to support equitable access to water and land, facilitating FLID. The assessment looked at public documents (including strategies and guidelines) and legislation relevant to access rights to water and land, as well as irrigation development.

Our diagnostic assessment and scoring followed the structure of the FLID Guide and was carried out in the following areas:

- Land and water tenure and security (policies, laws, and plans that address land rights, land use planning, and water rights and land use in Rwanda)
- Institutional set-up for irrigation development and water resources management (roles and responsibilities)
- Registration covering issues of water
- Water licensing and permitting
- Land administration and land rights supporting the development of farmer-led irrigation
- Monitoring and evaluation.

This annex concludes with recommendations about what should be included in the policy and legal framework or should be developed further to facilitate the increased adoption and sustainability of small-scale irrigation by small irrigators.

All consulted policies, laws, and regulations are listed in section 9 of this annex.

3.2 Roles and responsibilities in individual and small-scale irrigation development

3.2.1 Roles and responsibilities in water, land, and irrigation policy and regulations

To understand the place of irrigation in the policy and legal framework, one needs to understand the main planning structures for water and land, and their relationship with irrigation. The Ministry of Agriculture and Animal Resources (MINAGRI) implements irrigation through the Rwanda Agriculture and Animal Resources Development Board (RAB). MINAGRI is responsible for the agro-industrial use of water, livestock water demand, agriculture, irrigation, and fisheries. Agriculture is one of the largest users of water.

Districts are responsible for directly implementing irrigation/agricultural policies and programs and creating links to farmers supported by a decentralized RAB structure at stations. Stations support district irrigation engineers with monitoring and technology transfer to farmers. However, while MINAGRI coordinates irrigation development, water and land policies are within the remit of the Ministry of Environment and its implementing agencies. The Rwanda Land Authority (RLA) is responsible for issues relating to land administration and land-use planning. The Rwanda Water Resources Board (RWB) is responsible for water resource management, while issues to do with environmental management and the control of economic activities, including irrigation, are the responsibility of the Rwanda Environment Management Authority (REMA). The Ministry of Local Government, especially through the Local Administrative Entities Development Agency, helps districts to implement central government programs, including transferring required funds to implement annual activities identified by districts in their respective *imihigo*.[55] *Imihigo* include irrigation targets funded by the Ministry of Finance and Economic Planning through earmarked funds to districts. However, the following guidelines are provided by MINAGRI through its implementing branch, RAB.

[55] *Imihigo* is the practice of holding public officials accountable through performance contracts related to particular goals.

This introduces public controls and checks and requires regular consultations between MINAGRI, the Ministry of Local Government, and districts for any irrigation targets. The same applies to developing small-scale irrigation, as it cannot develop without considering the existing policy and legal framework. (The working relationship is outlined in Figure 3.1.) At the district level, RAB stations support staff in district steering irrigation committees and help district technical staff to monitor irrigation projects and implement technology transfer to farmers through extension services. At lower levels of government, sector agronomists help farmers build capacity.

At the farm and irrigation scheme level, individual farmers join irrigation water users' associations, which collect water fees and support the routine operation and maintenance of irrigation structures and equipment. During this study, however, we observed that farmers get support from other extension providers, such as nongovernmental organizations, and from young agriculture professionals who are either hired by RAB or provide extension services for a fee. The extension model on irrigation and other agriculture technologies is done through the national extension system known as "Twigire Muhinzi," which is based on peer learning through farmers' fields schools and farmer promoters, who support the dissemination of technologies by learning from example.[56] This has helped farmers adopt irrigation technologies in some drought-prone zones of the Eastern and Southern Provinces.

Apart from MINAGRI, the RWB is responsible for water use permits applied for through an online system.[57] At the district level, district watershed committees are responsible for issues related to water use, which also have committees at the catchment level. We observed that the RWB has no technical presence at district level to help implement the legal requirements. There is also no official body that groups all water users at the district level, and no apparent link between the catchment committee and the irrigation steering committee at district level (as per our interviews with RAB and the RWB).

Land administration and use is regulated at the district level by the district land bureau, which is responsible for ensuring that land is used according to the land use plan, which every district has the responsibility to define. The bureau is responsible for providing occupancy permits and supporting land transfers. These services have been decentralized to the sector level, where the land officer and notary support the transfer of land use rights for those who buy land, representing the one-stop center of the district land bureau to facilitate citizens to access services close to them.

In relation to the development of small-scale irrigation, MINAGRI is responsible for the development of policies and the regulatory framework. The RWB implements set policies and supports districts with the technical support necessary to deliver adequate services to farmers. For the SSIT program and other agriculture-development programs, the private sector helps MINAGRI to deliver services to farmers. For the SSIT program, private service providers were hired to help distribute irrigation technology to farmers. At the time of the study we listed 14 different service providers, but the numbers change each year.

MINAGRI is also responsible for initiating and managing programs designed to transform and modernize the sector to ensure food security and contribute to the national economy. These programs include irrigation development and crop productivity improvements (such as land use consolidation), managing supporting subsidy schemes (such as for seeds and fertilizers), and subsidies on SSIT and crop insurance.

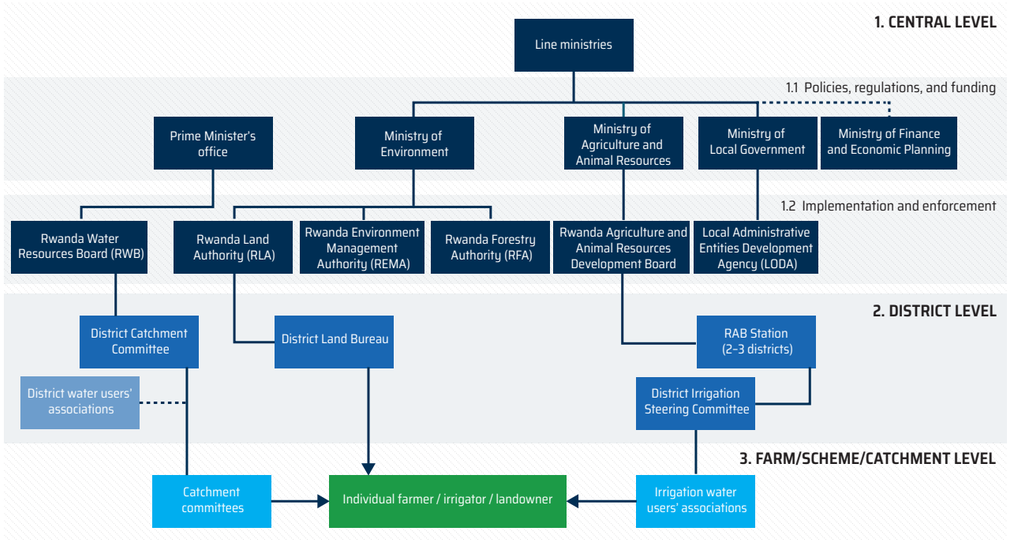
3.2.2 Existing institutional set-up

As illustrated in Figure 3.1, different institutions play a role in policy formulation and in implementing and enforcing the policy and legal framework. Different policies and legal documents have been drafted by relevant ministries, and they all set the basis for better and more equitable access to water resources and land for production. The policy and legal framework in Rwanda relating to water and land rights accommodates both safeguarding the environment and security for farmers, including small farmers who invest in the land.

[56] MINAGRI. 2014. *National Agricultural Extension Strategy.*

[57] Law N°71/2019 of 29/01/2020: Establishing Rwanda Water Resources Board.

Figure 3.1: Institutional framework (land and water policy and legal)



3.3 Regulations covering issues of access to water

Rwanda has abundant water resources, including 101 lakes covering almost 150,000 ha, 6,400 km of rivers, and 860 marshlands spanning an estimated 278,000 ha.[58] Water belongs in the public domain. Its use is a recognized right, accessible to all within the scope of applicable laws and regulations.

The Water Law (N°49/2018 of 13/08/2018) regulates the use and management of Rwanda's water and implements the Water Policy approved in 2011.[59] The objective of the National Water Resources Management Policy is to set policy direction on how the water resources of Rwanda are conserved, protected, and managed, to secure and enhance its availability for, and utility to, present and future generations.

The policy recognizes that water is a key finite resource required for the sustainable socioeconomic development of the country, which must be carefully used and managed to ensure maximum benefits and to minimize harms. It also identifies access to water as a human right. The policy identifies key challenges, including:

- Uncertainty related to climate
- Competition and conflict over water resources
- Poor land use practices, including deforestation and converting wetlands
- Limited infrastructure and limited supply of safe water
- Limited financial, technical, and administrative capacity to effectively manage water resources
- Limited functional framework to support decentralized water users and managers
- Limited data on water resources.

The Water Law (2018) provides legal backup to meet these challenges as highlighted by the Water Policy. The law provides that water is a public good, and responsibility for its proper use and protection lies with the state, the private sector, civil society, and citizens. This law recognizes principles such as protecting water resources from pollution; requiring water users and water polluters to pay; using water users' associations; and providing for the public distribution of water. The priorities set forth in this law for water distribution are domestic use; environmental protection; and economic activities, including agriculture/irrigation.

[58] USAID. 2017. *Rwanda: Land Tenure and Property Rights Profile.*

[59] MINIRENA (Ministry of Natural Resources of Rwanda). 2011. *National Policy for Water Resources Management.*

The Water Law replaced an earlier law, gazetted in 2011, which had a number of implementation Ministerial Orders. Some Ministerial Orders remained, as they were drafted in 2013; others have undergone revisions. Ministerial Orders that implement this law include:

- Ministerial Order N°002/16.01 of 24/05/2013: Determining the Procedure for Declaration, Authorisation and Concession for the Utilisation of Water
- Ministerial Order N°006/16.01 of 24/05/2013: Determining the Organization of Water Resources Data Collection, Treatment, Management, Exploitation and Communication
- Ministerial Order N°007/16.01 of 24/05/2013: Determining the Main Management Visions of Water Resources in the Main Hydrographic Basins in Rwanda.

Ministerial Order N°002/16.01 of 24/05/2013 proposed categorizing permits, including concessions primarily for fish farming, but the order being drafted does not provide for these categorizations.

The Water Law prioritizes small farmers in its water permit requirements by setting the threshold requirement for a water permit at 1 ha, meaning that small farmers irrigating less than 1 ha do not require permits. The law setting out requirements to conduct environmental impact assessments (EIAs) also does not apply to small farmers. EIAs are required for large projects or projects that involve large water storage structures (dams larger than 15 square meters).

During this study, we observed that the responsible institutions sometimes turned a blind eye to small farmers using irrigation water in agriculture, allowing some SSIT beneficiaries with more than 1 ha to irrigate without applying for water use permits. These threshold exemptions were a result of the need to support farmers in drought-prone areas of the Eastern Province.

Cases of collective permitting have been reported as a way of helping farmers comply with their legal requirements. For example, groups of farmers supported by the USAID-funded "Feed the Future Hinga Weze" project in Bugesera district were issued with a permit where they had land of 10 ha or more. The permits, paid for by the project, are registered in the name of "Feed the Future Hinga Weze" and will be transferred to the cooperatives at the close of the project.

The RWB wishes to regulate permits through planned inspections, monitoring farmers who have more than 1 ha and mobilizing them to comply with the requirement to obtain a permit. The RWB also wants this to be a requirement on application forms for SSIT subsidy support.

The Environment Policy (2019)[60] and the Environment Law (N°48/2018 of 13/08/2018) provide the framework for environmental conservation and protection from further degrading caused by economic activities such as irrigated agriculture that may cause irrational use of water. The 2018 Environment Law on determines modalities for protecting, conserving, and promoting the environment. Article 11 states that rivers, streams, underground water, springs, ponds, swamps, and lakes are part of the state's public domain and that their use is governed by law.

3.3.1 Requirements for legal water use

The 2018 Water Law sets the requirements for water rights as they relate to the extraction and use of water from natural sources. Water permits issued by the RWB are applied for online. Once the RWB receives an application, it conducts a technical assessment to determine whether there is enough water in the river, lake, or other source. The allocation process is based on Ministerial Order N°006/16.01 of 24/05/2013, which gives the RWB a mandate to allocate water to users and sectors (domestic use, environment conservation, and economic activities). Water allocation is determined by catchment plans—if a particular catchment demand is not yet exceeded, users can still be allocated water.

On the enforcement side, the RWB is facing problems of water-use verification under SSIT. The main issue is that the area indicated in the SSIT database is the total area owned by the farmer, which is often larger than the actual irrigated area.

3.3.2 Water licensing/permitting

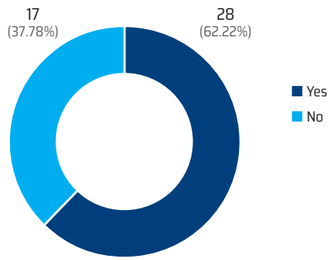
Law N°71/2019 of 29/01/2020: Establishing RWB also sets the RWB's responsibilities and functions, which include monitoring the use of water resources.

As set out in the Water Law (2018), the Environment Policy (2019), and the Environment Law (2018), water is considered a common resource that belongs to everyone and is, therefore, owned by no one, its use governed by law. Landowners must use water resources in a rational manner that optimizes its use as per these legal documents. Based on the requirements of the 2018 Water Law, no farmer can divert the course of a river or water body without permission, and no one may pollute water resources or water bodies.

[60] Ministry of Environment. 2019. *National Environment and Climate Change Policy*. Republic of Rwanda.

In total, 62 percent of the interviewed farmers indicated that they had permits to use water. However, it was not clear if these permits were formal permits from the RWB or permissions to use water bodies from district authorities or water users' associations in the surveyed areas. In any case, a large proportion (38 percent) reported using irrigation without a water-use permit (Figure 3.2). This was corroborated by the officer in charge of water permits at the RWB, who reported that many small-scale irrigators do not apply for water permits. Farmers interviewed indicated that the cost of a water permit is not prohibitive, as the average cost is about RF 34,000 (US$34).

Figure 3.2: SSIT farmers with water permits



MINAGRI is responsible for the rational use of water potential for agricultural purposes, including irrigation development and livestock development. MINAGRI, through RAB, also manages soil conservation through terracing, drainage, and irrigation, as well as technology transfer and research in these areas.[61]

The Ministry of Environment, through the RWB, regulates integrated water resources management and ensures the protection, conservation, restoration, and rational use of water resources covering all of the country's economic activities and environment conservation.[62] The Ministry of Environment is responsible for helping set water resources policy, ensuring compliance with relevant legislation, and representing the government in intergovernmental organizations on matters related to water. District-level catchment committees are responsible for preparing district-level water management plans. These committees have the power to delegate authority for managing water resources and water infrastructure to local water users' associations. Only irrigation water users' associations are functional in large irrigation schemes. REMA monitors compliance and enforces environmental measures relating to water management and large water bodies, including beneficiaries of SSIT.[63]

3.3.3 Public incentives and subsidies regarding land and water

The GoR provides public goods and services to help farmers adopt irrigation technology. These goods and services include hard infrastructure to facilitate access to water, and developing other enabling infrastructure, such as feeder roads to production areas and post-harvest structures, as well as markets. The GoR also provides an enabling environment through public services, including advocating for financial institutions to support SSIT; increased communication around SSIT; improved use of ICT in agriculture; proximity extension services that mobilize more farmers to adopt the program; and investing in a research component that provides reliable information about profitability for different value chains with different irrigation methods, enabling farmers to make informed choices about the equipment and value chain they invest in.

With the introduction of the revised extension strategy,[64] the GoR also provides services in the form of soft infrastructure, such as extension services customized to be farmer-led as proximity extension services using farmer-to-farmer education via farmers' field schools and peer-to-peer learning through study tours.

Other subsidized value chains include horticulture crops that use irrigation. The GoR has put other agricultural subsidies in place to support the SSIT program. Of these, we have previously discussed agriculture inputs (seeds and fertilizer) that can increase productivity and contribute to greater water profitability when the farmer who is using irrigation has benefited from other subsidies. MINAGRI wants to see these subsidies as a combined package to have an impact, but also to determine how much subsidy the farmer should receive to improve productivity.

This combination will help the GoR to concentrate its efforts where maximum impact can be generated. Scattering the subsidies may result in decreased impact, as all agriculture inputs are interlinked and contribute collectively to the increase in productivity. In our analysis and interviews, we have not seen any links between the application process of these three main inputs (seeds, fertilizer, and irrigation).

[61] GoR (Government of Rwanda). 2017. *Law Establishing Rwanda Agriculture and Animal Resources Development Board.*

[62] GoR. 2020. *Law Establishing Rwanda Water Resources Board.*

[63] GoR. 2013. *Law Determining the Rwanda Environmental Management Authority.*

[64] MINAGRI. 2014. *National Agricultural Extension Strategy.*

3.4 Land registration and land administration

Access to agricultural land is severely limited, and most farmers cultivate small, rain-fed plots. Seventy-five percent of Rwanda's labor force works in agriculture but produced only 33 percent of GDP in 2014. Average landholdings are 0.3 ha per household.[65] To address its land scarcity and low agricultural productivity, Rwanda instituted comprehensive land tenure reform, a systematic land registration program, and a crop intensification program. Participating in the crop intensification program requires the community to agree to accept land consolidation and resettlement.

The GoR's accomplishment of recording and registering rights to all land in Rwanda is a commitment to improving tenure security. The National Land Policy of 2019[66] provides that: (1) all Rwandans will enjoy the same rights of access to land, (2) all land shall be registered and alienable, (3) consolidating household plots is encouraged, and (4) land administration is based on a title deeds registration system.

3.4.1 The type of tenure governance system

The evolution of agriculture, long considered the backbone of the national economy, has become unpredictable, because land has been badly managed. Nonetheless, the agricultural sector employs over 66 percent of the Rwandan working population.[67]

Law N°43/2013 of 16/06/2013: Governing Land in Rwanda classifies land as either individual land or state land. Individual (private) land can be obtained under principles of customary law or under formal law. State land includes: (1) land in the public domain (for example, lake shores, national parks, roads, and tourist sites), which generally cannot be alienated; (2) land in the private domain of the state (such as vacant land, swamps, plantations, and expropriated land), which can be alienated; and (3) district, town, and municipal land that is controlled by local governments.

The formal law recognizes the following tenure types, some of which were issued prior to the Land Law but remain in effect:

- **Right to emphyteutic lease.** According to the 2013 Land Law, every person possessing land acquired through customary means or purchase is the recognized proprietor. The formal law recognizes individual rights to land through the right to emphyteutic lease.
- **Freehold right to land.** These rights apply to developed land with infrastructure reserved for residential, industrial, commercial, social, cultural, or scientific services.
- **Public land.** Public land is in the domain of the state and includes land belonging to public institutions and local authorities.

Other tenure types defined in the 2013 Land Law include: (1) state land in the public domain, (2) land in the public domain of local government, (3) state land in the private domain, (4) land in the private domain of local authorities, and (5) public institution land. Most of the land in Rwanda was titled during the land regularization program, where every private plot was registered, taking into account the family ownership where the husband and wife have equal (50/50) share on the title deed. The management of the land titles is the responsibility of RLA.

3.4.2 Land tenure and security

Having access to land is the fundamental basis for human shelter, food production, and economic activities, including activities of businesses and natural resource users of all kinds. Secure rights to land encourage people to invest in improved dwellings and in the land itself; they can also enable people to access public services and sources of credit. Land-related issues in Rwanda are multiple and varied. Some originate from the morphology and physiology of the land, while others are rooted in socio-demographic and socioeconomic conditions, combined with inadequate land policies, laws, and regulations of the past. Several policies, laws, and guidelines address land rights, land use planning, and rights and land use in Rwanda, thus ensuring security for land use of and investments in the land. Descriptions of selected policy and legal documents on land tenure and security follow.

However much the Land Policy and the Land Law have established the basis for land tenure security, some constraints were identified in implementing these documents. Key concerns relate to weaknesses preparing and implementing master plans for land use and development, expropriations in the public interest, relocating rural dwellers to grouped settlements, land use consolidation programs, confiscating unused and abandoned properties, housing plot size restrictions, and restrictions on the use of other land types, among others.[68]

[65] USAID. 2014. *Rwanda Land Report: Assessment of the Impacts of the Land Use Consolidation Component of the Crop Intensification Program.*

[66] Rwanda Ministry of Environment. 2019. *National Land Policy.* Rwanda Land Management and Use Authority. Republic of Rwanda.

[67] National Institute of Statistics in Rwanda (NISR). 2021. Labour Force Survey, 2021. https://www.statistics.gov.rw/publication/labour-force-survey-annual-report-2021.

[68] USAID. 2015. *An Assessment and Plan for a Comprehensive Review of Rwanda's 2004 National Land Policy.*

Constitution of the Republic of Rwanda, 2003 (as revised in 2015)

The Constitution provides that the state grants private ownership rights and that the law will determine how land can be acquired, transferred, and used. It guarantees every person an inviolable right to property that can only be interfered with for reasons of public utility, where this is established by law and subject to fair and prior compensation.

National Land Policy, 2019

The National Land Policy of 2019 builds on the achievements of the 2004 Land Policy. It provides for equal rights of access to land for all citizens, without discrimination of any kind, and calls for efficient land use planning and management to guarantee tenure security. The Land Policy of 2004 identified fragmented and sub-optimally sized agricultural land parcels (deemed to be primarily caused by patrilocal marriage and patrilineal inheritance and *inter vivos* bequests) as being inefficient and uneconomical. It called for an end to subdividing land (any further by way of succession) if it results in a parcel less than 1 ha in size, for the 1 ha minimum agricultural plot size for other transfers, and for the sale of the bequeathed parts of a parcel to one or more of the heirs by other heirs if the bequest would otherwise result in parcels smaller than 1 ha. For this, it proposed studying and encouraging the re-organizing and consolidating of agricultural parcels. For state private land in marshlands, the policy calls for larger farm units to be given to groups of farmers, and in conclusion it recognizes that land transactions will improve land use and encourage private investment. Customary land (and collective customary land) is no longer recognized in Rwanda, unlike other African countries, as land registration has regulated all land plots, and Ministerial Order N°43/2013 of 16/06/2013 defines the land transfer modalities and requirements for land transfer.

Law determining the use and management of land in Rwanda

The National Land Policy of 2019 emphasizes improving (1) land use planning, surveying, and mapping; (2) land use management; and (3) land administration. It provides for a shift from boundary-based planning to a sectorial and land suitability-based planning.

The organic land law N°08/2005 of 14/07/2005 defines land consolidation as "a procedure of putting together small plots of land in order to manage the land and use in an efficient manner so that the land may give more productivity." It permits the state to expropriate land for purposes of land management and to terminate leases for the purpose of promoting efficient land use. The law also permits the minister to order (by decree) land parcels to be consolidated, although each landholder retains their individual rights to their parcel. The Land Law recognizes rights to land obtained under customary law as equivalent to rights obtained under formal law. The law requires land to be registered, and it sets minimum plot sizes for agricultural land.

Law relating to expropriation in the public interest

The law permits land to be expropriated for the purpose of implementing the National Land Use Master Plan. It also permits the state to confiscate degraded and unused land. However, the law requires that just compensation should be paid to dispossessed land occupiers in both cases, thus granting an inalienable right to land for owners.

Land use consolidation decree

MINAGRI drafted and published Ministerial Order N°14/11.30 of 21/12/2010: Determining the Models of Land Consolidation and its Productivity in 2010 (revised in 2014) to consider new developments in shared infrastructure (including terracing and large-scale irrigation). The order provides details of investment models on consolidated land, including land developed with government funds for terracing and irrigation. This legal document gives the private sector legal backing to partner with landowners to invest in agriculture and expand the investments established on the land by GoR.

Rwanda land tenure security appears not to have hindered the success of the SSIT program completely but may have limited the success achieved over the past five years of the farmer-led irrigation intervention. This assessment was not able to confirm the role of tenure security in the development of SSIT at this stage, as land ownership among beneficiaries of the SSIT subsidy is mixed. We observed that the application forms for the subsidy program do not allow the government subsidy to be granted if the land is not owned by the applicant. Ownership of the land thus plays a major role in accessing the subsidy. However, the survey indicated that some SSIT beneficiaries accessed the subsidy on leased land, and we saw cases of farmers acquiring the irrigation equipment and expanding the area of production on leased lands. One farmer in Bugesera district (in the Rilima sector's Nyabagendwa cell) remarked: "Initially we were given a small pump, and we were using the land close to the lake. Last year, the district informed us that all farmers cultivating within the 50-meter buffer zone of the lakeshore will not cultivate the land again. We had to rent land above the 50-meter buffer zone, but then we faced an issue of the capacity of the land to push the water beyond 100 meters; therefore, we had to rent a larger capacity pump, and additional pipes." In this case, the farmers applied for the subsidy based on ownership but had to rent the land when the legal requirements of the environmental conservation were enforced.

3.4.3 The quality of tenure governance

All individual plots in Rwanda are registered with the RLA and are mapped in the national land registry, which helps local governments collect taxes on land (as part of the revenues decentralized to districts). However, users of land for agriculture sign a lease or contract with the GoR for 99 years (except for marshlands) and they pay a lease fee of RF 1,000 per ha per year. (Marshlands are exempt from this as they are considered publicly owned land.)

When this study was conducted (between March and August 2021), the Ministry of Environment had primary responsibility for land matters. This Ministry is responsible for addressing issues in policy, especially through Ministerial Orders and/or instructions that set out laws and procedures for administering, planning for, and allocating land. Specifically, the Ministry of Environment focuses on managing land and integrated water resources sustainably. The RLA oversees land registration and land use planning.

When private land is acquired by the government, the district or municipal level (for the city of Kigali) or the relevant ministry conducts the expropriation process and requires that the committee managing the process conducts consultative meetings with those affected by the expropriation.

District-level basin committees are responsible for preparing district-level water management plans. The district basin committees have the power to delegate authority for managing water resources and water infrastructure for local water users' associations.

3.5 Farmers' groups

To solve the problem of land scarcity, the National Land Policy recognizes that not every Rwandan will be able to possess their own plot of land. Land consolidation is prioritized in Rwanda as a means of developing economically viable production in the agriculture sector. Grouped farming of a cooperative type is favored to realize the policy goal of land consolidation. The law on cooperatives favors voluntary cooperative membership, and most farming—especially in government-owned marshlands—is done through cooperatives. Some SSIT beneficiaries are members of a cooperative in which the farmers' contribution was collected equally from members and the use of the irrigation equipment was based on an agreed irrigation plan set by the cooperative committee.

MINAGRI has promulgated water users' associations through Ministerial Order N°001/11.30 of 23/11/2011: Establishing Irrigation Water Users Associations in Irrigation Schemes. This Order governs the management of irrigation infrastructure, especially large projects in which the government has invested and where the management, operation and maintenance, water distribution, and collection of water fees has been entrusted to these irrigation water users' associations.

The National Agricultural Policy and the Strategic Plan for Agricultural Transformation both recognize the role that farmers' cooperatives have in developing agriculture. The Land Law also requires the relevant Ministerial head in charge of agriculture to facilitate the consolidation of agricultural land to promote its effective use and ensure optimum productivity.

Ministerial Order N°14/11.30 of 21/12/2010: Determining the Models of Land Consolidation and its Productivity was promulgated to develop large irrigation schemes and increase their productivity. The Ministerial Order proposes cooperative farming as one of the production models for increasing the productivity of land and linking farmers to markets. The Order specifically recognizes the use of subleasing to support lessees who are unable to invest labor and other resources in their land for a period of time.

As described by the Ministerial Order, cooperative farming occurs when farmers come together voluntarily to produce and sell a crop. This has been successful in cooperative rice-producing schemes, where the market linkage is clear from the original inputs to the sale of the product directly to the processing factory.

In this Ministerial Order, contract farming is defined as collaborative farming by a group of individual farmers growing a single or limited number of agreed-upon crops, where there is a contractual relationship between the farmers and one or more buyers. This has helped farmers to access different forms of government support, including subsidies on irrigation, crop insurance, seeds, and fertilizer. According to this Order, the GoR must assist local landholders and land tillers to: (1) understand and participate in market-based crop selection; (2) set prices; (3) access inputs, credit, and extension advice; and (4) sell crops to buyers.

3.6 Monitoring and evaluation

The monitoring of water use is not enforced. Water use data may be recorded by some water users, but the parameters serve the purposes of the water user and not necessarily those of the water manager. The RWB informed the study team that all information on water availability and demands can be found in the water portal, though the information was not readily verifiable.

Under Ministerial Order N°006/16.01 of 24/05/2013: Determining the Organization of Water Resources Data Collection, Treatment, Management, Exploration and Communication, the RWB is responsible for collecting and disseminating information relating to water resources management in Rwanda. As per the law establishing the RWB, the Board has a duty to follow up and supervise activities relating to the proper use of natural resources. This monitoring includes small-scale irrigation beneficiaries. However, the number and diversity of locations around the country limits the RWB's ability to follow up on all small-scale irrigators, and the Board does not yet have subnational structures.

The RWB oversees the monitoring of surface and groundwater resources. To this effect, it uses the Rwanda Water Resources Information System, which holds the quality and quantity records of a network of surface-water hydrometric stations, allowing for the quality control and analysis of data. The average daily flow for six important stations across the country is published in a bi-monthly bulletin.

Irrigation, including that under the SSIT program, is monitored by MINAGRI through the agricultural management information system, where districts feed in the data for areas irrigated according to earmarked funds that MINAGRI transfers to them. This is a reporting requirement for transferred budgets, but it could be used as a monitoring tool for districts to report on irrigated areas, including SSIT subsidy beneficiaries, and other irrigation initiatives outside the program. Thus, RAB will be able to access extensive information on how irrigation is progressing in different districts, including those where the SSIT program operates.

3.7 Conclusion and recommendations

In general, the policy and legal framework is well established and enables smallholder farmers to adopt irrigation. The scoring of the policy and legal framework indicates that although the legal and regulatory framework concerning water and land is not a constraint for farmers, including small irrigators, some challenges remain. For example, guidelines relating to implementing policies in the field, water permits, and the requirement for EIAs are not yet uniform.

After the analysis of the policy and legal framework, the consultants recommended the following to improve the SSIT process.

- There is a need for a continuous consultative framework to guide the implementation of the SSIT program that includes all institutions with some responsibility for the implementation of the program (RWB, REMA, RLA, and RAB). This framework would discuss, among other things, the selection of technologies, the selection of SSIT beneficiaries, and water permits.

- Thresholds in SSIT should be harmonized with those in the related laws regarding water permits and EIA requirements. SSIT thresholds—micro scale (0–0.5 ha), small scale (0.5–2 ha), and medium scale (2–20 ha)—are different from those stipulated by laws—for example, the requirement for water permits (for plots 1 ha or more) and the requirement for EIAs (for storage dams).

- As per the hierarchy of prioritization in the water resources law, domestic use is given top priority, with economic activities, including agriculture, given the lowest priority. However, agriculture is the main user of water. This should be reviewed to remove anticipated conflicts over water use.

- Water users should be coordinated at the district level. Only catchment committees and irrigation water users' associations are in place, and there is no coordination between them.

- More coordination is also needed between MINAGRI, RAB, and the districts when monitoring the SSIT program. Decentralization of the SSIT program in 2018 has limited RAB from accessing primary information on its overall performance (only irrigated land is reported on in the agricultural management information system managed by MINAGRI).

- The requirement for land ownership has not been fully respected, as some interviewed beneficiaries indicated that they use SSIT equipment on leased land. This was confirmed by district/sector agronomists who implement the program. It is important, therefore, to remove this requirement from future guidelines, and to allow applicants who use leased land to apply. This will increase the number of farmers who apply for the program.

3.8 Scoring the water resources management laws in Rwanda

There are several legal and policy documents on water and land tenure and administration. From the assessment, we have come up with the following findings.

Challenges and constraints in the implementation of the law

There are still some constraints in the implementation of different registration practices related to water resources management. For example, almost all SSIT farmers do not apply for water permits (as per interviews with the RWB and RAB), though the legal requirement is that anyone with a plot of 1 ha or greater requires a water permit. In addition, administering the water fee is not possible for SSIT farmers who are not irrigating on a large scale. There is thus a potential source of water conflict between water users of large plots and small plots of irrigable land.

It is worth noting that a large proportion of interviewed farmers (88.9 percent) indicated that they had had water conflicts in the past, either with their fellow farmers or with other water users. A total of 82 percent expressed fears about future water conflicts (Figures 3.3 and 3.4).

This indicates that the Rwanda Water Resources Board should increase the licensing and monitoring of water use, including rational distribution, especially in drought-prone areas in Eastern Province. The constraints reported are not caused by a lack of clarity in the legal documents or how they are implemented but are related to enforcement and administration of the law. Accordingly, we score this point 3 out of 5.

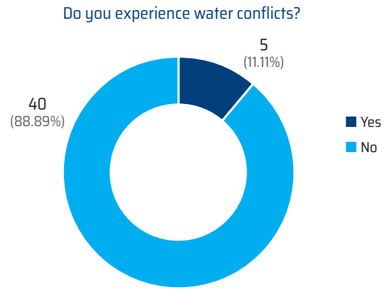
Status of implementation of legislation on the ground

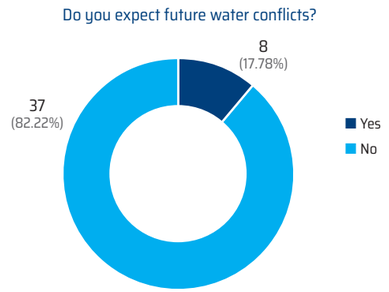
Large irrigation projects apply for water permits, and collective water permits were requested in some cases of SSIT (for example, farmers supported by Hinga Weze). EIAs are conducted for large projects, but very few, if any, SSIT farmers have conducted EIAs, despite it being a requirement in law for anyone constructing a storage dam. Farmers were instructed not to use the water in the 50-meter buffer zone of a lake, as required in the Environment Law. As the RWB was only recently established, implementing the law on the ground is still new. However, the law is clear on permit requirement for water use. Thus, the score here is 3 out of 5.

Actual practice regarding water rights for smallholder farmers

Legal instruments give all farmers equal rights to access water, a point confirmed in field visit interviews. However, some large water users may be impinging on the free flow rights of water users who do not pay water fees. This was seen as an implementation and inspection challenge by both MINAGRI and the RWB. Priority is given to domestic use; where farmers pump irrigation water from the same sources as a water utility, farmers may be requested to allow the water to flow freely for domestic use (for example, the Yanze River in Rulindo district was mentioned in an interview with the RWB). No customary rights are observed in Rwanda. Ministerial Order N°002/16.01 of 24/05/2013 on the utilization of water resources provided for concessions (especially for fishing), but the new document under discussion has removed categories of water rights, as water is considered public property. Existing legal and regulatory documents relating to water and land guarantee the rights of smallholder farmers, but implementing them is sometimes overshadowed by making domestic use a high priority, even if that domestic use is not necessarily for distribution within the vicinity of the water body. This point scored 2 out of 5.

Figures 3.3 and 3.4: SSIT farmers and (expected) water conflicts





Place of smallholder irrigators in the policy

The Water Resources Master Plan states that water allocation for smaller users, including small irrigators, does not have be very precise; there is no need to specify the time of the year when the allocation is likely to take place.[69] Only small plots less than 5 ha require a declaration,[70] while small dams (15 m2) require authorizing. The Irrigation Policy (2013) recognizes the development of irrigation by irrigators of small plots. While one of the strategic actions was "to support micro scale (0–0.5 ha), small scale (0.5–2 ha), and medium scale (2–20 ha)," the SSIT program has supported many small farmers (irrigating less than 0.5 ha), though some farmers could oversee 10 ha.[71] Smallholders are well considered in the existing legal and regulatory documents relating to water. Thus, the score for this point is 5.

Enforcement of legal requirements vs small irrigators

The following stakeholders are responsible for enforcing water-related legal requirements: REMA and districts enforce distance requirements to water bodies; the RWB plans inspections on water-permit requirements; irrigation water users' associations collect water fees; Ministerial Order N°002/16.01 of 24/05/2013 on Water Resource Management sets the water fee rates; and the Water Law provides for the punishment of defaulters and the application of user-pays and polluter-pays principles. Responsibilities are separated between implementing and enforcing institutions, which provides good checks and balances on the regulatory side. However, small-scale irrigators may be provided with irrigation equipment by one institution but be told to apply (or not to apply) for a water permit by another institution, while a third institution monitors defaulters who do not follow set guidelines. This has, at times, been a source of confusion for small irrigators and has resulted in poor enforcement of set guidelines. Accordingly, we score this point 2.

Different kinds of permits (collective/individual) and transferability

The Water Law and Ministerial Order provide for transferring water permits, and we saw cases of collective water permits in the field. The score is 5.

3.8.1 Overall scoring of the policy and legal factor

The overall score of the policy and legal factor is 3.3 out of 5. The Rwandan policy and legal framework accommodates small-scale irrigation. In some cases, this study has identified areas where the enforcement institutions have turned a "blind eye" to legal requirements to the advantage of small-scale irrigators, enabling them to adopt irrigation.

The legal and regulatory framework for water and land does not present a constraint for farmers, including small irrigators. However, challenges remain in implementing set guidelines in the field, and the system of water permits is not yet uniform or implemented as per the legal requirements. Land policies and legal requirements are clear, and land administration is well organized.

3.9 Policy and legal documents assessed

3.9.1 Guidelines and manuals

- The National Land Use Planning Guidelines 2017 (Ministry of Environment/Rwanda Land Authority)
- Rwanda National Water Resources Master Plan 2015 (Rwanda Water Resources Board, formerly RNRA)
- The Irrigation Master Plan 2020 (Ministry of Agriculture and Animal Resources/Rwanda Agriculture and Animal Resources Development Board)
- Land Administration System Manual 2012 (Ministry of Environment/Rwanda Land Authority)

3.9.2 Laws implementing institutions

- RAB: Law N°14/2017 of 14/04/2017: Establishing Rwanda Agriculture and Animal Resources Development Board (RAB) and Determining its Mission, Organization and Functioning
- RWB: Law N°71/2019 of 29/01/2020: Establishing Rwanda Water Resources Board
- REMA: Law N°63/2013 of 27/08/2013: Determining the Mission, Organization and Functioning of Rwanda Environment Management Authority (REMA)
- RLA: Law N°05/2017 of 03/02/2017: Establishing Rwanda Land Management and Use Authority (RLA) and Determining its Mission, Organization and Functioning

[69] RWB. 2018. *Water Resources Master Plan*, p. 49.
[70] RWB. 2018. *Water Resources Master Plan*, p. 139.
[71] MINAGRI. 2014. *Irrigation Policy and Action Plan*, p. 12.

3.9.3 Policy documents

Water

- National Policy for Water Resources Management, 2011
- National Environment and Climate Change Policy, 2019

Land

- National Land Policy, 2004
- National Land Policy, 2019

Agriculture/irrigation

- National Agricultural Policy, 2018
- Strategic Plan for Agriculture Transformation – 4, 2018
- National Agricultural Extension Strategy, 2016
- Irrigation Policy, 2014

3.9.4 Laws

Water

- Law N°49/2018 of 13/08/2018: Determining the Use and Management of Water Resources in Rwanda
- Law N°48/2018 of 13/08/2018: on the Environment
- Ministerial Order N°001/2019 of 15/04/2019: Establishing the List of Projects that Must Undergo Environmental Impact Assessment, Instructions, Requirements and Procedures to Conduct Environmental Impact Assessment
- Ministerial Order N°002/16.01 of 24/05/2013: Determining the Procedure for Declaration, Authorisation and Concession for the Utilisation of Water
- Ministerial Order N°006/16.01 of 24/05/2013: Determining the Organization of Water Resources Data Collection, Treatment, Management, Exploitation and Communication
- Ministerial Order N°007/16.01 of 24/05/2013: Determining the Main Management Visions of Water Resources in the Main Hydrographic Basins in Rwanda

Land

- Law N°43/2013 of 16/06/2013: Governing Land in Rwanda
- Presidential Order N°30/01 of 29/06/2007: Determining the Exact Number of Years of Land Lease
- Ministerial Order N°14/11.30 of 21/12/2010: Determining the Models of Land Consolidation and its Productivity
- Law N°18/2007 of 19/04/2007: Relating to Expropriation in the Public Interest

Irrigation

- Ministerial Order N°001/11.30 of 23/11/2011: Establishing Irrigation Water Users Associations in Irrigation Schemes

ANNEX 4: KNOWLEDGE

4.1 Introduction

Innovation is the process of creating new knowledge whereby novel ideas are put into practice, usually involving other players. Knowledge and innovation are strongly interlinked and are considered important drivers for agricultural development. For irrigation and other technological changes in agriculture, the knowledge base and the possibility of introducing innovation to rural people are key to bringing about change in the sector. Farmers normally acquire knowledge from different sources, including from peer-to-peer leading. The Rwandan context is a good example of how the promotion of peer-to-peer learning has achieved good results where classic knowledge transfer systems have failed. Under the SSIT program, peer leading has played an important role in the adoption of irrigation systems and technologies. It is common to find neighboring farmers with the same type of irrigation equipment, because the first farmer in the area used that equipment and others simply followed suit.

Key findings

The extension system in Rwanda is a farmer-led system called the "Twigire Muhinzi" extension model, which combines the farmers' field school (FFS) approach with the farmer promoter (FP) approach. Farmers learn from each other by observation and informal discussions, and they innovate continually. Innovations in irrigation equipment or techniques travel by word of mouth, or with migrating farmers who bring new knowledge and practices to their new locations. Farmers gather information from outsiders via private sector input (technology suppliers), extension officers, and research institutions. Knowledge of irrigation development, as well as the whole production chain, is crucial to adoption of the small-scale irrigation technology (SSIT) program.

In this assessment, we observed that the dominant knowledge among farmers was of water resources and transportation methods, while knowledge of field application methods and irrigated agronomic practices was very limited. From the stakeholder assessment, we found there were mixed roles and multiple motivations, whereby different players provide knowledge to farmers based on their own development agendas or opportunities in the sector, and not necessarily for the sake of supporting farmers. Irrigation suppliers, market off-takers, and non-government knowledge and innovation networks have all contributed to the improvement of farmers' skills.

We also observed that knowledge of irrigation engineering, irrigation agronomy, and farmer-led irrigation development (FLID) processes, present and operationalized, are available in the public sector, where agronomists and irrigation specialists at sector and district level seemed capable but very limited in their capacity to interact at field level. The most common form of interaction was desk support for farmers. This study also revealed a discrepancy between private companies' claims about service providers hired by the Rwanda Agriculture and Animal Resources Development Board (RAB) to distribute irrigation equipment to farmers and what technology transfer happens in the field, as most companies did not actually engage with farmers on SSIT at the field level, and some farmers did not know which company supplied them with equipment. The study also observed that collaboration, coordination, and the alignment of services and approaches between players in the FLID ecosystem are still lacking and need to be strengthened. We saw a lack of cooperation between SSIT and some government-donor projects, such as the Sustainable Agricultural Intensification for Improved Livelihoods, Food Security and Nutrition Project, and in some cases we saw competition between them.

The knowledge transfer framework is rated as "partially enabling" the development of farmer-led irrigation (scoring 2.5 out of 5), as government seems to be driving the full innovation and technology transfer. The educational (for example, through technical and vocational education and training (TVET)) and policy environment (for example, through Twigire Muhinzi) in Rwanda are favorable for FLID, but irrigation-specific knowledge among farmers, private sector service provision, and the alignment of services between different stakeholders could be improved.

Although knowledge comes from experience, education is always formal or informal and is provided by public or private institutions. In the Rwandan context, education is provided by the formal education system. This annex describes the formal education system as it relates to irrigation and how farmers gain knowledge related to irrigation, water resources, costs, benefits, and irrigation practices. Stakeholder analysis in the field of knowledge transfer is also discussed. Apart from short training sessions organized by nongovernmental organizations (NGOs), the informal education system is not well developed. Looking at the FLID/SSIT in Rwanda, knowledge is acquired when farmers actively pursue information and skills about irrigation farming businesses.

This annex also assesses how farmers in Rwanda access knowledge, how government policies promote knowledge transfer and innovations in irrigation, and the role of different stakeholders in the development and sharing of knowledge related to the development of irrigation.

This annex includes a review of background information relating to the policy, legal, and institutional framework of the knowledge, innovation in irrigation, and field data results. The field data was collected and tabulated and include results relating to sources of information regarding weather, market prices, and agronomic information, and how farmers irrigating before SSIT learned about irrigation.

4.2 Policy and legal aspects of agricultural knowledge and extension

4.2.1 Competence-based education

Rwanda has set out ambitious plans to create a growing knowledge economy based on a skilled workforce that can compete both regionally and internationally.[72] Policies relating to education are drafted by the Ministry of Education, and Rwanda has opted to combine universal education focused on competence-based education with the development of skills and competencies. The Nine-Year Basic Education program is the foundation for human resource development, while improved access to and quality of upper secondary schools, teacher training colleges, TVET institutions, and higher learning institutions supply the demand for higher-level skills and competencies. Formal professional education and training are available at national level, where the Rwanda Polytechnic is responsible for vocational training, including agricultural training, through TVET. This is provided at vocational and technical training level and at the Integrated Polytechnic Regional College (IPRC) level. Curricula are set in consultation with relevant institutions. The Ministry of Agriculture and Animal Resources (MINAGRI) and its agencies are involved in setting TVET curricula for agriculture. Agriculture is also offered at IPRCs, which are post-secondary institutions that train graduates in more practical skills.

One of the challenges identified by IPRCs is that because they admit students from different educational backgrounds (primarily from the agricultural and veterinary training schools, but also from others, particularly science combinations), instructors find it difficult to deliver the same level of practical skills to the students. High schools that teach agriculture and veterinary education normally use competence-based training, where practical skills are emphasized; in contrast, those with a science-combination background are not exposed to practical skills. There is thus a need to create a curriculum that either accommodates preliminary training in practical knowledge for those need it, or to only admit those from agricultural and veterinary schools.

4.2.2 Extension policy in Rwanda

Extension in Rwanda is under two ministries: MINAGRI, which sets policies and guidelines, and the Ministry of Local Government, which implements policies and coordinates activities at the subnational level, where sector and district agronomists operate. The RAB, which operates under MINAGRI, has a mission to develop agriculture and animal husbandry through modern methods of crop and animal production, research, agricultural extension, education, and training farmers in new technologies. The lowest level of extension is at the village (*umudugudu*) level, where FPs, who are outstanding or lead farmers, coordinate extension activities. At the cell (*akagari*) level, extension activities are coordinated by socioeconomic development officers. The next level is the sector level, headed by the sector agronomist and the officer in charge of livestock. The district level is next, where the district agronomist and the officer in charge of livestock operate.

MINAGRI has been delivering extension services under the farmer-led model Twigire Muhinzi since the revision of the National Agricultural Extension Strategy[73] in 2014. The model, which combines the FFS approach with the FP approach, helps farmers access advisory services and relevant technology and knowledge. This model has helped farmers adapt and adopt technology such as irrigation and has increased the flow of information among producers, farmers' organizations, and other partners. The model promotes peer learning among farmers and the demonstration of technologies on farm demo plots established in the farming community.

[72] Munezero, D. 2019. *Assessment Report on the National Stock-Taking on Agriculture TVET in Rwanda.* GIZ/NEPAD.

[73] MINAGRI. 2014. *National Agricultural Extension Strategy.*

The model has been used extensively to demonstrate different irrigation kits and differences in the yields and profitability of irrigated and non-irrigated land.

Both approaches complement existing services delivered by public extension services and have reduced the gap between extension agents and farmers and brought research findings closer to the farm. Private extension service providers have also recently emerged, offering fee-based extension and advisory services. These include YEAN-Rwanda, YPARD Rwanda, HoReCo, AGRIWIN, Expanders Ltd, and RYAF.

4.2.3 The Information and Communication Technology for Agriculture Strategy

In 2016, the government of Rwanda developed the information and communication technology (ICT) for the Rwandan Agriculture (ICT4Rag) strategy[74] to complement agricultural development and the above agriculture extension system and to enhance agriculture and rural development by improving information and communication processes.[75] The strategy's three main principles are:

- A national ICT4Rag vision that corresponds to the development and achievement of national goals of the modernization of agriculture.
- A national ICT4Rag action plan that reflects Rwanda's agricultural and rural development priorities.
- A national ICT4Rag implementation, monitoring, and evaluation plan to manage the implementation and associated risks and measure the outcomes and impact in the context of the stated objectives.

This strategy addresses the gap between smallholders' knowledge of agricultural practices and the knowledge available at agricultural research institutions. The ICT4Rag strategy helps the government provide farmers, including SSIT beneficiaries, with advice and extension services at all levels of the value chain. At each level, an ICT solution or application is necessary to systematically contribute to and accelerate agricultural productivity.

4.2.4 Research and technology transfer

Law N°14/2017 of 14/04/2017: Establishing Rwanda Agriculture and Animal Resources Development Board (RAB) and Determining its Mission, Organization and Functioning defines the general mission of RAB as being responsible for the development of agriculture through research and extension. Through this law, RAB is responsible for researching, collecting, providing, and disseminating information, services, and other agricultural extension activities to farmers to increase the quantity and quality of productivity demanded on the market and by industries.[76]

In this assessment, we have observed evidence of research on cost-benefit analyses for different technologies, although much of the basic research on different irrigation technologies is still lacking. The research on water-use efficiency and water productivity in different regions has not yet been developed, although we observed that technologies that are not water efficient are widely used among SSIT beneficiaries.

The Agricultural Information and Communication Center is also managed by MINAGRI. The main objective of the center is to regularly collect, produce, process, adapt, store, share, and disseminate agricultural information and knowledge. The center coordinates the collection and archiving of all technical information, as well as radio and TV talk shows broadcast by the State-run Rwanda Broadcasting Agency, through which the Ministry delivers key communications on different technologies. On these talk shows, different Ministry programs and policies are explained to citizens, while the Ministry's technical staff present different technological achievements in the sector in easy-to-understand language for the public.

4.3 Field survey findings

4.3.1 Farmers' access to and use of suitable knowledge and innovations

Much theoretical knowledge is available on how farmers access knowledge. This assessment has reviewed how farmers get access to information in the Rwandan context. We looked at the possibilities of accessing digital information, (in)formal learning, and so on, and what the best knowledge distribution pathways are in the country.

Information on agronomy and irrigation practices (Figure 4.1) is mainly accessed through district/sector agronomists (48 percent), other farmers (25 percent), and input providers (12 percent). This is an indication that information is readily available to farmers.

[74] MINAGRI. 2016. *ICT4RAg Strategy*.

[75] USAID. 2018. *Rwanda: Desk Review of Extension and Advisory Services.*

[76] Official Gazette N°18 of 01/05/2017. Law N°14/2017 of 14/04/2017: Establishing Rwanda Agriculture and Animal Resources Development Board (RAB).

Farmers get most of their information on irrigation knowledge (Figure 4.2) from other farmers (53 percent), mainly though peer learning and FPs, while a substantial number get information from other sources (23 percent), probably a result of FFSs and study tours.

4.3.2 Knowledge of irrigation engineering, irrigation agronomy, and current FLID processes operating in the public sector

To support the transfer of knowledge about irrigation, the National Agricultural Policy[77] proposes strategic actions for the capacity building of farmers and structured training in irrigation operation and maintenance, marketing, and emerging technologies. RAB has developed technical information, primarily about different irrigation technologies, but has also developed cost-benefit analyses for different value chains and technologies to help farmers make informed decisions about which technology to choose.

Although research has supported the identification of highly profitable value chains for irrigation, there have been no efforts to research the efficiency of different irrigation equipment (water management efficiency or environmental consideration). Many farmers have opted for pump and hose pipe sets, though this technology is not ideal for crops, water, or energy and labor management. Farmers who were interviewed did not indicate having chosen the equipment based on prior technical information; instead, private service providers distributing the irrigation equipment made the choice on their behalf, resulting in simple pump and hose systems being the standard choice. Little distinction was made based on pumping capacity needs and field layout.

The capacity-building side, where observed, was limited to properly indicating the results of irrigation, but other forms of capacity building, such as the repair and maintenance of irrigation kits, were limited or absent. This assessment did not see capacity-building guidelines for farmers ("Who?" and "How?") or guidelines on who supports operation and maintenance.

4.3.3 The collaboration, coordination, and alignment of services and approaches between players in the FLID ecosystem

Rwanda's agricultural innovation system is mainly composed of research, education, extension, civil society, and public and private sector institutions engaged in agriculture. MINAGRI is responsible for policy making, planning, and the monitoring of programs. It is also responsible for leading the Agricultural Policy and different strategies for the modernization of agriculture, including irrigation, and for providing policy guidelines for the implementation of the SSIT program.

On the implementation side, RAB is responsible for research and technology transfer and capacity building to farmers. Several universities are involved in research and capacity building, supported by the competence-based Education Policy that supports the development of skilled labor in agriculture. Farmers' organizations also support farmers in different development projects. Local and international NGOs support individual farmers to access information and build technical capacity.

At the Ministry level, the agricultural sector working group helps stakeholders in agriculture discuss progress in the sector and harmonize information given to farmers. However, as not all stakeholders are represented in this working group, the link with education institutions has been found wanting, and the research conducted by universities is rarely shared, creating a weak interaction between these major arms of the innovation system.[78]

Figure 4.1: Sources of agronomic information

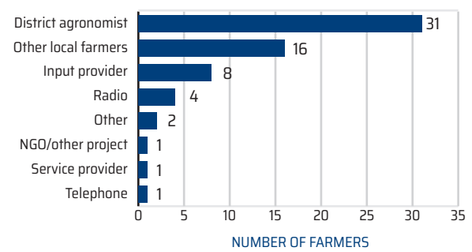
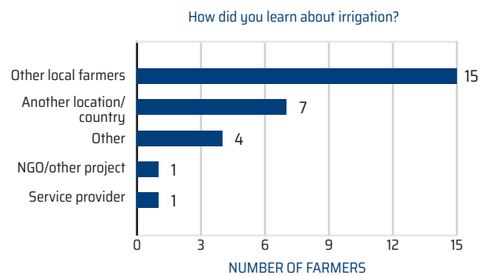


Figure 4.2: Sources of information on irrigation



[77] MINAGRI. 2018. *National Agricultural Policy.*

[78] Yongabo, P, and Göktepe-Hultén, D. 2021. "Emergence of an Agriculture Innovation System in Rwanda: Stakeholders and Policies as Points of Departure." *Industry and Higher Education* 35(5): 581–597.

Besides policy making and the implementation of research and capacity building, a third category of stakeholders—including funding institutions such as the Ministry of Finance, international NGOs, and other development partners—supports the efforts of knowledge transfer. This category includes the private sector and FPs who support technology transfer through their economic activities. The role of farmers in knowledge sharing has been described under the Extension Policy, specifically the roles of FFSs and FPs in supporting knowledge transfer from farmer to farmer. In the adult-learning approach of FFS, a group of farmers lead at a physical location, such as an irrigated field for irrigation. The school teaches farmers how to experiment and solve problems independently based on local challenges and solutions. FPs, who are also part of the existing extension system, are volunteer model farmers selected to share agricultural knowledge using extension skills. FPs are trained from time to time to equip them with knowledge and new skills for crop and livestock production, to be transferred in turn to other farmers.

4.4 Stakeholder roles and importance in Rwanda's FLID process

4.4.1 Farmers

In the Rwandan SSIT development context, farmers have supported the spread of information about the irrigation subsidy and knowledge of irrigation and agronomic practices. Farmers have proven a good vehicle for technology transfer and information sharing (53 percent of surveyed farmers reported receiving information on irrigation practices from other farmers). Using farmers as a source of information for their fellow farmers, and equipping them with the right knowledge, could trigger a multiplier effect on the adoption of irrigation and the operation and maintenance of irrigation equipment.

4.4.2 Farmers' organizations

During the phases of irrigation development in Rwanda, farmers' organizations—both cooperatives and water users' associations—have played a role in knowledge transfer from farmer to farmer, but their main role has been the management of irrigation infrastructure. In rice schemes, for example, cooperatives are the main source of information about season planning, input availability, and agronomic practices. In most cases, the cooperatives recruit paid agronomists to support farmers. As per the Ministerial Order Establishing Irrigation Water Users Associations in Irrigation Schemes,[79] smallholder farmers who are organized into cooperatives and irrigation water users' associations pay water fees to maintain the equipment and irrigation infrastructure.

4.4.3 Irrigation technology suppliers

A small proportion of farmers (4 percent) surveyed during this assessment reported getting irrigation information from service providers. The involvement of private service providers in mobilizing the uptake of irrigation equipment by farmers is still low, as most of them were recruited by the government to supply SSIT kits under the subsidy scheme. The surveyed service providers indicated the need to develop their market base and build on their marketing strategies. They also indicated that the number of farmers buying irrigation equipment outside the SSIT subsidy scheme has been increasing.[80] Accordingly, there is still a large gap in knowledge sharing and irrigation adoption that can be covered by the private sector.

4.4.4 Market off-takers

Small-scale irrigation has largely been influenced by the availability of guaranteed markets. Farmers producing horticultural crops were likely able to expand the area of land under irrigation, because the market for horticultural products was almost assured. Some farmers worked under contracts with exporters, while others had informal contracts with local aggregators. These off-takers often advanced inputs to farmers at the beginning of the season, increasing their chances of being supplied with good produce.

Market off-takers are important drivers of the increased adoption and sustainability of small-scale irrigation in Rwanda. MINAGRI encourages formal farming contracts between market off-takers and farmers, while the Land Use Consolidation Ministerial Order[81] specifies different farming models for consolidated land, including irrigated land. Among others, the Order covers facilitated contract farming and a land lease system whereby farmers can lease their land to develop commercial farming. Article 4 of the Ministerial Order on sublease contracts stipulates that the sublessee (usually a farmer) and sublessor (off-taker) must conclude a contract determining activities to be conducted on the land, the duration of the contract, the agreed rent, and any other matters that relate to the management and use of the land during the contract.[82]

[79] Ministerial Order N°001/11.30 of 23/11/2011: Establishing Irrigation Water Users Associations in Irrigation Schemes.

[80] Interview with Holland GreenTech on May 31, 2021.

[81] Ministerial Order N° 14/11.30 of 21/12/2010: Determining the Models of Land Consolidation and Its Productivity.

[82] Ministerial Order N°001/14 of 14/04/2014: Determining Modalities of Sub-Leasing of Agriculture, Livestock and Forest Land.

4.4.5 Government and government-affiliated institutions

Various government departments and agencies have spearheaded the development of small-scale irrigation, starting with MINAGRI and its implementing branch, RAB, mainly by setting policies, regulations, and guidelines. Other government institutions, especially public institutions affiliated with the Ministry of Environment, have supported the implementation of SSIT through measures that include water permits, land administration, and environmental safeguarding. These public institutions are important at both national and local levels for the support of knowledge development and knowledge transfer to farmers, especially for program rollout, technical support, and extension services. MINAGRI decentralized the distribution of the SSIT subsidy to districts in 2018 so that farmers can receive a better service and access services closer to them. Since then, the program has been administered by the district, technically monitored by the district irrigation staff, and is supervised by the district irrigation steering committees. Many farmers interviewed during this assessment received information about the SSIT subsidy program from district agronomists.

Coordination between different stakeholders has improved with the introduction of joint planning between different institutions since 2013. The development of irrigation has been included under joint *imihigo* (shared performance) contracts, representing a synchronization of planning and budgeting across different sector ministries.

4.4.6 Non-state actors

Non-state actors, including NGOs and financial institutions, have also played a role in the development of SSIT and knowledge sharing. Farmers interviewed reported getting information about agronomy and irrigation from these players (4 percent from NGOs and 14 percent from other non-state actors, which could include financial institutions and private players). The National Agricultural Policy[83] recognizes NGOs and community-based organizations as key partners in providing extension services to farmers. The policy establishes a clear framework in which organizations may initiate partnerships between smallholder farmers and off-takers. It is recommended, however, that MINAGRI and RAB develop guidelines governing non-state actors' intervention in SSIT development to avoid different approaches and uncoordinated interventions. During the assessment, some farmers reported that NGOs gave them full support for their contribution to the government subsidies, while others had to find their contribution through financial institutions or from their own savings. This does not set a level playing field, with some farmers receiving limited benefits from the subsidy program and others getting irrigation equipment almost entirely free. Such inequality will not help the sustainability of the program.

4.4.7 Media

Media, especially radio, has played a key role in informing farmers about irrigation technologies. About 6 percent of farmers interviewed reported getting agronomic information from radio broadcasts. Other communication platforms used include the e-SOKO platform, which updates farmers on the prices of different agricultural products on different markets, helping them grow what they can sell. MINAGRI runs the Agricultural Information and Communication Center, a repository of different information packages related to agricultural extension. The center also hosts TV and radio talk shows that help farmers learn about different agricultural technologies, including irrigation.

4.5 Formal professional education and training available at national level

The Ministry of Education is responsible for the policy and regulatory framework governing professional and vocational training in the country. For agriculture, TVET is provided by private and public technical secondary schools and vocational training centers at the secondary level, and by IRPCs at the post-secondary level (see Table 4.1). At secondary schools, training includes initial vocational training and continuing vocational training. The IRPCs offer diploma and advanced diploma courses in TVET subjects.

IPRC East (Gishari), IPRC North (Musanze), and IPRC South (Huye) offer courses in agriculture, while IPRC South (Huye) and IPRC East (Gishari) offer courses on irrigation. The Workforce Development Authority is mandated to set standards, quality assurance, and accreditation so that TVET schools produce a competitive workforce, while the Rwanda Polytechnic is mandated to implement technical skills development through TVETs.

[83] MINAGRI. 2018. *National Agricultural Policy*.

Table 4.1: Training institutes and locations related to irrigated agriculture

S/N	School name	Status	District	Province
A. Technical secondary schools				
1.	ES Gahunga	Private	Burera	Northern
2.	EAV Rushashi	Public	Gakenke	Northern
3.	Lycee Catholic St Alain de Mataba	Private	Gakenke	Northern
4.	Nemba Secondary School—Apredesoc	Private	Gakenke	Northern
5.	ES Bukure	Public	Gicumbi	Northern
6.	EAV Kabutare	Public	Huye	Southern
7.	EAV Kinazi	Public	Ruhango	Southern
8.	GS Nyabikenke	Government-aided	Muhanga	Southern
9.	Gakoni Polytechnic	Public	Gatsibo	Eastern
10.	EFA Nyagahanga	Government-aided	Gatsibo	Eastern
11.	EAV Gitwe	Government-aided	Ngoma	Eastern
12.	GS Gisovu	Government-aided	Karongi	Western
13.	Apejerwa Nyange	Government-aided	Ngororero	Western
14.	EAFO Kibisabo	Public	Nyabihu	Western
15.	EAV Bigogwe	Government-aided	Nyabihu	Western
16.	GS Amitie de Jomba	Private	Nyabihu	Western
17.	EAV Ntendezi	Public	Nyamasheke	Western
B. Integrated polytechnic regional colleges (IPRCs)				
18.	IPRC South (Huye)	Public	Huye	Southern
19.	IPRC North (Musanze)	Public	Musanze	Northern
20.	IPRC East (Gishari)	Public	Rwamagana	Eastern
C. Universities				
21.	UR-CAVM—Musanze campus	Public	Musanze	Northern
22.	UR-CAVM—Nyagatare campus	Public	Nyagatare	Eastern
23.	University of Technology & Arts of Byuma-Utab	Private	Gicumbi	Northern
24.	Institute of Applied Sciences—INES	Private	Musanze	Northern

4.6 Diagnostic scoring

To score the knowledge factor of the FLID environment in Rwanda, the following aspects were considered and scored from 1 (very poor) to 5 (very good):

- Education: 4. Technical and vocational education and training (TVET) exist around the country.
- Policy: 4. The farmers' field school (FFS) approach and the farmer promoter (FP) approach are successful in transferring agricultural knowledge to farmers.
- Knowledge: 2. There is little knowledge about field application techniques among smallholder farmers, and irrigated agronomic practices are not well developed.
- Irrigation engineering: 3. SSIT seems to be limited to hose/pipe systems; there is no tailored design.
- Private sector service: 1. Limited engagement and after care; some providers push their own solutions.
- Alignment of services: 2. Projects seem to compete for technicians.

This results in an overall score of 2.5 out of 5.

4.7 Recommendations

The FLID knowledge environment is most conducive when key stakeholders systematically align their efforts to respond to farmers' real needs. Enabling policies for stakeholder coordination exist, but this assessment has not seen coordination in practice in the field. Several areas must be harmonized and mainstreamed to ensure SSIT development and knowledge transfer are well coordinated by MINAGRI in collaboration with the Ministry of Local Government and the Ministry of Education. MINAGRI needs to harmonize guidelines on how non-state actors will support SSIT to avoid divergent approaches.

We recommend the following for proper knowledge sharing in the SSIT development framework in Rwanda:

- Strengthen farmers' access to and use of suitable knowledge and innovations (through the FFS and FP), especially about:
  - —Knowledge of field application methods
  - —Irrigated agronomic practices.
- Increase the demand-responsiveness of private sector service providers by:
  - —Improving the relationship between farmers and service providers through education and demand-side financing
  - —Developing irrigation as a paid service (the government can subsidize this irrigation service rather than subsidizing the equipment).
- Improve ICT and communication outreach by:
  - —Developing mass media communication messages and social media content to encourage the development of small-scale irrigation
  - —Developing digital extension service delivery that involves young agriculture graduates.

ANNEX 5: FINANCE

5.1 Introduction

Within farmer-led irrigation processes, farmers take the initiative, make decisions, and lead the development process of irrigation. Accordingly, farmers also pay for and own the irrigation equipment. However, the affordability of irrigation equipment is often a major constraint and limits the uptake of small-scale irrigation (SSI). Although subsidy schemes like the small-scale irrigation technology (SSIT) program are important tools for bridging existing affordability gaps, there are still challenges on the financing side.[84]

Available studies on the SSIT program indicate that one of the key challenges that (smallholder) farmers face is that the costs of irrigation technologies are still too high, despite a 50 percent subsidy. To respond to this challenge, the government of Rwanda (GoR) aims to partner with financial institutions and non-governmental organizations (NGOs) to facilitate loans and grants for the non-subsidized part of irrigation equipment. As described in the feasibility study of the SSIT program, donors and financial institutions have a role to play in facilitating farmers' payment of the non-subsidized portion.[85]

This annex assesses the extent to which the financial environment limits or enables farmers to finance irrigation equipment. It touches on the affordability of equipment and available financial support to pay for the non-subsidized part of SSIT equipment. Along the lines of the Farmer-led Irrigation Development (FLID) Guide, different aspects relating to financing are assessed. The first aspect is farmer financing—the ability of the farmer to finance the non-subsidized part of the SSIT equipment through their savings, formal or informal loans, microcredit, and so on. The second aspect is private financing—the capacity and experience of financial institutions to provide financing solutions to farmers who want to purchase irrigation equipment. The third aspect considers government- and donor-funded projects, and it assesses the extent to which donor-funded projects can help farmers to access irrigation equipment and other agricultural inputs and disbursement methods (either individually or in groups).

Observations and recommendations on farmer, private, and government/donor financing are made based on interviews, field visits, and the farmer survey carried out for the purpose of this full assessment. Representatives from the following financial institutions were interviewed: AB Bank, Banque Populaire du Rwanda, the Business Development Fund (BDF), the International Fund for Agricultural Development (IFAD), SACCO Rwabicuma, and Urwego Opportunity Bank.

Additional interviews were held with program managers of the following government- or donor-funded programs: Hinga Weze, the Kayonza Irrigation and Integrated Watershed Management Project, the National Insurance Scheme run by the Ministry of Agriculture and Animal Resources (MINAGRI), and the Solar Irrigation Rwanda (SIR) market development program.

It is important to note that the survey was conducted among farmers who have already accessed the subsidy program. Accordingly, there is a blind spot to (small-scale) farmers whose subsidy applications were rejected; farmers who have never applied for the subsidy; and farmers who have been discouraged by the financial burden of the equipment or by the long application process.

It is also worth noting that aspects such as production finance, the role of brokers, and financial arrangements with other market players are not part of the scope of this work.

5.2 Diagnostic and scoring

5.2.1 Farmer financing

In general, the SSIT subsidy program subsidizes 50 percent of the irrigation equipment. In some districts in the Southern Province, the district adds a 25 percent subsidy, resulting in a 75 percent subsidy for the farmer. We observed that some farmers were also able to combine the Rwanda Agriculture and Animal Resources Development Board (RAB) subsidy with other grants. For example, the SIR market development program provided farmers with a top-up 20 percent grant, resulting in a total subsidy of 75–95 percent, depending on the farmer's location. In all cases, however, farmers need to finance the balance of the equipment costs themselves.

[84] Izzi, G, Denison, J, and Veldwisch, G J, eds. 2021. *The Farmer-Led Irrigation Development Guide: A What, Why and How-to for Intervention Design.* Washington, DC: World Bank, pp. M5-05.

[85] MINAGRI. 2014. *Feasibility Study on Farmer-Led SSIT Program.*

This subsection focuses on the ability and willingness of farmers to finance the non-subsidized part of SSI equipment through their own savings, formal or informal loans, microcredit, or other options. Based on a survey of SSIT farmers, field visits, and various interviews,[86] we made three observations regarding the ability and willingness of farmers to pay for irrigation equipment. A key takeaway from the three observations is that the ability to pay for the equipment extends beyond the procurement of the actual equipment. When talking about the affordability of irrigation, there is often a focus on the procurement costs. However, the ongoing costs of operation and maintenance, or even household expenses (school fees, housing, and the like) also affect farmers' livelihoods and should be considered, particularly if they have used their savings for irrigation.

Observation 1: The use of savings for irrigation equipment

Our survey data shows that 76 percent of SSIT farmers financed the non-subsidized part of the SSIT equipment fully or partially from their own savings (Figure 5.1). This high degree of payment with their own savings suggests that most of the SSIT farmers in our sample are able and willing to pay for irrigation equipment. In turn, this indicates that they recognize the benefits and economic value of irrigation practices.

The fact that such a high proportion of SSIT farmers financed their equipment with savings also suggests that available financial services are not necessarily used to finance irrigation. Of our sample, 97 percent indicated that they have access to financial services, of which savings and credit cooperatives (SACCOs) are the most important source (Figure 5.2). This indicates that access to financial services is not a central issue for farmers in the SSIT program, and that these services are not used to finance irrigation equipment.

Figure 5.1: Source of funds for contribution to SSIT equipment

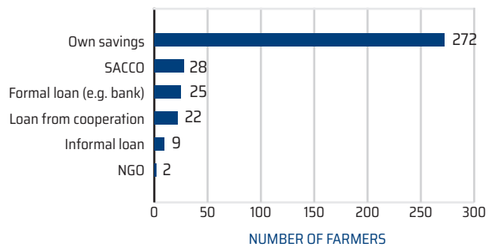
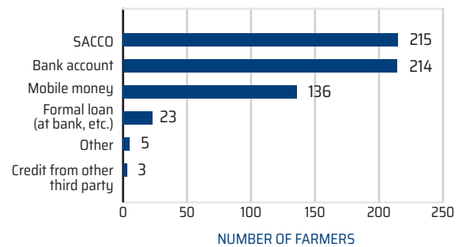


Figure 5.2: Available financial services, out of 97% of people who indicated they have access to any financial service



Through our field visits, we were able to derive more details about the various financing combinations that farmers use to obtain equipment under the SSIT program. By gaining a better understanding of the challenges that farmers face, it is possible to develop suggestions for improvement. These suggestions relate to the lack of flexibility around equipment down payments and the importance of creating awareness of the benefits and usage of irrigation, as both influence farmers' decisions to irrigate and dedicate resources.

Limited flexibility for down payments

As noted elsewhere in this report, farmers must pay for the non-subsidized part of the irrigation equipment themselves. This payment is made in one installment to the equipment provider. We have encountered farmers who had to sell their cattle or rely on income streams outside of farming to do so. There are no alternative means of financing the remaining costs—for example, it is not possible to request a subsidy with multiple people and share the costs or to pay in installments. Based on interviews with farmers and sector agronomists from Gashari sector in Karongi district and Rukomo sector in Nyagatare district,[87] this is perceived as a barrier for farmers, as it forces them to either step away from the program or delay the process of irrigation until they can make the full payment. Sector agronomists indicated that they have encountered farmers who were willing to buy irrigation equipment under SSIT but were unable to raise enough funds for the non-subsidized part and had to step away.

Although the program does not allow for alternative procurement methods, we observed that some farmers came up with innovative solutions. In one example, two farmers in Nyagatare shared the costs of the equipment.

[86] Additional interviewees that provided insights into farmer financing included sector agronomists and non-SSIT farmers during field visits.

[87] Interviews with sector agronomists Nizeyimana Aimable in August 2021 and Dusabeyezu Josephine in September 2021.

One farmer owned less than 0.5 ha of land and was therefore not eligible for the subsidy. His neighbor, however, owned more than 0.5 ha of land but was not able to cover the required 50 percent of the remaining costs. They decided to apply in the name of the eligible farmer but to share the costs of the non-subsidized part and share the equipment. A potential follow-up program could facilitate arrangements such as this to allow farmers to procure irrigation equipment on their own terms.

In terms of procuring equipment, the program only allows farmers to make a full down payment and does not facilitate alternatives for farmers who are unable to do so at a certain time (which is most often the case for smallholder farmers). The standardized approach in place assesses farmers on several criteria but does not offer other payment options based on the needs or situation of the farmer—which would be the case in a farmer-led situation. This can cause delays for farmers or even force them to step away from the program entirely. We suggest including other ways of financing the non-subsidized part. Examples include being able to pay one's contribution in multiple installments and being able to share the costs with other farmers to procure the equipment jointly.

Box 5.1: A farmer's story: Nyagatare district

In one of the areas visited in Nyagatare, farmers were irrigating with diesel pumps at about every 50 meters along the river. One farmer who was interviewed had bought a pump entirely with his own savings and was thus not part of the SSIT program. This farmer stated that he initially wanted to buy the irrigation equipment with a subsidy, but the timeline did not meet his needs, as the sector agronomist told him that it would take a month for the subsidy application to come through. As the farmer needed the equipment at the beginning of the season to improve his harvest of maize in season C, he had to decide whether to buy the equipment himself or wait for the subsidy to come through.

In his case, the perceived benefit of the equipment outweighed the full cost, and he thought it was worth getting it without the subsidy. For him, the perceived risk of acquiring the equipment was relatively low, as he had already observed many neighboring farmers benefiting from irrigation equipment, either through the SSIT subsidy program or financed by themselves.

This story demonstrates that the willingness to save up and pay for equipment is higher among those who have seen its benefits firsthand. It also indicates the need for a more flexible program, and the importance of raising awareness and knowledge assimilation among farmers.

The importance of awareness about the benefits of irrigation

Raising awareness on the practices and benefits of irrigation and promoting the subsidy program are covered elsewhere in this report, but it also has a financial component. In the field, we saw that the willingness to save up and pay for irrigation equipment is highest among farmers who have witnessed the associated benefits of irrigation experienced by neighboring farmers (see Box 5.1). Accordingly, to allow farmers to make an informed decision about financing options and the economic viability of irrigation in their particular situation, it is important to increase farmers' knowledge of irrigation options and practices, but also of ways to procure equipment.

Raising awareness among individual farmers, farmer groups, and other stakeholders, such as district agronomists and local politicians, can be achieved in different ways. In the program, we have not encountered demo plots that show the different equipment available. As one of the sector agronomists told us, farmers mostly "buy what they know," which is most often a diesel pump.[88] Setting up demo plots that present a wide range of equipment helps farmers see the differences between the types of equipment (for example, labor intensity and how to use the equipment) and make a better decision on how to pay for it (whether to apply for a loan or use savings). Other awareness-raising options are the use and training of farmer promoters (experienced farmers who can share their knowledge and experience with other farmers)[89] and broadcasts on tv and radio shows.

Observation 2: Costs that occur after receiving equipment

Down payment for the irrigation equipment is only one part of the puzzle. In terms of affordability, there is often a focus on the cost of the non-subsidized part of the irrigation equipment. However, our research shows that financial difficulties often occur after receiving the equipment. The running costs associated with the equipment are an issue for many farmers we spoke to. These include the costs of fuel, maintenance and repairs, loan repayments, and equipment replacement after a couple of years. In addition, farmers often face difficulties gaining access to spare parts and they lack guidance in the correct use of the equipment to keep running costs low.

[88] Based on a conversation with a sector agronomist from Busoro-Nyanza on June 18, 2021.

[89] As suggested by sector agronomists from Busoro-Nyanza on June 18, 2021, and Rwimbogo-Gatsibo in August 2021.

In terms of maintenance and repairs, farmers are given a one-year guarantee, which is indicated in the contract signed by the farmer, RAB, and the service provider. The service provider is responsible for maintenance and repairs in that first year, but it is the responsibility of the farmer thereafter. As noted elsewhere in this report, the unavailability of equipment, spare parts, and technical support in rural areas is a major issue. This indicates that even if farmers can pay for repairs, they incur additional costs, such as travel costs to Kigali, or bank costs associated with transferring money to third parties. Farmers are also not trained in the use and maintenance of the equipment, and equipping farmers with the right skills to perform small maintenance tasks could reduce their expenses. Another suggestion is to permit farmers to rent or share irrigation equipment, which would allow them to share the corresponding costs.

All in all, irrigation is costly for farmers, as it has maintenance costs and is often associated with the increased usage of complementary inputs, including labor, fertilizer, improved seeds,[90] and the costs of handling an increase in produce, such as transport or storage costs. Some financial institutions provide financial products for running and maintenance costs, but the uptake of these kinds of products appears low in an SSI context.[91] Shifting the focus of the SSIT program by moving away from an exclusive emphasis on purchasing equipment, instead adopting a more encompassing view to support farmers with the additional costs that come with irrigation, might remove a major barrier for farmers.

Observation 3: Limited uptake of external financing

A third observation that can be made regarding farmer financing is the limited number of farmers who use formal loans or additional grants to finance the non-subsidized costs of the SSI equipment. Our data shows that if external financing is used to pay for the non-subsidized part (indicated by 23 percent of the farmers), it is most often by means of a SACCO loan (in 37 percent of those cases; see also Figure 5.1). Within this third observation, comments were made on the role of cooperatives in accessing finance for irrigation, and on the limited uptake of financial instruments from (private) financial institutions. Regarding the latter, an important issue raised was the need for specific loans or financial products for irrigation, which is not being addressed.

Box 5.2: A farmer's story: Nyanza district

A farmer we observed in Nyanza district, Busoro sector, needed repairs to his equipment after it had broken down. The sector agronomist gave him the contact details of the service provider who had provided the equipment. The service provider was based in Kigali and had no repair shop close by. The service provider indicated that his repair service would come to Nyanza district and repair the equipment if the farmer would transfer the repair costs up front using mobile money or via the bank.

As the farmer had never seen or worked with this service provider, he decided not to pay such a large sum up front. However, this resulted in his equipment not being used for more than two years.

This story demonstrates the SSIT program's focus on purchasing equipment and its lack of support to farmers after procurement (for example, capacity building, knowledge transfer, maintenance, and repair) that would allow them to use the equipment to the fullest.

Mismatch between financial requirements of farmers and requirements of financial institutions

There is a mismatch between farmers' financial requirements and the lenders' requirements of farmers. It is important for lenders to understand farmers' financial requirements so that they can design financial products that fit farmers' needs and financial situation (see also section 5.2.2). In general, farmers' primary financial requirements relate to production (such as inputs and labor costs), consumption (school fees, healthcare, funeral expenses, and food), and investments (for example, for value addition to crops or farming business, such as machinery, diversifying into other crops, or irrigation). All these costs require some form of financial liquidity to meet expenses. Based on interviews in the field, we observed that farmers occasionally divert cash from their businesses to meet these financial needs and/or are involved in other endeavors outside of their farming business. This is especially true in times when revenues are lower, such as at the start of the season or during the dry season.

Within the design of the SSIT program, it is assumed that farmers are able and willing to take on loans to finance the non-subsidized part of the equipment. However, both ability and willingness may be barriers for farmers.

[90] Jones, M R, Kondylis, F, Loeser, J A, and Magruder, J. 2020. "Factor Market Failures and the Adoption of Irrigation in Rwanda." World Bank: Policy Research Working Paper 9092, p. 4.

[91] See also section 5.2.2.

In terms of willingness, it should not be assumed that (smallholder) farmers want to borrow from local banks.[92] An external loan is not necessarily the best or most attractive solution for farmers. In Rwanda, collateral requirements often go beyond the loan size, interest rates can be as high as 21 percent,[93] and regular repayment schemes can be a burden for farmers and their households. Farmers will only agree to these terms when there is a clear financial benefit.

In terms of the ability to secure an external loan, we observed that farmers often face difficulties meeting the requirements set by financial institutions. Based on interviews with local financial institutions,[94] requirements to obtain a loan include (but are not limited to) insights into the performance of the farm, providing market contracts, and/or providing collateral in the form of cash, land title, properties, or other assets. The ability to provide collateral is especially challenging for farmers who own very little. We observed that smallholder farmers with small plots of fragmented land and irregular revenue streams are not able to meet the collateral and other requirements for long- and short-term credit provision. This affects the uptake of FLID schemes.[95] Households that have more land, labor, and money to buy farm inputs, or farmers who have grouped together and thus provide each other with collateral, are better positioned to obtain financial products. The SSIT program suggests that farmers obtain a loan, but there is no support to help them to do so. Support could be in the form of testing the economic viability of getting irrigation by using external loans, support in getting collateral, or by facilitating group lending.

Group lending/cooperatives

In our survey of SSIT farmers, 41 percent of our sample were members of a farming cooperative. However, only 8 percent of our total sample financed SSI equipment through a cooperative. The remaining 92 percent financed it individually. This indicates that although some farmers are part of a cooperative, these groups do not appear to be used—or to provide support—for financing equipment for farmers.

This is an interesting observation when compared to statements made by private financial institutions. Banks prefer to lend to farmers who are part of a cooperative or group rather than to individual farmers. While individual farmers are often unable to obtain the requested collateral, farming groups are inherently a form of collateral: if one farmer is in default, the other farmers are responsible for the outstanding balance.[96] Therefore, financiers and NGOs often prefer to work with groups rather than individual farmers, as it increases the farmers' knowledge, networks, and financial means (when they work in groups). The mismanagement of cooperatives and groups is, however, perceived as a clear barrier. Internal disputes and frequent changes in group membership provide challenges for both the farmer groups and the financiers, who see this as an additional risk to their lending scheme. The SSIT program mainly targets individual farmers rather than groups of farmers/cooperatives. Facilitating group loans and supporting cooperatives with their (financial) internal management to obtain financing are underdeveloped areas of the program.

5.2.2 Private financing

It is mentioned in the implementation strategy of the SSIT program that MINAGRI should approach and mobilize financial institutions to provide access to loans for those who cannot afford the remaining 50 percent of the investment cost for an SSIT package.[97] As noted in section 5.2.1, there is a limited uptake of external financing within the sample of SSIT farmers. Only 8 percent of the farmers in our sample obtained a formal loan to cover the non-subsidized part of their equipment, either fully or partially. However, assessing the role of financial institutions in the SSIT program does not only cover the uptake of external loans by farmers. Private financing also relates to the capacity and experience of financial institutions to provide financing solutions for farmers who are interested in purchasing equipment with an SSIT subsidy. Based on our research and interviews with local banks, SACCOs, and other stakeholders, this section identifies four factors that limit the role of financial institutions within the SSIT program.

Observation 1: Rwanda's nascent financial market system

Rwanda's financial sector consists of commercial banks, microfinance institutions, a stock exchange, SACCOs, insurance companies, pension funds, and other institutions, such as foreign exchange bureaus. Table 5.1 outlines the structure of the financial system, in which the banking sector dominates with 67 percent of the Rwandan financial sector's total assets.[98]

[92] Energy4Impact. 2021. *Solar Irrigation Rwanda: Developing a New Market for Smallholder Farmers.* https://energy4impact.org/news/solar-irrigation-rwanda---developing-new-market-smallholder-farmers.

[93] Nzeyimana, I. 2021. *Assessment of Farmer-Led Irrigation Development in Rwanda.* World Bank Group, International Finance Corporation.

[94] Based on interviews with, among others, Banque Populaire du Rwanda, the Business Development Fund (BDF), the International Fund for Agricultural Development (IFAD), and Urwego Opportunity Bank.

[95] Nzeyimana, I. 2021. *Assessment of Farmer-Led Irrigation Development in Rwanda.* World Bank Group, International Finance Corporation, p. 69.

[96] Based on an interview with Banque Populaire du Rwanda, August 2021.

[97] MINAGRI. 2014. *SSIT Implementation Strategy*.

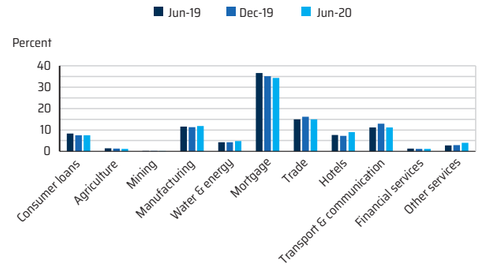
[98] National Bank of Rwanda. 2021. *Annual Financial Stability Report, 2019-2020*, p. 52. https://www.bnr.rw/news-publications/publications/financial-stability-reports/.

Table 5.1: Structure of the financial system in Rwanda[99]

Regulated financial institutions (Assets in RF billion)	June 2019			June 2020		
	Number	Assets	% of TA	Number	Assets	% of TA
Banks	**16**	**3,252**	**65.7**	**16**	**3,854**	**67.0**
Commercial banks	11	2,622	53.0	11	3,142	54.7
Microfinance banks	3	76	1.5	3	66	1.2
Development banks	1	247	5.0	1	265	4.6
Cooperative banks	1	307	6.2	1	381	6.6
Pension schemes	**13**	**877**	**17.7**	**13**	**990**	**17.2**
Public	1	837	16.9	1	941	16.4
Private	12	40	0.8	12	49	0.8
Insurers	**14**	**477**	**9.6**	**14**	**544**	**9.5**
Life	3	49	0.9	3	52	0.9
Non-life	11	428	8.6	11	492	8.6
Microfinances	**457**	**313**	**6.3**	**459**	**330**	**5.7**
U-SACCOs	416	138	2.8	416	139	2.4
Other SACCOs	22	89	1.8	24	97	1.7
Limited companies	19	86	1.7	19	94	1.6
Foreign currency dealers & remittances	**99**	**8**	**0.2**	**97**	**9**	**0.2**
Forex bureau	85	8	0.2	83	9	0.2
Remittance companies	8	-	0.0	8	-	0.0
Money transfer agencies	6	-	0.0	6	-	0.0
Lending-only institutions	**4**	**18**	**0.4**	**4**	**20**	**0.3**
Grand total	**603**	**4,945**	**100.0**	**603**	**5,747**	**100.0**

It seems, however, that the banking sector is not suited to the small-scale, market-oriented farmers who are part of the SSIT program. First, because of its high interest rates and limited availability in rural areas, the sector is not favorable for obtaining loans. Second, despite agriculture being one of the most important and largest sectors in Rwanda, loan distribution for the agricultural sector is limited. Figure 5.3 shows the distribution of banking sector loans to other sectors. Loans to the agricultural sector (1.2 percent) are very limited, especially when compared to other sectors, such as manufacturing (11.8 percent), transport and communication (11.1 percent), and restaurants and hotels (9 percent).[100] In addition, limited experience with the sector, on the part of both the banks and farmers, can influence the uptake of loans in an SSI context. Third, it is also important to note that the number of farmers, cooperatives, and agribusinesses with the capacity to borrow and repay loan funds is limited in the agricultural sector.[101]

Figure 5.3: Outstanding loans of the banking sector to other sectors[102]



[99] National Bank of Rwanda. 2021. *Annual Financial Stability Report, 2019-2020*. https://www.bnr.rw/news-publications/publications/financial-stability-reports/.

[100] National Bank of Rwanda. 2021. *Annual Financial Stability Report, 2019-2020*, p. 30. https://www.bnr.rw/news-publications/publications/financial-stability-reports/.

[101] World Bank Group. 2018. *Agriculture Finance Diagnostic Rwanda.* https://collaboration.worldbank.org/content/usergenerated/asi/cloud/attachments/sites/collaboration-for-development/en/groups/agrifin/documents/jcr:content/content/primary/blog/rwanda_agriculturef-X2kD/Rwanda%20Agriculture%20Finance%20Diagnostic.pdf.

[102] National Bank of Rwanda. 2021. *Annual Financial Stability Report, 2019-2020.* https://www.bnr.rw/news-publications/publications/financial-stability-reports/.

The fourth largest sector within the financial structure is microfinance, of which SACCOs are a part. SACCOs are also known as "Umurenge SACCO," as they are present at the sector level (*umurenge* is the Kinyarwanda word for sector). Umurenge SACCO is a government initiative aimed at increasing the financial inclusion of Rwandans, boosting rural savings, and providing access to loans to complement earnings and enhance livelihoods. Most of the banks and financial institutions are concentrated in urban areas, while a large part of the Rwandan population resides in rural areas. In 2009, when SACCOs were established, the number of Rwandans (18 years and above) with access to financial services was 21 percent. In 2020, this proportion had increased to 77 percent. The Umurenge SACCO offers basic microfinance services that vary from one SACCO to another.

As our survey data shows, SACCOs play an important role in providing access to financial services. However, we observed that SACCOs are not necessarily the cheapest option for farmers. The interest rate varies between SACCOs but is typically between 20 and 30 percent per year.[103] As they perform at a sector level, they are closest to farmers in rural areas and are thus often the only available option. As such, SACCOs are a good way of getting more capital into the agricultural system, and they supplement the role that commercial banks and financial institutions can play.

Observation 2: Lack of knowledge and understanding of the agricultural sector

Based on desk research and interviews with three local banks in Rwanda, there seems to be a limited appetite for lending to smallholders. Agribusiness and agricultural lending are perceived as risky endeavors because of the seasonality and uncertainty of incomes, leading to higher interest rates and extensive application requirements. Also, banks' limited experience with the sector (Figure 5.3) has led to inappropriate lending policies and products, high transaction costs to reach remote rural populations, and a lack of expertise to manage agricultural loan portfolios. It is important to help financial institutions to gain confidence and create a deeper understanding of the sector to ensure that financiers are willing to take more risks and create policies and products that allow them to take a bigger stake in the agricultural sector.

Observation 3: Financial products—not fit for purpose and not supportive of SSI development

It is not realistic to expect existing (lending) products offered by commercial banks to automatically fit within the context of SSI development. Although some financial institutions provide loans and financial services to farmers, we did not come across specific products that support irrigation development. The feasibility study of the SSIT program advised an outreach to financial institutions to enable farmers to pay for the non-subsidized part of the SSIT equipment; however, we have not come across any financial institutions that received a formal invitation to do so. For a potential follow-up program, we advise financial institutions to try a formal outreach and even to jointly design financial products that can be used by farmers who are part of the SSIT program. Financial institutions should design products that fit the needs and farming cycles of SSIT farmers.

Specific features, such as the repayment terms, the type of loan (short, medium, or long term), collateral requirements (such as the option to use SSIT equipment as part of collateral), and pricing should be designed to fit the context of farmers starting irrigation using the government subsidy. Products could also be designed in formal partnership with institutions such as the BDF,[104] while insurance companies could design credit products whereby insurance premiums are bundled into the loan products, and development finance institutions could provide guarantees to national financing institutions, suppliers, or agribusiness companies.[105] It is recommended that arrangements are designed within the subsidy scheme to transfer risks from the private to the public sector and help farmers to finance irrigation equipment.

Observation 4: Limited uptake of insurance

Using insurance is a way of protecting businesses from financial losses. In agriculture, insurance is mainly promoted to reduce the negative impacts of crop failure and livestock illness and can support farmers with accessing credit and increase their willingness to invest in labor and inputs. The FLID Guide stresses that insurance limits risk and is therefore part of an integrated financial response to increase the uptake of irrigation.[106]

[103] Based on an interview with SACCO Rwabicuma, Nyanza district.

[104] BDF helps Rwandan small and midsize enterprises to access finance, particularly those without sufficient collateral to obtain credit from traditional financial institutions at reasonable rates. See also https://www.bdf.rw/.

[105] Izzi, G, Denison, J, and Veldwisch, G J, eds. 2021. *The Farmer-Led Irrigation Development Guide: A What, Why and How-to for Intervention Design.* Washington, DC: World Bank, pp. M5-12/13.

[106] Izzi, G, Denison, J, and Veldwisch, G J, eds. 2021. *The Farmer-Led Irrigation Development Guide: A What, Why and How-to for Intervention Design.* Washington, DC: World Bank, pp. M5-09.

There are several types of agriculture-related insurance, such as animal agricultural insurance (for example, livestock mortality), crop agricultural insurance (such as weather-index insurance to protect a farmer from drought and excessive rain), and farm property and equipment agricultural insurance.[107]

Our survey data shows that 92.5 percent of our sample farmers do *not* insure their crops. When asking about insurance in the field, we observed that there was a limited knowledge about insurance, how it works, and what the benefits are (especially compared to its costs). Although insurance can be used to reduce lending risks and increase the number of financial institutions that lend to farmers, based on our data it seems that insurance is simply not part of the SSIT landscape in Rwanda.

Ongoing initiatives are in place to support farmers' access to insurance. In Nyanza district, for example, the Busoro sector agronomist indicated that he would actively promote insurance products from the Radiant and SONARWA insurance companies to the farmers he works with. In addition, Rwanda has operated a national insurance scheme since 2019. Managed by MINAGRI, the scheme is meant to mitigate risks and losses for farmers caused by unpredictable natural disasters, pests, and diseases that affect their livestock and crops. Through this insurance scheme, the GoR ensures an increasing flow of credit to the agricultural sector.[108]

Although we recommend seeing how these kinds of schemes can be leveraged in the context of the SSIT program, there does not seem much overlap yet. The first reason that the national insurance scheme does not fit the SSI development context is that the scheme focuses on farmers on consolidated land, whereas the SSIT program focuses mainly on smallholder/individual farmers. Second, the scheme only includes four crops: maize, rice, potato, and chili. (Irish potatoes are seen as tubers, and maize as cereals.) Vegetables are not part of the scheme, but most SSIT farmers irrigate and grow vegetables.[109]

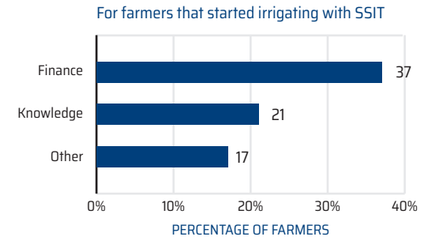
5.2.3 Government/donor-funded projects

Various government- and donor-funded projects in Rwanda aim to improve access to markets, access to finance, and/or install large- and small-scale irrigation schemes. We have been looking at the interaction between those different projects and programs and the influence that each has on the other. This subsection starts with a brief review of the role of the GoR in enabling farmers to finance irrigation equipment and is followed by remarks on the role of NGOs and other donors.

The role of the government

As the SSIT program is a government-led and -funded project, it exemplifies the role of the GoR in supporting and facilitating a larger uptake of irrigation equipment by farmers. Our data shows that for 49.3 percent of farmers who started irrigation with support from the SSIT subsidy, finance was the main constraint to an earlier start with irrigation (Figure 5.4). This indicates that the SSIT program has contributed to irrigation development in Rwanda by facilitating farmers' ability to purchase irrigation equipment.

Figure 5.4: Main constraints for irrigation before SSIT, as indicated in the farmer survey



In addition to the national SSIT program, lower-level government has played a role in an even larger uptake of the program. Since 2016, farmers in Nyanza district have received an additional 25 percent subsidy from local government, on top of the existing 50 percent subsidy from the national government. This example shows that interventions to provide support to farmers are also possible on a district level.

The GoR has a wide range of policies and strategies in place nationwide that influence SSI development in one way or another. These include, but are not limited to, the Strategic Plan for Agriculture-4, the Rwanda Irrigation Master Plan, Vision 2050, the National Policy for Water Resources Management, and the National Agricultural Policy. In our desk research and field work, we have not come across clear examples of where other government interventions are clearly linked to the SSIT program.

[107] Agricdemy. 2016. "Agricultural Insurance." https://agricdemy.com/post/agricultural-insurance.

[108] MINAGRI. 2019. "Government Launches a Subsidized Agriculture Insurance Scheme." https://www.minagri.gov.rw/updates/news-details/government-launches-a-subsidized-agriculture-insurance-scheme.

[109] Based on an interview by MINAGRI with the program coordinators of the insurance scheme, August 2021.

It is recommended to adopt a more holistic approach to irrigation development by linking multiple subsidies. Examples include the agricultural subsidy inputs program under Smart Nkunganire,[110] where farmers buy inputs (seeds and fertilizer) on subsidy from agro-dealers and pay though an online platform called IKOFI (e-wallet). The program was initiated by the Bank of Kigali to drive financial inclusion and is intended to mitigate the risks and losses incurred by farmers because of unpredictable natural disasters, pests, and diseases that affect their livestock and crops.

In terms of bridging the affordability gap within the SSIT program, other activities the GoR can pursue relate to enhancing the willingness of financial institutions to provide irrigation financing. Examples referred to elsewhere in this annex include initiatives to lower the (perceived) risks by lenders (for example, through insurance schemes, credit guarantees, and the promotion of group lending), activities to lower transaction costs (for example, by facilitating closer collaboration with SACCOs), and to support farmers' ability to repay loans (for example, by facilitating access to markets and contract farming).

The role of donors

The implementation strategy of the SSIT program states that there is a need to mobilize local and international NGOs to support socioeconomically disadvantaged beneficiaries who are unable to approach financial institutions.[111] This subsection highlights different findings on the roles of donors and NGOs, focusing on their ability to increase access to finance by means of additional grants and capacity building. The findings are based on interviews with representatives of different programs and donors, including the U.S. Agency for International Development (USAID)/Hinga Weze, the Kayonza Irrigation and Integrated Watershed Management Project, MINAGRI's National Insurance Scheme, IFAD, and the SIR market development program.

We observed that donor- and government-funded projects tend to work in silos, which hinders each program from tapping into the successes of other irrigation-related programs and larger schemes. Major schemes and donor programs determine in advance when, where, and what kind of systems are implemented. For example, IFAD is financing major schemes throughout the country, but these are not formally linked to the SSIT program. It would be beneficial to investigate whether these schemes can promote the SSIT program and support farmers who are close to irrigation schemes to tap into the infrastructure for smaller-scale solutions.

Access to finance

Over the years, donors have supported the institutional development of the Rwandan financial sector to increase the capacity of Rwanda's financial landscape. Donors such as IFAD and bilateral projects managed by USAID provide multiple matching grants to farmers and agribusinesses to stimulate an increase in the use of inputs, the adoption of technology, and commercialization. As such, donors can play a large role in matching grants, thereby increasing access to irrigation financing. The SIR market development program has actively supported farmers in an SSI development context by offering a top-up grant for SSIT farmers involved in solar irrigation.[112] However, this project is not applicable to farmers interested in buying non-solar equipment.[113] There are other ongoing SSI projects that are financed by international organizations, international financial organizations, and local and international NGOs, and they implement different irrigation financing models, but they are not linked to the SSIT subsidy program, nor do they refer to the possibility of accessing a subsidy elsewhere.

Knowledge

Interviewees indicated that private finance players lack knowledge and understanding of the agricultural sector. We observed that many farmers also have limited knowledge of financing, which hinders both their ability to reach out to financial institutions and the uptake of external financing. Donors could step in in this area. There are already examples of donors in Rwanda that support farmers to become financially literate, such as the Irrigate to Win project by the Interchurch Organization for Development Cooperation (ICCO) (part of Cordaid), which pilots sustainable financing solutions for farmers to access innovative irrigation technologies.[114] One of the ICCO project's components is training in financial literacy to support cooperatives' administration procedures and keep better track of their bookings, including their costs and profits. The beneficiaries of this program differ from the SSIT beneficiaries (the Irrigate to Win program focuses on selected cooperatives rather than individual farmers), so there is no direct overlap. Lessons can be learned from different programs, however, and it is recommended that to assess the relevance of a potential follow-up phase of the SSIT program, connection be made with donors with experience in training farmers in financial matters.

[110] IFAD (International Fund for Agricultural Development). 2021. "Smart Nkunganire System: Digitalizing the Agriculture Inputs Subsidy Program to Increase Agricultural Productivity Among Smallholder Farmers in Rwanda." https://ruralsolutionsportal.org/en/-/smart-nkunganire-system-sns-.

[111] MINAGRI. 2014. *SSIT Implementation Strategy.*

[112] Energy4Impact. 2021. *Solar Irrigation Rwanda: Developing a New Market for Smallholder Farmers.* https://energy4impact.org/news/solar-irrigation-rwanda---developing-new-market-smallholder-farmers.

[113] Ibid.

[114] ICCO Cooperation. July 2020. "ICCO in Rwanda Program Overview." https://www.icco-cooperation.org/en/wp-content/uploads/sites/2/2020/07/Rwanda-Factsheet-2-1.pdf.

Table 5.2: Score for financing

Findings	Score
Financial policies and regulations that are unsuitable for irrigation equipment markets and irrigated value chain development	3.25
Appropriate financial products (for smallholder farmers) are limited in the formal credit market	1.50
Laws and regulations related to finance pay little attention to equal access; women and other recognizable groups (for example, those based on religion or ethnicity) are constrained in their access to credit	4.33
Information and communication technology (ICT) systems are underdeveloped, with few opportunities to reduce the transaction costs of credit provision and the risks of default for borrowers	3.60
Average scoring for financial factors	**3.17**

5.2.4 Scoring

To score the financial axis on the diagnostic spider plot, we have considered the structure as presented in the FLID Guide.[115] The scoring is based on a ranking from very weak (1) to very strong (5). The average scoring for financing is 3.17.

5.3 Other financing models

A clear recommendation that emerged in the previous sections is the need to work with the financial sector to create financial products that fit the needs of farmers in a FLID/SSI development context. There is ongoing research into new financing models with the potential to bridge existing affordability gaps by, for example, reducing transaction costs, managing risks, or providing other incentives for financial institutions to become more active in the agricultural sector. This section highlights a few of those new models. It is critical to note, however, that these models are not necessarily ready to use in the context of SSI development in Rwanda. The overview below can provide inspiration for what is possible but must be tested for and tailored to the Rwandan context, which will take time and a coordinated effort between affected stakeholders.

5.3.1 Agricultural insurance

Agricultural insurance and how to link it to finance for farmers were discussed earlier in this annex. Insurance can reduce the negative impacts of crop failure and livestock illness, thereby improving a farmer's ability to access credit and their willingness to invest in inputs and labor. Different types of agriculture-related insurance include weather index, area yield, livestock mortality, and price insurance.[116]

5.3.2 Agricultural value chain finance approach

Value chain financing is provided to a player (or actor) in the value chain to increase value-chain growth and competitiveness. This approach helps identify financing needs and gaps, which partner can provide financing, and ways to improve access to finance throughout the value chain. Although enabling agricultural value chain finance is a difficult task that requires strong collaboration between a wide range of players along the value chain and supporting systems, it is a holistic and rewarding financing model. Any financial institution that wishes to provide agricultural value chain finance should be prepared to invest considerable effort and resources to deeply understand players, relationships, and financial needs at each level and along each segment of the chain. By working in collaboration with these players, financial institutions may benefit from the comparative advantage of having in-depth knowledge of the agricultural value chain, as well as market-based risk management mechanisms that can contribute to the design of sounder agricultural value chain finance strategies.[117]

[115] Izzi, G, Denison, J, and Veldwisch, G J, eds. 2021. *The Farmer-Led Irrigation Development Guide: A What, Why and How-to for Intervention Design.* Washington, DC: World Bank, pp. M5–20.

[116] G20 Global Partnership for Financial Inclusion (GPFI), SME Finance Sub-Group. October 2015. *New Trends in Agricultural Finance*. https://www.gpfi.org/sites/gpfi/files/documents/02-New%20Trend%20Agricultural%20Finance%20Report-Final-LowRes.pdf.

[117] Rural Finance Partnership. 2016. *Successful Models for Financing the Rural and Agricultural Sectors.* https://incofin.com/wp-content/uploads/Incofin-IM-Successful-Models-for-Financing-the-Rural-and-Agricultural-Sectors.pdf.

5.3.3 Direct smallholder lending

Direct finance models enable smallholders to benefit from a full range of financial services. To mitigate risks and improve this financing model, the financial institution can: (1) attempt to establish deep knowledge of the farmer and their business; (2) provide a cap on the loan to a single farmer; (3) encourage group lending (collective responsibility); (4) improve integration into a supply chain; and (5) attempt to provide cash to the farmer during the lean period between the planting and harvesting seasons to lower the side-selling risk.[118]

5.3.4 Indirect lending through farmer-based organizations/cooperatives/group lending

In this model, a financial institution lends indirectly to smallholders through a larger aggregator organization, such as a farmer-based organization or a cooperative, whereby all group members become borrowers and thus become each other's guarantors. The model has low costs for administration related to creditworthiness and the burden of loan administration, and it reduces perceived risks for lenders relative to lending to individual farmers.[119]

5.3.5 Pay-as-you-go

Pay-as-you-go is another potential solution to bridge the affordability gap. In this model, farmers make a down payment and pay off the balance in installments, which are often facilitated by mobile payments. This model is common in financing environments where low levels of savings are available for equipment with a relatively high capital cost.[120] The SIR program tested this approach within its solar irrigation subsidy model. The results were not entirely fruitful, however, and the program offered a clear recommendation that further research is needed to gain a better understanding of how much farmers can afford to pay, both up front and via installments, and whether those installments should be paid on a regular, monthly basis or should be timed to be made after the harvest.[121]

To summarize, developments and research are ongoing to find new financing models that offer opportunities to improve private incentives, reduce transaction costs, and manage the risks associated with investing in SSI. As seen in the lessons learned from the SIR program, however, these models cannot be expected to be a perfect fit for the SSI development context. Integrating these models in programs such as the SSIT program requires sufficient time for trial and error and to adapt these models to the local context. The list above can provide inspiration for what is possible and could be a starting point for further product development.

5.4 Recommendations

Based on our observations, we have identified recommendations that could be considered for a second phase of the SSIT subsidy program.

[118] International Finance Corporation. 2012. *Innovative Agricultural SME Finance Models.* Washington, DC.

[119] Ibid.

[120] Nzeyimana, I. 2021. *Assessment of Farmer-Led Irrigation Development in Rwanda*. World Bank Group, International Finance Corporation.

[121] Energy4Impact. 2021. *Solar Irrigation Rwanda: Developing a New Market for Smallholder Farmers.* https://energy4impact.org/news/solar-irrigation-rwanda---developing-new-market-smallholder-farmers.

Table 5.3: Recommendations to improve financing

Recommendation	Related to
1. Increase flexibility for payment The current program does not allow for much flexibility in terms of down payment, criteria, and so on. Suggestions include: • Farmers rent or share irrigation equipment, allowing them to share the corresponding costs. • Provide alternative ways for farmers to pay for the non-subsidized part of SSIT, for example by paying in installments or collectively as a group. Payment modalities should be aligned with the individual farmer's situation, socioeconomic status, and productivity plans/targets. • Support farmers to finance the maintenance and running costs of equipment by offering additional financing solutions beyond the purchase of the equipment.	Farmer financing Government and donor involvement
2. Co-develop financial products with financial institutions to meet the needs of farmers in an SSIT context • Include the financial sector to jointly create fit-for-purpose financial products. Formal outreach to financiers is needed to work closely together to design products that fit irrigation. • Invest in improving financial institutions' knowledge and experience of the agricultural sector. • It cannot be assumed that the existing financial products of commercial banks automatically fit the Rwandan context. Time and resources are needed to test and fine-tune.	Private financing Government and donor involvement
3. Formalize loans and structures with SACCOs Although SACCOs are not the only solution (because of high interest rates and a focus on household expenses rather than on agricultural expenses/irrigation equipment, for example), they appear to be the main source of financing for rural farmers. Collaboration with a SACCO for specific irrigation products is worth consideration.	Private financing Government and donor involvement
4. Support farmers to put collateral requirements in place Support farmers to meet financiers' loan-collateral requirements: • Work with NGOs or organizations such as BDF to provide guarantees or other types of support for collateral. • Allow SSIT irrigation equipment to be submitted as collateral. • Support group lending and/or cooperatives to ensure that farmers can obtain loans together (lowering the perceived risk for financial institutions). Supporting proper management of the group to ensure that they are able to manage and repay the loan is key.	Government and donor involvement Private financing
5. Proactively connect with other subsidy programs and schemes • Collaborate with other government subsidies (such as input subsidies) to lower the farmer's contribution and increase the number of smallholders benefiting from the program. • Design/involve complementary policies. Subsidizing irrigation equipment is not enough; interventions are needed across the value chain, reflecting the benefits a farmer should obtain (such as access to markets, operations and maintenance, seed availability, and pre-financing the seeds).	Government and donor involvement

ANNEX 6: MARKETS

6.1 Introduction

Remoteness, low production, low farm-gate prices, and a lack of information are often stated as the main reasons for poor farmer linkages in Africa.[122] To assess market linkages and the extent to which market outputs are present in the context of the small-scale irrigation technology (SSIT) program, different crops were followed from the farmer and upstream along the supply chain. The key question that this annex assesses is whether the SSIT program contributed to making farmers (more) market-oriented, meaning that the program encouraged or enabled farmers to sell their increased produce.

To answer this question, we review different elements of the market system in Rwanda, based on the structure of the Farmer-Led Irrigation Development (FLID) Guide.1 Here, the main elements of a market system are defined as the core market, the suppliers of supporting goods and services, and the enabling environment (Figure 6.1).

This annex starts with an analysis of the findings related to the core market (producers, buyers, and consumers) in the light of three market access models. The analysis is followed by findings that relate to the suppliers of supporting goods and services, and a review of the enabling environment (such as the role played by government).

6.2 Diagnostics and scoring

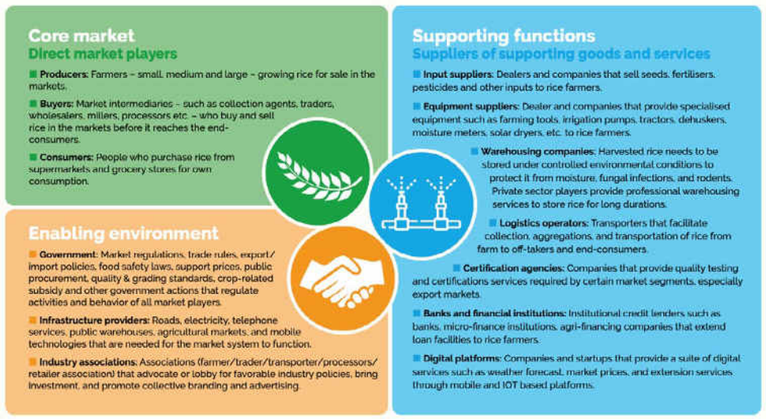
6.2.1 Description and analysis of the core market

This subsection identifies and describes the producers, buyers, and sellers in the Rwandan market structure. In the FLID Guide, these three players are defined as direct market players within the core market (Figure 6.1).

To determine the core market in the context of the SSIT program, we outline various players in the supply chain across different models, as identified in the FLID Guide and observed during our field visits. The FLID Guide refers to four types of market-linkage models: (1) producer-forward model; (2) aggregator-back model; (3) processor-back model; and (4) vertically integrated model.[124]

Based on our fieldwork and desk research, we created an updated overview of observed market linkages within the SSIT context and along the lines of the models presented in the FLID Guide (Figure 6.2). As we did not see any examples of SSIT farmers engaging in the fourth model, we limited our analysis to the first three models.

Figure 6.1: The main elements of a market system according to the FLID Guide[123]

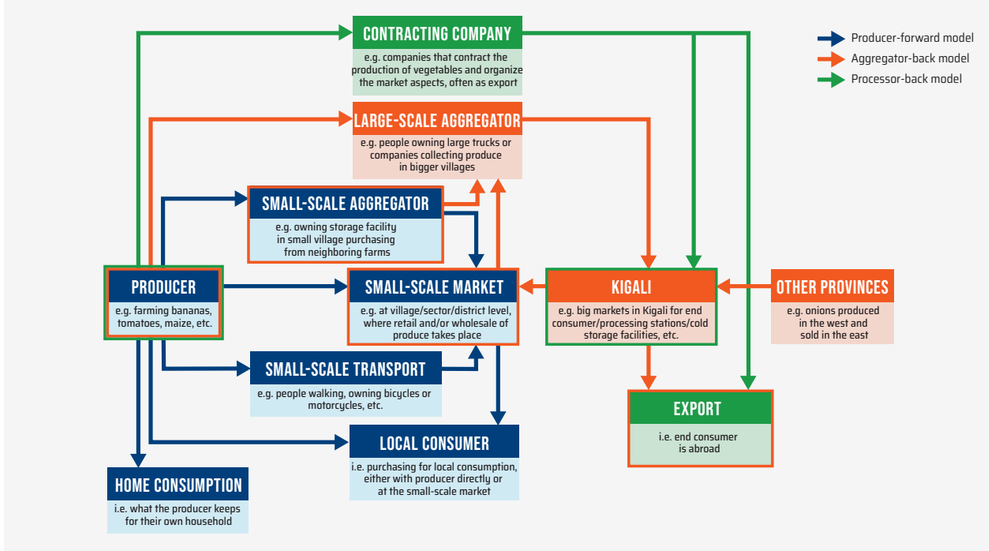


[122] Izzi, G, Denison, J, and Veldwisch, G J, eds. 2021. *The Farmer-Led Irrigation Development Guide: A What, Why and How-to for Intervention Design.* Washington, DC: World Bank.

[123] Ibid, pp. M06-annex07.

[124] Izzi, G, Denison, J, and Veldwisch, G J, eds. 2021. *The Farmer-Led Irrigation Development Guide: A What, Why and How-to for Intervention Design.* Washington, DC: World Bank. Figure 6.2, pp. M06-08.

Figure 6.2: Identified market linkages following crops upstream



Note: The arrows indicate the direction of the crops along the value chain (created for the purpose of this research. See also Annex 6: Markets).

The linkages are considered from a producer's point of view and are linked to the three market access models presented in the FLID Guide. The purpose of Figure 6.2 is to present the identified market linkages, to ultimately identify where the market-related bottlenecks and challenges are for the SSIT farmers. In turn, we make some observations about the SSIT program and the extent to which the program addresses those bottlenecks and challenges.

Producer-forward (model 1)

In the producer-forward model, which was the model we observed most in the field, the producer (an individual farmer or a formal or informal groups of farmers) carries their own produce forward along the value chain. A producer can keep some produce for home consumption, sell it directly on the farm to local producers or small-scale aggregators, or take it to a local small-scale market themselves, either through a small-scale transport intermediary or by taking the crops to the market directly and negotiating a price with small-scale retailers in the market.

Farmers' ability to sell their crops in the producer-forward model depends mainly on their location, distance to the village/small market, and the proximity of customers. The further the farmer can carry their product along the supply chain, the more bargaining power they have. The farmers with the most bargaining power take their produce to a local small-scale market where they sell it to small-scale retailers or to larger aggregators who collect large quantities of different farmers' produce. These farmers transport their produce to the market themselves in owned or rented transport (such as a bicycle, motorcycle, or small car) or they pay someone to transport for them; the farmer also goes to the market and negotiates a price directly with the buyer. In contrast, farmers who sell directly to customers (who come to the farm to buy) have less bargaining power and face difficulties selling their produce for a reasonable price.

Farmers in this first model expressed various difficulties with linking up with markets, especially when they relied on small-scale aggregators and local consumers to purchase directly on the farms. Taking crops to the market requires access to transport, either their own or hired trucks belonging to small-scale transporters, which requires investment. As such, farmers face a trade-off between spending time and money to take crops to the market, where they may be able to obtain a higher price or accepting the price that customers who come directly to the farm are willing to pay. The SSIT program has a focus on increasing production, but it offers no support on how to balance this trade-off and whether further investments are needed, such as for transport.

A second barrier is that farmers have limited Information on market prices. No large aggregator or contract farming is involved in the producer-forward model, and the farmer's agency is relatively high in terms of crop choice, chosen inputs, and so on. The model has a high level of informality, and many of the players described can be characterized as precarious labor, partaking in the supply chain one season and then dropping out the following season, thus making it difficult to predict supply and demand. The farmers lack a comprehensive understanding of the market that they engage with (in terms of buyers and prices, but also in terms of marketing), which hinders them from effectively selling their produce. Later in this report, we consider the lack of market-related information in more detail.

A third barrier is the lack of (cold) storage facilities. When production increases but no market is available, farmers are likely to sell at a lower price to keep their produce from spoiling. Farmers need better storage facilities nearby to store their extra produce, so they have more time to find a market at a better price. A sector agronomist interviewed in Nyanza region[125] mentioned that this barrier discourages farmers from engaging in horticultural crop production. A retail seller in Nyagatare touched on the same point. For her, the largest challenge for small-scale farmers was the "lack of a good market." As a retail seller for 11 years, she often saw farmers start producing a new crop. Come harvest time (usually the same time for everyone), the farmers faced difficulties offloading their crops, got discouraged, and changed strategy for the following year, producing other crops or quitting production altogether. This kind of behavior causes market rigidities, and when farmers regularly change their crop strategy based on limited information about supply and demand in the region, market equilibrium cannot be achieved.

As the examples above show, farmers in the first model are dependent on small-scale aggregators, direct buyers who come to the farm, or their own ability to pay for transportation to markets to secure higher prices. If the producer's outputs change, it is crucial that the capacities of the other players in the value chain are able to absorb these changes. This is not facilitated under the SSIT program. Complementary programs are recommended to support farmers in the producer-forward model to link up with markets more efficiently and/or to help them and buyers match supply and demand.

Box 6.1: A farmer's story: Limited bargaining power at the farm gate

A farmer in Kamonyi, who mainly produced bananas and Irish potatoes for his own consumption, told us that he found it difficult to sell his fruits as "there is no market"—a common phrase used by farmers. The farmer used to sell his bananas to a juice company, who picked them up directly from him at RF 100/kg, but they had suddenly stopped coming, and he was no longer in contact with the company. The farmer indicated that it is very difficult to find customers in the area, and he relied solely on people like small-scale aggregators to purchase from him directly on the farm. When we were on his farm, small-scale aggregators on bicycles were collecting bananas from him at a price of RF 80/kg. The small-scale aggregators then took the bananas to a market in the village, approximately 10 minutes' ride from his house. As we drove from his house, we saw a large truck collecting bananas in this village, paying RF 130/kg to take them on to Kamonyi town, where they would be sold for RF 150. This example illustrates farmers' limited bargaining power when selling individually at the farm gate.

Photo 6.1: A small-scale transporter bringing bananas to a small-scale market on behalf of a farmer for the price of RF 200

Source: Resilience B.V.

[125] Interview with sector agronomist from Busoro, Nyanza district, on June 18, 2021.

Aggregator-back (model 2)

In the second model, large-scale aggregators come directly to the farm to purchase produce from (often small-scale) farmers. Different players—such as intermediaries, traders, and wholesalers—purchase, aggregate, and transport agricultural produce from farmers to off-takers. These players add margins on top of the farm-gate prices paid to the farmer.[126] Arrangements are made either at the beginning of the season or post-harvest and, in addition to the purchase of the produce, can include other types of pre- and post-harvest support.

The aggregator-back model was particularly visible in the maize value chain, where commercial companies such as Minimex and Africa Improved Foods sign a contract with farmers or cooperatives (often through collective companies such as Kumwe Harvest Ltd for Africa Improved Foods). These companies come to the farm directly and purchase the crops, as arranged at the beginning of the season. The upside of these contracts is that farmers know when and where they will sell their produce. As such, these aggregators address certain bottlenecks described in the producer-forward model, such as low farm-gate prices and a lack of market information on prices and buyers.

In other value chains, the aggregators are not necessarily large commercial companies but are traders from Kigali or other brokers from the region. We also came across individuals who aggregate produce in a small storage facility and arrange transport to Kigali when there is enough (see Box 6.2).

Sometimes aggregators provide farmers with other instruments, such as sacks to be used for harvest (see Photo 6.2). In one example, a trader in Kigali arranged to sell produce to local brokers at the beginning of the season. The brokers visited the farmer just before harvest to make a first-installment payment and deliver empty sacks. After harvest, they came to the farm again to pick up the filled sacks. It is important to note, however, that these arrangements are often made without a formal contract. We talked to SSIT farmers who were not certain that their off-taker would show up, or who had had experience of traders not returning the following year. Although the second model provides more certainty to farmers, they still face uncertainties and challenges when selling their produce.

As in the producer-back model, there is no additional support for farmers who are part of the SSIT program or for players with an active role in the agricultural system the farmer is operating in. There is also no support for other players in the value chain, although they must increase their capacity and purchasing power to absorb the increased production of individual farmers who start to irrigate. Partnerships with other subsidy or donor programs that focus on increasing market linkages could help address some of these issues.

Photo 6.2: Tomato sacks, originally provided to the farmer at the beginning of the season, are filled and ready to be collected from the farm

Source: Resilience B.V.

Processor-back (model 3)

In the processor-back model, a large aggregator signs contracts with farmers regarding production, inputs, quantity, and scale of specific produce. After harvest, the aggregator picks the produce up directly from the farm. In addition to the actual sale and quality of produce, contracts may include agreements on specific inputs, technical assistance, or financial support. We saw very few examples of SSIT farmers who use this model. In Bugesera, contracting company Proxifresh contracts farmers to produce French beans for the export market. Here, the trader Proxifresh is involved in most aspects of the farming—from the choice of seeds and fertilizer to the planning, purchasing, and storage of the harvested beans.

The processor-back model is valuable for farmers, as it provides them with more certain access to markets. In addition, the contracting companies often provide support to help farmers increase their yields and change their agricultural practices. However, a limited number of companies work to this model in Rwanda, largely because there is a shortage of processing factories and exporters.

[126] Izzi, G, Denison, J, and Veldwisch, G J, eds. 2021. *The Farmer-Led Irrigation Development Guide: A What, Why and How-to for Intervention Design.* Washington, DC: World Bank, pp. M06-07.

Photo 6.3: Beans in Bugesera, ready to be collected by a horticultural export company

Source: Resilience B.V.

Donor-funded programs and government activities aim to strengthen supply chains for export markets, value addition, and/or market demand. For example, Rwanda put in place agricultural export growth targets, seeking to increase exports from about US$23 million in 2018 to US$205 million by 2024. Other initiatives and projects, as outlined in the National Agricultural Export Development Board Strategic Plan 2019–2024, can provide opportunities and new markets for SSIT farmers. When designing new irrigation programs, we recommend aligning these with the targets and initiatives already in place. Other examples of donor-funded projects can be found in section 6.2.3.

Vertically integrated cooperation (model 4)

The vertically integrated model is the fourth model described in the FLID Guide. In this model, farmers have contracts with (inter)national players, such as large-scale corporations, manufacturers, and fast-moving consumer goods companies. We did not encounter this model among SSIT farmers. It is outside the scope of this report to interview larger corporations that integrate several farmers into their supply chains by means of contract farming. However, these companies could be potential partners for the SSIT program, as larger corporations have access to many farmers and are often interested in increasing the quality and quantity of produce. This is an underdeveloped area that might be explored in a follow-up phase.

6.2.2 Description and analysis of the supporting functions

The description of the various market-access models highlights the dependencies within an agricultural system, including that of Rwanda. As shown in Figure 6.1, so-called "supporting functions" play an important role in the agricultural system the farmer is operating in and can support (or limit) farmers to connect with output markets. The SSIT subsidy program focuses on lowering the investment costs for irrigation equipment; taking a broader approach by connecting to supporting functions could support farmers to access markets and increase private sector engagement in small-scale irrigation (SSI) development. This section reviews supporting functions that are in operation in the following areas: (1) input and equipment supply to farmers; (2) infrastructure; and (3) digitalization and market information.

Input and equipment supply to farmers

In a farmer-led irrigation context, farmers are dependent on input suppliers and equipment providers to obtain the right inputs and irrigation equipment for their farming businesses. Input suppliers encompass agro-dealers and private companies that sell fertilizers, pesticides, seeds, and other inputs. The distribution of inputs in Rwanda is managed on the government side by the Rwanda Agriculture and Animal Resources Development Board (RAB) under the Ministry of Agriculture and Animal Resources (MINAGRI).

This analysis is focused on the output markets outlined in the FLID Guide, and it only touches on the input market as part of the supporting functions. However, we found a series of issues that relate to input markets, such as difficulties in obtaining seeds at the right time for planting, the required amount of fertilizers, and a lack of knowledge about the quality demanded by the market. Multiple farmers suggested during qualitative interviews that as part of the subsidy program, RAB could play a role in price reduction and increasing the availability of inputs. For example, an SSIT farmer in Nyagatare highlighted difficulties in acquiring seeds at the right time, which often delayed his planting activities too far into the season for optimal growth conditions. Further studies should seek to investigate the relationship between input supply and the overall ability of farmers to improve their livelihoods with farmer-led irrigation.

In terms of obtaining irrigation equipment or related spare parts, the equipment providers selected as part of the SSIT program are important players from the farmers' perspective. In terms of private sector development in an SSI development context, the supply and maintenance of irrigation equipment also provide opportunities for the local private sector to tap into.

In our sample of SSIT farmers, more than 66 percent of the farmers indicated that their main constraint to improving irrigation was related to the availability and price of irrigation equipment. During our field visits, many farmers disclosed that suppliers are not around to help set up and run the irrigation systems, that service providers often do not set up a local office or small shop in the districts in which they supply equipment despite their agreement to do so with RAB, and that, overall, the availability of good technicians and spare parts is a key challenge. These challenges provide opportunities for the local private sector to tap into. For example, a partnership between RAB, MINAGRI, and Rwanda TVET Board could focus on capacity building and the training of young technicians and professionals in rural towns who already run mechanical/electronic repair centers.

The Rwanda Workforce Development Authority has also initiated national programs to support local manufacturing subsectors and to limit/reduce imports of FLID equipment. The SSIT program's feasibility study refers to the importance of locally fabricating and assembling SSIT to increase the manufacturing sector and local job creation.[127] The idea was to encourage equipment providers to procure as much equipment as possible locally, but this has not been strongly implemented. In our survey of equipment providers,[128] we observed that there are very few locally produced supplies. Of the seven service providers, two indicated that none of their equipment is produced in Rwanda. Others indicated that only a limited amount of equipment, such as trolleys, pipes, and water tanks, are produced locally. We advise putting new arrangements for equipment production in place to boost local private manufacturing companies.

Infrastructure

Infrastructure has a big impact on farmers' ability to access markets. As the three-market access model shows, farmers must get their produce to buyers or find buyers who will come to them. Physical infrastructure is needed to facilitate this, for example in the form of feeder roads, transport, or (cold) storage facilities. These supporting functions are avenues for increased private sector engagement, such as warehousing companies, logistics operators, and contractors involved in the building of infrastructure. The following subsections touch on the role of these companies and provide a short reflection on how they are integrated into the SSIT program and how they could provide opportunities for private sector engagement in SSI development.

Feeder roads

The government of Rwanda (GoR) defines "feeder roads" as "any roads linking farms to markets, which include the district class one and two (D1, D2) and unclassified roads."[129] For farmers in remote areas, like many of the SSIT farmers, a lack of feeder roads can significantly hamper their access to markets, a crucial aspect of improving their incomes and livelihoods.[130] Improved feeder roads could help SSIT farmers bring their irrigated goods to nearby markets, particularly farmers in the producer-forward model. There is no formal connection between the SSIT program and the establishment of feeder roads, but this could be an avenue for creating one. For example, private providers could conduct regular independent appraisals and evaluations of existing roads, and/or be involved in capacity-building activities or in the planning, design, procurement, delivery, and maintenance of feeder roads that allow SSIT farmers to connect to markets more easily.

Transportation

The role of transporters who facilitate the collection, aggregation, and transportation of crops from farm to off-takers and end consumers is described throughout the different models in this section. We observed an important role for these players, but no formal role within the SSIT subsidy program exists for them. Most small-scale farmers use bicycles, motorcycles, power tillers (connected to trailers), and/or wheelbarrows to transport harvested produce. Many large-scale farmers and some well-managed cooperatives purchase their own transport equipment, such as trucks and trailers. Some farmers use transport services, often private trucks owned by local traders. We advise finding a formal way for SSIT beneficiaries to connect with transporters, either by creating new activities or by connecting to ongoing projects, subsidies, or programs.

Storage facilities

The lack of storage facilities is a challenge for farmers, and some buyers take advantage of it. We came across farmers who were forced to sell their produce at whatever price buyers offered them, because no other options were available. This is particularly true for perishable products, and even more so for SSIT beneficiaries who have not yet found a market for their increased volume of irrigated produce.

[127] MINAGRI. 2014. *Feasibility Study on Farmer-Led SSIT Program*, p. 11.

[128] Survey conducted in August 2021 and sent to 12 service providers, of whom seven responded.

[129] Ministry of Infrastructure. 2017. *National Feeder Roads Policy*, p. i. https://www.rtda.gov.rw/fileadmin/templates/documents/NATIONAL_FEEDER_ROADS_POLICY_AND_STRATEGY_FOR_RWANDA.pdf.

[130] Ibid.

A report by the Food and Agriculture Organization shows that limited modern storage, handling, and processing infrastructure contribute to high proportions of food loss. For example, it is estimated that about 56 percent of tomatoes produced in the country are lost every year.[131]

More warehouses and cold rooms for storage after harvest could provide farmers with time to identify suitable markets. It is advised to take best practices from other sectors into account. For example, the GoR has created collection centers for the dairy and potato sectors so that farmers can store their produce. These centers address some storage and price issues, as farmers do not have to wait for buyers who may not even come. The centers have also reduced the bargaining power that buyers have over farmers.[132] Nationwide initiatives and programs to develop more storage facilities include the National Agricultural Export Development Board, which is constructing various cold storage facilities across the country. In this way, the GoR aims to reduce food losses and allow farmers more time to find suitable markets. Similarly, donor programs such as HortInvest support companies to develop storage facilities. However, challenges remain—the facilities are expensive to use and, considering the weak level of market linkages, farmers do not have the financial capacity to utilize the facilities, nor do they have linkages to buyers with the capacity to finance crop storage.

Increasing storage facilities is another business opportunity that the private sector could tap into. It is advised to proactively connect SSIT beneficiaries to developments in this area to ensure they become part of the FLID context. Clear guidelines are needed here to facilitate market access for irrigated goods. To establish even clearer linkages between the SSIT program and ongoing initiatives on cold storage, the GoR could devise new ways of allowing SSIT farmers access to these facilities, providing early access, additional subsidies, and/or taking the location of SSIT beneficiaries into account when planning new facilities.

Other infrastructure functions

Other infrastructure functions, such as expanded mechanization, access to affordable sources of electricity (needed for processing, cold storage, and drying), and agro-processing, can also provide avenues for private sector involvement in SSI development. However, none of these subsectors are linked to the SSIT program. Further studies should be done to assess the full potential and concrete linkages of farmer-led irrigation and the private sector's provision of supporting functions.

Box 6.2: A farmer's story: Providing storage facilities for friends and neighbors

Small-scale solutions to storage issues can contribute to local entrepreneurship and private sector development. During our field visit, we came across an SSIT farmer renting a small storage facility. The famer would buy potatoes from neighbors and friends and store them; when the storage was full, she would call a transporter from Kigali to pick up the bags to sell them at the local market. This entrepreneurial farmer was thus able to overcome challenges related to storage, finding new ways to improve her income.

Photo 6.4: A small-scale storage facility for potatoes

Source: Resilience B.V.

[131] Puri, M, Rincon, L, and Maltsoglou, I. 2021. *Renewable Energy for Agrifood Chains: Investing in Solar Energy in Rwanda.* Rome: FAO, p. 54. https://doi.org/10.4060/cb6387en.

[132] See also https://www.minagri.gov.rw/updates/news-details/government-intensifies-efforts-to-streamline-irish-potato-value-chain, https://rab.gov.rw/index.php?id=203, and https://www.agriterra.org/rwanda-increased-its-irish-potato-production/.

Digitalization and market information

Access to market-related information (for example, on prices, buyers, and available extension services) is important for farmers to increase their incomes and business success. The digitalization of agriculture is increasingly being seen as a game changer that can support farmers to boost their productivity, profitability, and their resilience to climate change.[133] Following this trend, more companies now offer a suite of digital services, such as easy access to weather forecasts, market prices, and extension services through online and mobile-based platforms. In our desk research, we identified numerous digital services that attempt to link farmers and markets in Rwanda. Examples include Eprod, FtMA, Smart Nkunganire System, Farmforce, Pula, SCOPEinsight, and Matajua. Government-led online platforms also contribute to improved awareness of local market prices among growers, such as the e-SOKO platform. During our field visits, however, we did not come across any farmers who used these digital tools. Through our field survey, we found that the most common source of information for market prices and weather was the radio, followed by intermediaries, shops, and telephones (Figure 6.3).

Digital platforms can facilitate the transfer of other types of knowledge to farmers, for example on best agricultural practices, certification (especially important for farmers who produce for the international market), or access to finance. As Rwanda is digitalizing rapidly, we see significant potential for SSIT farmers to use these platforms to increase their access to information and knowledge. This is not built into the SSIT program's project design but could be pushed by the GoR.

Digitalization of agriculture also provides a clear avenue for private sector engagement, as many of these platforms are (partly) managed and developed by the private sector. Increasingly, the private sector, such as commercial banks, also use digital platforms to increase digital lending in rural areas.[134] We recommend that RAB and/or MINAGRI align with this trend using complementary digital market tools on online platforms.

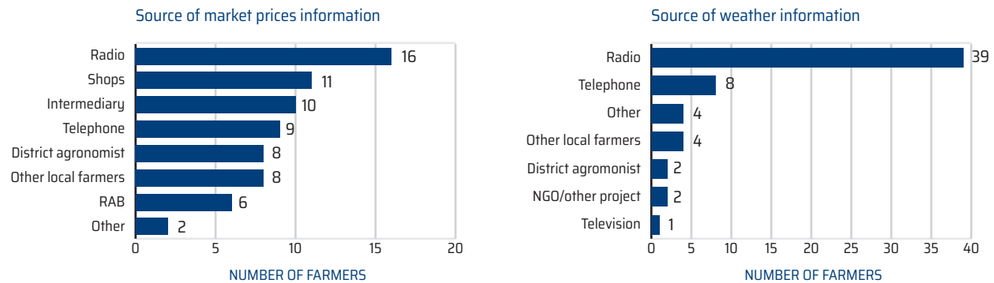
6.2.3 Description and analysis of the enabling environment

A third component of the market system is the enabling environment, which includes government and donor interventions. The following subsections briefly cover the role of the government and donors in enabling SSIT farmers to access markets more easily. There is no formal connection between the SSIT program and donor and governmental programs that facilitate market access for irrigating farmers. This section also includes a brief overview of government/donor programs that have, or could have, an impact on SSI development in Rwanda.

Government interventions and programs

During our field work, both vendors at small-scale markets and farmers expressed concerns about the availability of output markets and indicated that they believed the government should do more to secure markets. On the one hand, the GoR can influence access to markets by putting certain policies in place—such as minimum prices—or specific interventions—such as establishing infrastructural works like cold storage or providing extension services. On the other hand, ongoing governmental and donor programs already have an impact on market access for farmers.

Figure 6.3: Information sources for farmers on market prices and weather



[133] Tsan, M, Totapally, S, Hailu, M, and Addom, B. 2021. *The Digitalization of African Agriculture Report 2018–2019*, p. 10. https://www.cta.int/en/digitalisation-agriculture-africa.

[134] An example of a project in Rwanda can be seen at https://www.icco-cooperation.org/en/news/simbuka-and-icco-digitize-loan-tool-for-african-smallholders/.

An example of a government intervention at the policy level is the establishment of minimum prices for certain crops. In specific value chains, such as rice, maize, tea, coffee, and potato, the GoR sets minimum prices to regulate the market and ensure a higher income for farmers.[135] With the exception of maize, these value chains differ from those that SSIT farmers engage in (for example, tomato, cabbage, or eggplant[136]), so these developments are not relevant to their specific context. Depending on the outcomes and impact in other sectors, similar minimum prices could be set for irrigated crops, which could directly contribute to farmers within the SSIT program producing these crops.

The provision of extension services by the GoR is a clear benefit for farmers. However, in the context of the SSIT program, the support of sector agronomists is mainly focused on the technicalities surrounding SSI development. Extension services could also target increased capacity, focusing on transportation, storage, and the marketing of irrigated produce.

In recent years, various government programs have increased market access for farmers. There is no formal link with the SSIT program, but it is advised to link up with these programs—or at least to take lessons learned into account. Identified programs are listed in Table 6.1.

Table 6.1: Government programs that have increased market access for farmers

Name of the program	Description	Funded by	Year
Crop Intensification Program (CIP)	The GoR motivated farmers to grow on consolidated land, targeting the production of maize, rice, wheat, Irish potatoes, beans, and cassava. As part of the program, the GoR also arranges the importation and distribution of inputs through a public-private partnership. The program aims to help farmers access high-quality seeds and organic fertilizers through government subsidies.	Ministry of Agriculture and Animal Resources (MINAGRI)	Ongoing (2007-)
The Great Lakes Trade Facilitation (GLTF)	GLTF was established to facilitate cross-border trade by increasing the capacity for commerce and reducing the costs faced by traders, especially by small-scale and women traders, at targeted locations in the borderlands.	Ministry of Trade and Industry (MINICOM)	Finalized (2016–2020)
Sustainable Agricultural Intensification for Improved Livelihoods, Food Security and Nutrition Project (SAIP)	SAIP's objective is to supports farmers' efforts to increase the agricultural productivity, market access, and food security of the targeted beneficiaries in the project intervention areas. The five-year project aims to strengthen the development of sustainable market linkages and value addition through increased performance and commercialization of selected value chains.	World Bank Group	Ongoing (2018–2023)
Kayonza Irrigation and Integrated Watershed Management Project—Phase I	The project's overall goal is to contribute to poverty reduction in the drought-prone Eastern Province of Rwanda. The development objective is to sustainably improve the food security and income of 50,000 rural households and boost their climate resilience by, among other measures, increasing levels of production, market access, and business development.	International Fund for Agricultural Development (IFAD)	Ongoing (2019–2022)
The Rural Sector Support Project (RSSP)	The project was conducted in three phases from 2001 to 2018. Phase I focused on building the institutional and technical capacities needed to support the generation and adoption of efficient cropping and post-harvest technologies, launching the intensification process. Phase II focused on increasing productivity in marshlands and hillsides, targeted in a sustainable way. Phase III focused on increasing agricultural productivity for farmers operating in the areas targeted, and on engaging more women.	World Bank Group	Finalized RSSP1: 2001–2008 RSSP2: 2008–2012 RSSP3: 2012–2018
Land Husbandry, Water Harvesting and Hillside Irrigation Project (LWH)	The objective of this program was to increase the productivity and commercialization of hillside agriculture in target areas, as well as to reduce soil erosion and introduce hillside irrigation in the country. The program left farmers with infrastructure for irrigation; different sites for irrigation were developed; and through training, farmers gained knowledge of agricultural practice and the management of water infrastructures. In terms of market access, the construction of post-harvest infrastructure, such as storage facilities, drying facilities, and collection centers, was also part of the project.	USAID, World Bank Group, GAFSP, CIDA, GoR	Finalized (2010–2018)

[135] See, for example, https://www.newtimes.co.rw/news/cheer-coffee-farmers-farm-gate-price-jumps-15 for the coffee sector and https://www.newtimes.co.rw/news/production-costs-factor-irish-potato-prices for the potato and maize sectors by the Ministry of Trade and Industry.

[136] For a full overview of irrigated and rainfed crops based on the farmer survey, see https://resiliencebv.com/ssit/.

Donor interventions and programs

Through our desk research we came across various donor-funded and donor-implemented projects that aim to improve market development and market linkages for farmers in the country. For example, the Improving Market Systems in Rwanda for Agriculture project helps to commercialize agriculture, while the HortInvest project supports exporting companies to build warehouses and cold storage facilities. Many of these projects have no formal connection with the SSIT program. Although such projects could have an impact on the SSI development context and improve access to markets for many farmers, we did not come across formalized agreements or targeted activities in relation to the SSIT program and access to markets for irrigated goods. There are best practices in the SSIT program, where donor projects such as Hinga Weze and Solar Irrigation Rwanda established formal connections with the SSIT program, often in the form of additional grants for SSIT farmers or capacity building. We also came across large-scale irrigation schemes that benefited SSIT farmers, but we did not come across such a collaboration to specifically improve market access.

In a potential second phase of the SSIT program, we advise identifying overlaps in beneficiaries and investigating how different programs and subsidy schemes might feed into one another—for example, by sharing information about the availability of irrigation programs, subsidy schemes, and market possibilities—to optimize numerous farmers' practices with large-scale public investments in irrigation and other agricultural areas.

Identified donor projects with an emphasis on increasing market access for farmers are shown in Table 6.2.

6.2.4 Scoring

To score the financial axis on the diagnostic spider plot, we have considered the structure as presented in the FLID Guide.[137] The scoring is based on a ranking from very weak (1) to very strong (5). The average scoring for markets is 3.55.

Table 6.2: Donor projects that have increased market access for farmers

Name of the program	Description	Funded by	Year
Improving Market Systems in Rwanda for Agriculture (IMSAR)	IMSAR helps to commercialize agriculture by improving the way agricultural market systems function. The program combines market development services, technical assistance, and a short-to-medium-term grants finance facility to address market constraints, increase incomes, and catalyze inclusive growth.	Foreign, Commonwealth & Development Office (FCDO) (formerly DFID)	Ongoing (2018–2022)
Kigali Wholesale Market	The project aims to construct a wholesale market that will offer different services, such as cleaning, grading, drying, and cold storage. The primary goal of the establishment of the wholesale market is to increase productivity and reduce the spoilage of unsold products.	N/A (TBD)	Development phase
HortInvest	This program aims to increase farmers' incomes, grow the relative contribution of the horticultural sector to the regional economy in north-west Rwanda, and improve the food and nutrition security of the targeted households. The project focuses on production for domestic and regional markets, improving food and nutrition security, strengthening the supply chain for export markets and strengthening the enabling market.	Embassy of the Kingdom of the Netherlands in Kigali	Ongoing (2017–2021)
Export Targeting Modern Irrigated Agriculture Project (ETI)	The objective of this program is to develop modern agricultural facilities. The project includes the construction of watershed works, farm mechanization, and the establishment of post-harvest processing units for agricultural produce.	India Exim Bank	Ongoing (2013–2022)

[137] Izzi, G, Denison, J, and Veldwisch, G J, eds. 2021. *The Farmer-Led Irrigation Development Guide: A What, Why and How-to for Intervention Design.* Washington, DC: World Bank, pp. M16-19/20.

Table 6.3: Score for markets

Findings	Score
A rural investment climate provided by the government that is inappropriate for development of market linkages.	3.75
Insufficient spending on rural public goods that is vital for production, agro-processing, and export of high-value produce.	3.00
Lack of regulatory and compliance systems that restrict farmers' participation in domestic, regional, and export markets.	3.33
Poor level of digitization of value chains, with few opportunities to access market intelligence and reduce transaction costs.	3.67
Laws and regulations related to the marketing of agricultural produce that do not ensure equitable access to markets for women and youth.	4.00
Average scoring for financial factors	**3.55**

6.3 Recommendations

The ability of farmers to expand, intensify, and increase profit from irrigated produce is dependent on their access to markets. Enabling efficient access to, and effective engagement with, markets is a key aspect of facilitating farmers' business success. Our analysis shows that this aspect is underdeveloped within the SSIT program. As such, our main recommendation is to add a component to the program design that targets the productivity/market gap that some SSIT farmers face: the issue of increased productivity (because farmers start to irrigate) without a market offering a reasonable price—or any market at all.

Potential add-ons to the program could be integrated into the program set-up by working closely with an implementing partner, or through a pre-existing program that aims to improve market linkages with farmers. Suggested activities could include, but are not limited to the following:

- Actively connect traders to farmers, for example by leveraging digital platforms such as the e-SOKO platform of the GoR.
- In addition to increasing productivity, put more emphasis on access to markets, for example through capacity building to market produce and increasing access to information about buyers and prices.
- Facilitate market access for irrigated goods by developing supporting functions such as digital tools, improved infrastructure, and improved input and equipment supply.
- Support/organize farmers into associations or cooperatives to increase their bargaining power.
- Push for the development of infrastructure that increases market access for farmers, such as feeder roads and storage facilities.

In terms of private sector development in an SSI development context, our analysis shows that most opportunities lie within the supporting functions of a market system and are related to input and equipment supply to farmers; infrastructure; and digitalization and market information.

In terms of input and equipment supply to farmers, the local private sector could tap into opportunities related to providing and maintaining inputs and equipment, establishing local shops and repair centers, and manufacturing irrigation equipment locally. In terms of infrastructure, private sector parties could be engaged in the design, building, operation, maintenance, and finance of feeder roads; (cold) storage facilities; transportation and other infrastructural work, such as expanded mechanization; access to affordable sources of electricity (needed for processing, cold storage, and drying); and agro-processing. The private sector could also play an important role in digitalization and increasing access to market information. The design of the SSIT program does not have a formal link or modality to engage the private sector regarding these opportunities, and we advise conducting further research into ways to do so.

ANNEX 7: TECHNOLOGY

7.1 Introduction

This annex describes the technology aspect of the SSIT assessment. It includes an assessment of the kinds of on-farm irrigation systems that are widely used (with a particular focus on systems adopted under SSIT) and what the related areas of difficulty may be. The demand and need for new technologies that can support growth in farmer-led irrigation development (FLID) in the various geographical settings are also analyzed, as is the ability of service providers to meet demand for irrigation equipment.

7.2 Methodology

The assessment consisted of a literature review based on the feasibility studies of the SSIT program, after which we determined what information was needed from the service providers and the field survey. This information was then collected during semi-structured interviews with representatives of the contracted SSIT service providers and from farmers in telephone and field surveys.

Key findings

- Most farmers who have adopted irrigation in Rwanda use small fuel pumps in combination with hosepipes. This is also the main technology combination provided with the small-scale irrigation technology (SSIT) subsidy. Alternative innovative technologies are not readily available and are virtually non-existent outside of Kigali. There is untapped demand for different technologies among farmers, particularly for solar pumps (for their low operation costs) and water application technologies such as sprinklers and spray tubes.
- Renting equipment is a common practice among farmers in Rwanda. To increase the adoption of irrigation, this practice could be facilitated by building capacity and providing support from input suppliers.
- The service provision for SSIT equipment was found to be poor. Most farmers had simply acquired a pump and hose system through the sector or district agronomist, were not given the opportunity to choose between different technologies and had no contact with the supplying service provider. Almost no proper designs for specific production systems were made, and farmers were generally not aware of their technological needs. This has resulted in the provision of suboptimal systems and has led several farmers to abandon irrigation.
- The SSIT contract prices need to be revised to accommodate proper design and after-sales services. Service providers indicated that the low margins linked to the subsidy program do not cover the costs of designing the systems and providing training on operation and maintenance. There is also a need to make the entire range of technologies available for farmers to choose from.
- Farmers' experience with irrigation systems and knowledge of operation and maintenance were low. Fuel pumps were often found to have a short lifespan (two to three years), indicating a lack of knowledge regarding operation and maintenance. Water application techniques found in the field were rather laborious, which could be improved by capacity building. Farmers' field schools and lead farmers could play a key role in raising farmers' knowledge of technology.

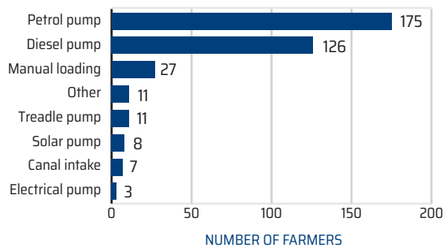
7.3 Results

7.3.1 Technologies

Water extraction

The data from the field survey reveals that most farmers use either a petrol or diesel pump for water extraction. Manual loading is used by some farmers, while other forms of water extraction (solar pumps, for example) are less commonly used.

Figure 7.1: Types of water extraction



When looking at the distribution of water extraction methods over area categories (Figure 7.2), it is noteworthy that manual loading is still used in the category for land sizes between 1 and 3 ha.

Figure 7.3 presents the water extraction methods used per crop type. Manual loading is most notable with maize—and not with higher-value crops such as vegetables as might be expected.

During the field survey, it became clear that many farmers rent pumping equipment, often paying a fee based on the amount of fuel used. Therefore, irrigation is still possible when farmers cannot afford to buy equipment. However, many farmers find that pumps break down after only two or three years of use. This could be because of the use of cheap, low-quality pumps, although it seems that there is little knowledge of maintenance, and skilled mechanics are generally only available in major towns.

Solar pumps are not very common (yet), but farmers seem enthusiastic about their low operation costs. Several large-scale (10+ ha) solar systems were found, operated by farmer cooperatives and funded by other projects.

Figure 7.2: Water extraction type per area category

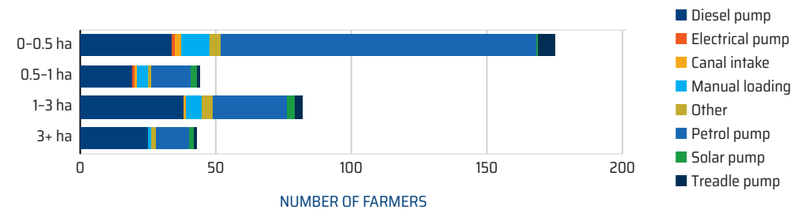
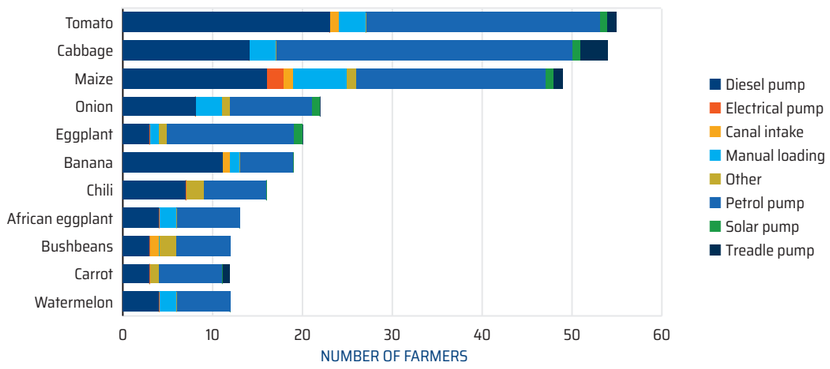


Figure 7.3: Water extraction method per crop type



Water application

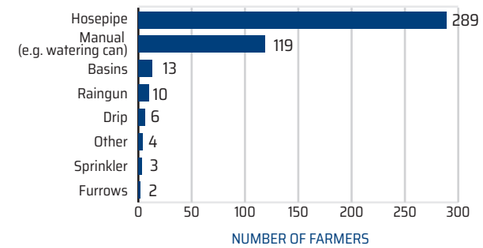
Most farmers use either hosepipes or manual methods such as buckets or watering cans (Figure 7.4) for their water application.

It is notable that manual methods are widely used, including for large areas over 3 ha (Figure 7.5) and for irrigating maize (Figure 7.6).

The overall impression from field visits was that smallholder farmers in Rwanda have little experience of different water application methods. The vast majority use hosepipes to apply water directly to their crops. Many indicated that crop damage and soil erosion are problems, but they did not seem to know of an alternative application method; some farmers squeezed the hose such that it sprayed the water upwards to prevent these problems.

A connected issue is that the amount of labor does not differ much between manual and hosepipe application—the average length of time required to grow 1 ha of tomatoes is 370 days for manual and 360 days for hosepipe application. This indicates the relatively low efficiency of the application methods, as one would expect irrigation with hosepipes to be labor-saving relative to manual application. However, often many laborers are used to carry the hosepipe through the fields, and less

Figure 7.4: Types of water application



laborious techniques for hosepipes (such as using them to fill short furrows) were not observed in the field.

7.3.2 Availability of technology and service provision

The overall impression of the availability of irrigation technologies in Rwanda is that many farmers face difficulties obtaining the right equipment. There are a few suppliers, primarily located in Kigali, but they are seldom to be found in other parts of the country. Fuel pumps and hosepipes are available in major towns across the country, but the level of service provision regarding advice and maintenance is low.

Figure 7.5: Water application type per area category

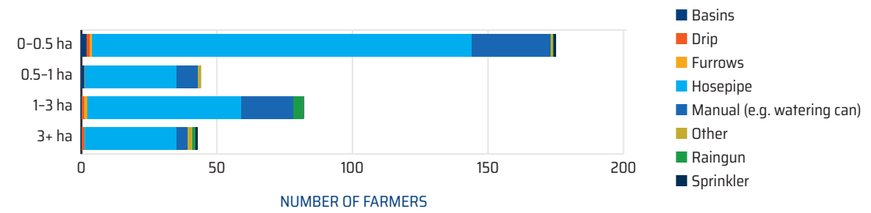
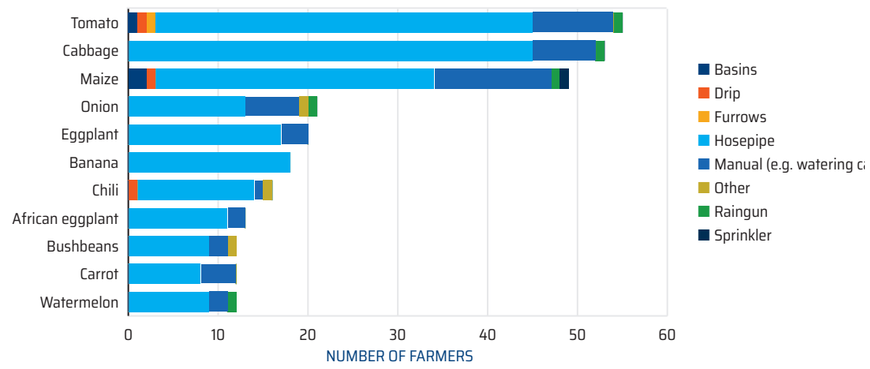


Figure 7.6: Water application methods per crop type



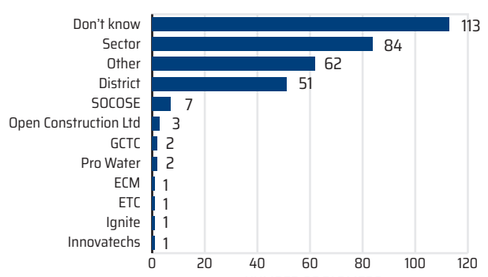
Transformative technologies other than fuel pumps are not readily available on irrigation equipment supplier shop floors across the country. Items such as small portable solar pumps, low-pressure spray-lines, small sprinklers, and driplines are not well known or routinely supplied by irrigation equipment outlets. There are thus few places for farmers to find innovative, enterprise-transforming technologies and obtain information about their suitability, costs, and operational advantages and disadvantages.

The service provision for equipment supplied through the SSIT program was often poor—in many instances, poor designs were made, there was a general lack of training on the use of the sold equipment, and inadequate after-sales services were available. One striking example of this was a farmer who was supplied with a raingun sprinkler for a 0.5-ha field located about 1 km from his house. To prevent theft, he stored the raingun at his house, but having to carry the heavy equipment to his field every time led him to abandon irrigation altogether.

In the field survey, it also became clear that most of the farmers did not know who had provided their equipment (Figure 7.7)—the sector or district agronomist chose it for them, and they simply picked up the equipment at their office. There was often no interaction between the service provider and the farmer, which can increase the likelihood of less suitable types of equipment being provided. This situation was confirmed by farmers when asked if, in the future, they would choose to use the same equipment they were originally provided with—36 percent said they would not, indicating that the equipment they had been given was suboptimal for their specific situation.

The interviews with representatives of the SSIT service providers revealed that the costs of designing the systems and providing training in operation and maintenance are not covered by the subsidy, and that listed prices for the equipment are too low, such that the subsidy covers only the supply of the equipment.

Figure 7.7: Providers of SSIT equipment as indicated by farmers



7.4 Conclusion

Farmers who have adopted irrigation mainly use small fuel pumps in combination with hosepipes. This is also the main technology combination provided with the SSIT subsidy. Innovative technologies other than these systems are not readily available and are virtually non-existent outside of Kigali. However, there is untapped demand for different technologies among farmers—mainly solar pumps (for their low operation costs) and water application technologies such as sprinklers and spray tubes. Equipment rental is common among farmers in Rwanda.

Service provision regarding the SSIT equipment was found to be poor. Most farmers simply received a pump and hose system through the sector or district agronomist, were not given the option to choose between different technologies and had no contact with the supplying service provider. Almost no proper designs for specific production systems were made, and farmers themselves were generally not aware of their technological needs. This has resulted in the provision of suboptimal systems, leading several farmers to abandon irrigation. Service providers indicated that the low margins linked to the subsidy program do not cover the costs of designing the systems and providing training on operation and maintenance.

In general, farmers' experience with irrigation systems across Rwanda is low and there is a lack of knowledge on how to operate and maintain the systems. Fuel pumps often have a short lifespan of no more than three years, indicating a lack of knowledge around maintenance and operation. Finally, water application techniques found in the field are laborious, which could be alleviated by education and building capacity.

7.4.1 Recommendations

There is a great need for building farmers' capacity regarding irrigation systems and techniques. Farmers' field schools and lead farmers could play a key role in raising farmers' knowledge about technology.

There is also a need for suitable, farmer specific SSIT equipment that is properly designed. The costs of this design and after-sales services should be included in the contract prices of the service providers. The entire range of technologies should also be made available for farmers to choose from.

Renting irrigation equipment is already a common practice among farmers in Rwanda. To further increase the adoption of irrigation, this practice could be facilitated by capacity building and support from input suppliers.

7.5 Diagnostic and scoring

7.5.1 Scoring the technical environment

To assess the strength of the technical enabling environment, we first had to understand what type of equipment is preferred and used by farmers, what is available on the market, and what the market demand is (from the diagnostic process above). We paid attention to technology gaps in Rwanda and to technologies that can fill these gaps, informed by the wider regional and global market. Key parameters for assessing the environment were the degree of physical access, quality, and costs of the needed (known) equipment and potentially useful (not widely known) equipment.

A weak technical environment is scored low and is one in which technical solutions of sufficient quality are not locally available at a reasonable price.

The score of the surrounding technical environment, ranging from very weak to very strong, indicates how important it is for an intervention to address the technology supply chain. The scoring is informed by the issues outlined below.

Appropriate/transformative technology is not readily available on irrigation equipment supplier shop floors across Rwanda

- There are few suppliers (and those that exist are based in Kigali) from whom farmers can acquire innovative, enterprise-transforming technologies and information about their suitability, costs, and operational advantages and disadvantages.
- Items such as small, portable solar pumps (<1 ha mobile or semi-portable systems), low-pressure spray-lines, sprinklers, and driplines are not widely known or routinely supplied by irrigation equipment outlets.
- Larger solar pump installations (>2 ha) for irrigation are few in practice, and the related design and operational experience among suppliers is lacking.

Transformative technology is relatively costly for farmers

- Supplier prices are so high that sales turnover is limited.
- Returns on investment for technologies are marginal.

National quality standards for equipment are absent or are weakly formulated to ensure the necessary quality control for all irrigation equipment

- National quality-standard documents have gaps in their technical system specifications for component elements and installation requirements.
- The testing facilities and knowledge around quality testing are inadequate to ensure quality control nationally.
- The compliance and regulation of equipment quality are weak in practice.

7.5.2 Final score of technology in Rwanda

The final score of technology in Rwanda was calculated using the three parameters discussed above, as indicated in Table 7.1. The score will be used to inform the next phase of proposed recommendations.

Table 7.1: Overall scoring of the technological environment in Rwanda

Technology type	1 Very weak	2 Weak	3 Medium	4 Strong	5 Very strong
Availability of appropriate/ transformative technology to farmers		X			
Cost-effectiveness of the appropriate technology			X		
National quality standards on equipment				X	

The overall technological environment in Rwanda can be ranked as medium (scoring 3/5). There is an important knowledge gap as most farmers do not understand their technological needs. Essentially, the choice of technology is not farmer-led but market-led. There is a need for basic teaching and extension services. Education, training, and capacity building on basic irrigation principles will add significantly to FLID in Rwanda. Improving the situation regarding appropriate and transformative technology does not require introducing new and innovative types of equipment or techniques, but rather increasing farmers' knowledge about the equipment and techniques already available. Poor designs, lack of training, and inadequate after-sales services from service providers are key elements that have rendered the supplied technologies inappropriate and inefficient.