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Current state of irrigation-as-a-service for smallholder farmers in Rwanda

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Current state of irrigation-as-a-service for smallholder farmers in Rwanda

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DAUGHERTY WATER FOR FOOD GLOBAL INSTITUTE AT THE UNIVERSITY OF NEBRASKA

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Table of Contents

Photo Captions

Front Cover: Farm workers irrigate a pepper nursery in Bugesera district, Rwanda. Credit: Rachel Williss

Pages 2 & 3: A group of farm workers turns on a diesel pump to transfer water to a field in Bugesera district, Rwanda. Credit: Rachel Williss

Pages 4 & 5: A pile of pipes to be used with sprinkler irrigation systems in Rwanda, like the one pictured on page 11. Credit: Frances Hayes

Page 6: Cabbage plants on a field in Rwanda. Credit: Rachel Williss

Page 8: Pipes used for irrigation loaded in a truck in Nyagatare district, Rwanda. Credit: Natacha Akaliza

Page 11: A sprinkler, supplied by a water pump, irrigates fodder grass in Nyagatare district, Rwanda. Credit: Raïssa Urujeni

Page 12: Farm workers use watering cans to simultaneously irrigate and apply fertilizer to rows of peppers in Bugesera district, Rwanda. Credit: Rachel Williss

Page 13: A farm worker tends to rows of peppers in Bugesera district, Rwanda. Credit: Rachel Williss

Page 18: A dam sheet holding water to be used in irrigation in Nyagatare district, Rwanda. Credit: Natacha Akaliza

Page 20: Grace Mukarusagara interviews a farm worker about irrigation practices used in Bugesera district, Rwanda. Credit: Rachel Williss

Page 21: Mango trees are irrigated using drip irrigation in Bugesera district, Rwanda. Credit: Rachel Williss

Back Cover: A cabbage field in Rwanda owned by a smallholder co-op. Credit: Rachel Williss

Executive Summary

Access to irrigation for smallholder farmers is critical to increase food security, income, and climate resilience in rural communities in Sub-Saharan Africa. This report presents findings from dozens of field interviews on how smallholder farmers access irrigation services even when they do not own the irrigation equipment. There are various business models providing irrigation services within informal markets in Rwanda, including farmer-to-farmer lending, entrepreneur-to-farmer rentals, and water tanker trucks. Loaning and renting pumps leverages investments in irrigation equipment to increase access to irrigation and irrigated areas. For example, based on observed behavior, we estimate that lending and renting of small pumps has increased actual irrigated area between 8-45% in Bugesera district and 3-30% in Nyagatare district. To support scaling up informal markets, we recommend that the government of Rwanda considers encouraging farmers to lend their equipment and supporting irrigation-as-a-service entrepreneurs with startup grants and by adjusting policies.

Definitions

Smallholder farmer:
a farmer who cultivates less than 10 hectares.

Irrigation-as-a-service (IAAS):
a business model whereby farmers and entrepreneurs support access to irrigation for those who do not own irrigation equipment.

Farmer-to-farmer:
an IAAS business model between a farmer who owns irrigation equipment and a farmer who does not. This transaction is often viewed as a favor and assistance for a neighbor.

Entrepreneur-to-farmer:
an IAAS business model between an entrepreneur and farmer. An entrepreneur is someone who exchanges service for money and who is willing to take risks and invest in irrigation equipment with the goal of growing their business.

INTRODUCTION

This report examines the current state of the provision of irrigation-as-a-service for smallholder farmers in Rwanda, with the goal of finding scalable, farmer-led solutions to increase irrigated agriculture. Access to irrigation increases farmer food security, income, and climate resilience. There is currently unmet potential and demand for irrigation in Rwanda. Only slightly more than 10 percent of irrigable land is currently irrigated.[1] Irrigation-as-a-service (IAAS) refers to one mechanism by which farmers and entrepreneurs support access to irrigation for those who do not own irrigation equipment. These informal markets influence the landscape in important ways that are not fully recognized.

This research is based on dozens of interviews conducted in Kirehe, Nyagatare, and Bugesera districts in Rwanda during 2021 and 2022 (Figure 1, Page 7). The team spoke with many different actors in the agricultural ecosystem, including smallholder farmers and livestock owners who pay for irrigation services, cooperatives who own and rent irrigation equipment, entrepreneurs who provide irrigation services, and government officials.

The interviews we conducted were one-on-one discussions based on asking open-ended questions. The interviewer is encouraged to talk less and listen more. This method allows for unexpected insights from the subject. Our field team first became aware of the extent of farmer-to-farmer pump lending based on comments in previous interviews. Farmers mentioned that they lend their equipment, and some said they started to irrigate because their neighbor rented the equipment to them at first. By digging deeper, we discovered extensive informal markets using multiple business models.

This report is structured as three key insights about IAAS, including discussion of similarities and differences between three of the common business models found in Rwanda. The key insights are:

1. Farmers who do not have their own equipment get access to irrigation in a lot of different ways.
2. Various business models provide irrigation services within informal markets, including:
   - Farmer-to-farmer lending,
   - Entrepreneur-to-farmer rentals, and
   - Water tanker trucks.
3. Informal markets have an effect on the landscape that is unrecognized but important. Loaning and renting leverages investments in irrigation equipment to increase access to irrigation and irrigated area.

The report concludes with recommendations on how policies might be structured to support the lending and renting of small pumps and on how irrigation service businesses might be scaled up successfully.

The insights we present are relevant to various groups, including entrepreneurs who can identify new opportunities and learn lessons from other start-ups, investors who can discover where there are gaps in funding, and policymakers–both governmental and non-governmental–who can support access to irrigation services by removing barriers and facilitating investments in informal markets.

[1]63,742 hectares out of approximately 600,000 hectares. Source 1: Ministry of Agriculture and Animal Resources, Republic of Rwanda. 2020. Annual Report 2019-2020. <https://www.minagri.gov.rw/fileadmin/user_upload/Minagri/Publications/Annual_Reports/Annual_report_2019-20_FY_.pdf>. Accessed 8/23/2021. Source 2: Rwanda Water Resources Board, Republic of Rwanda. 2021. Rwanda Water Portal. <https://waterportal.rwb.rw/toolbox/471>. Accessed 8/26/2021.

Map of Districts in Rwanda

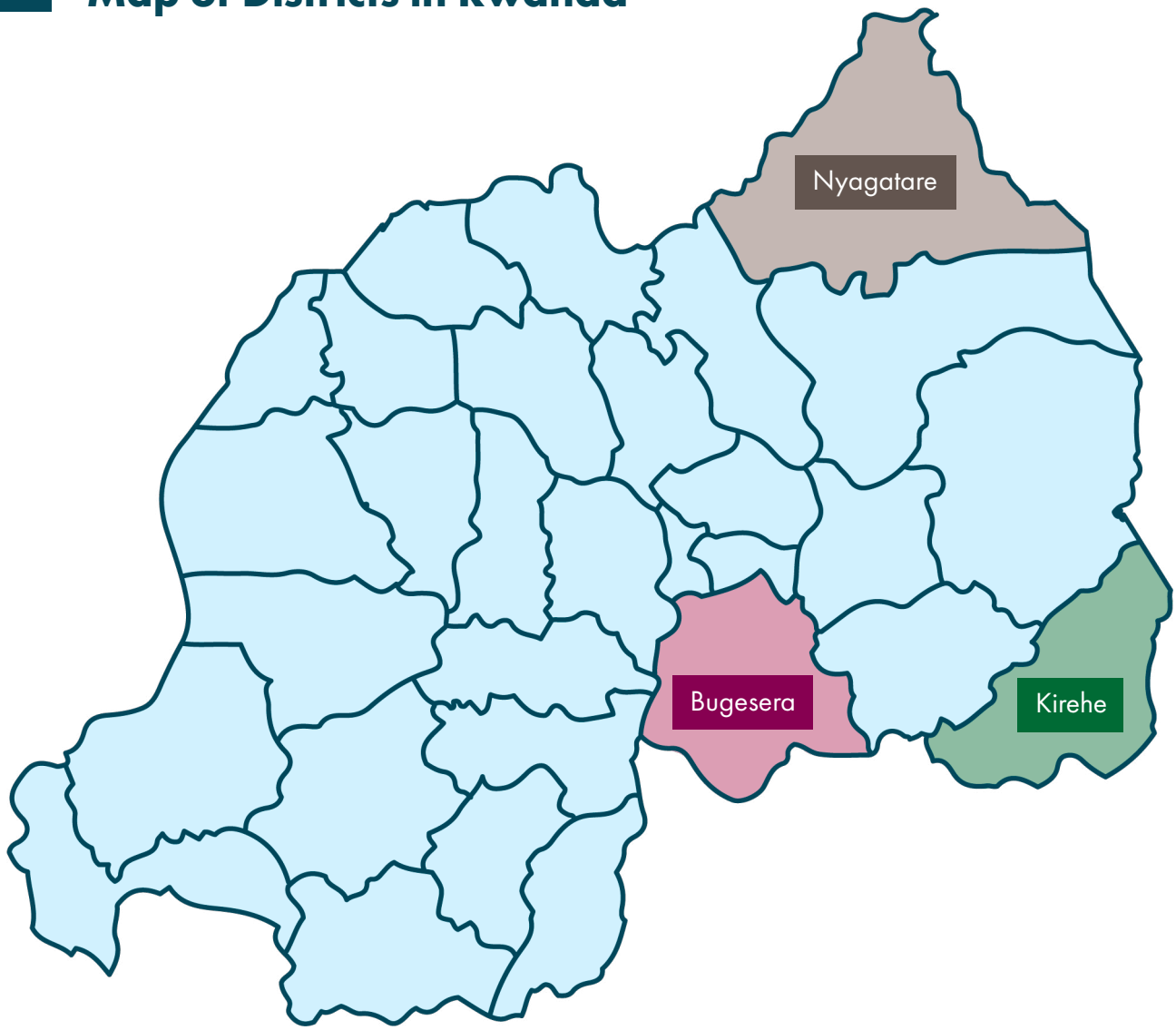


Figure 1

The interviews that informed this research were conducted in the districts of **Bugesera**, **Nyagatare**, and **Kirehe** in the Eastern Province. These districts are located in the eastern plains climatic region, the hottest and driest region in Rwanda, which has an annual rainfall of between 700 mm and 1,100 mm and mean annual temperature between 20°C and 22°C.[2] **Bugesera**, **Nyagatare**, and **Kirehe** were chosen for this research because they have a great need for irrigation while also having the surface water to support it. They contain rivers, lakes, and swampy areas which make irrigation possible. Additionally, these three districts have the greatest number of small irrigation pumps sold through the government's Small-Scale Irrigation Technology program.

Nyagatare has the wealthiest farmers of the three districts. Smallholders here have relatively more land and irrigation services cost more overall. Additionally, irrigation-as-a-service interactions are handled as business interactions with a professional tone, rather than a casual exchange between neighbors as in the other two districts. Farmers in **Bugesera** and **Kirehe** own smaller farms, tend to have more casual exchanges, and charge less for services. Smallholders here often request help with using government programs and accessing irrigation technology.

[2]*World Bank Climate Change Knowledge Portal. 2021. Rwanda Climatology. <climateknowledgeportal.worldbank.org>. Accessed 12/20/22.*

For more details on SSIT, see: Akaliza, N., et al. 2022. DWFI. Mapping and analysis of the business ecosystem for smallholder irrigation in Rwanda. <https://waterforfood.nebraska.edu/-/media/projects/dwfi/resource-documents/reports-and-working-papers/mapping-and-analysis-of-the-business-ecosystem-for-smallholder-irrigation-in-rwanda.pdf>

KEY INSIGHT 1

Farmers who do not have their own equipment get access to irrigation in a lot of different ways.

Why some farmers loan or rent pumps

Farmers and pump owners are motivated by different reasons when deciding to lend or borrow a pump for irrigation. Smallholder farmers who own pumps often consider lending their pumps to fellow farmers as a favor rather than a business transaction. This is mainly due to personal relationships built from living near one another or farming on neighboring fields. This relationship likely influences a pump owner to lend their pump to another farmer, but the owner may still decide to charge a lending fee to preserve the pump since it's an asset that depreciates with use.

On the other hand, for those farmers who rent pumps as a business, they started renting pumps as a way to help their community tackle dryness within the region. The pump rental business owners we talked to in Nyagatare told us that they are also farmers, and they understand the pain and impact of lack of water, especially for smallholder farmers.

Pump owners are also influenced by profit when deciding to rent out pumps. There are a lot of smallholder farmers in drought-prone regions of the country and, as a result, there is a high demand for water within these districts. In many areas, the available pump rental businesses are not enough to satisfy the demand for irrigation service. One pump owner in Nyagatare district told us that he bought irrigation equipment to irrigate his farm at the start, but when other farmers started approaching him to irrigate for them, he realized that there was a big opportunity which led him to start a pump rental business. He said, "there is a higher demand than I can satisfy."

There are several reasons why a farmer may decide to borrow or rent a pump. One reason is lack of money to purchase a pump. There are two ways in which smallholder farmers purchase irrigation equipment in Rwanda: either at full price from any equipment shop or through the government's Small-Scale Irrigation Technology (SSIT) subsidy program, which reduces the equipment price by 50-75% at specified retailers. For smallholder farmers with very small plots (less than a hectare), even with the subsidy they may not be able to pay the upfront cost to purchase an irrigation pump. Such farmers find it more affordable to pay for irrigation service.

Another related reason why a farmer may decide to rent a pump is a lack of the subsidy program in the area. Sometimes, the subsidy is put on hold in a certain

Main Points

Why equipment owners will loan or rent their pumps:

1. Personal relationships
2. Service to the community
3. Profit and opportunity

Why farmers will pay for pump rentals:

1. Inability to afford owning equipment
2. Lack of equipment subsidy
3. Personal preference

area so that the government can finish paying off the retailers for pumps sold through the program. During this period, farmers are not able to apply to the subsidy program. Since it is expensive for smallholder farmers to purchase equipment at full price, they may rent the pumps from other farmers or from entrepreneurs whose businesses provide irrigation services.

For other farmers, the decision to rent comes down to their personal mindset and preference. On the surface, it may appear hard to understand why some farmers rent when they can afford to purchase their own equipment. For example, a farmer in Bugesera district who has been renting a pump for four years told us that he can't afford to purchase the equipment, even with a subsidy, yet he spends 20,000 RWF (about 20 USD) per week renting the pump. Depending on size and fuel type, pumps used by smallholders cost several hundred thousand Rwandan Francs. Hose pipes and sprinklers can add a similar amount. On the other hand, his neighbor said that he decided to purchase his own equipment because renting at that cost is more expensive in the long run than buying the pump. Though the first farmer cited cost as the main reason, an additional reason could be the view that acquiring, managing, and maintaining a pump are obstacles or unwanted responsibility. We also met a farmer, who works with an IAAS entrepreneur in Nyagatare district, who stated outright that he prefers to rent rather than buy, even though he can afford to purchase equipment. This preference may indicate that some farmers believe it does not make sense to own an expensive, depreciating asset that they do not use very often, or to own items that are bulky, heavy, need attention, and are coveted by their neighbors.

How farmers loan or rent pumps

When it comes to lending or renting out pumps, owners have different systems. Districts in which farmers live have an impact on this as well. Based on the interviews we conducted, we identified three successful methods that farmers use to rent out their pumps: 1) renting to trusted users only, 2) assigning an employee to oversee the pump, or 3) providing the irrigation service in addition to the pump rental.

Due to risk management and pump breakdown, some owners only rent their pump to other farmers they know and trust. Farmers who do not own a pump may have limited knowledge about how to use it and renting one to them could result in the pump breaking down. Furthermore, because the pump is not theirs, borrowers may misuse it through overuse or by neglecting to do regular maintenance. As a result, owners often prefer to lend or rent pumps to someone they know and can trust to look after them as if they were their own.

Another rental method is for farmers to assign someone to check up on their pump while it is operating. This procedure is carried out differently depending on the two farmers' agreement. Some pump owners send their employee to look out for the pump and the pump owner is responsible for paying that employee. In other cases, owners send out their employee, and the farmer renting the pump is the one responsible for paying that employee.

A third approach is when the pump owner irrigates for other farmers. In this method, the owner has complete control over how the pump is operated and maintained. This also reduces the risk of a farmer renting out the pump to another farmer without the owner's permission.

As stated previously, the owner's decision on how to rent out a pump is also influenced by the district in which he or she lives, what works best in that area, what crop is grown, or the farmers' mindset. Farmers in Nasho and Bugesera, for example, would rather rent their pump to someone they know and trust. Comparatively, in Nyagatare, where farms are generally larger and farmers have higher income, renting is treated more professionally as a business. Here it is more common that the pump owner will have an employee to check up on the pump or that the owner and his employees will provide not only the pumps but also the irrigation service.

Main Points

Successful rental methods:

1. Rent to trusted users only
2. Assign an employee to oversee the pump
3. Provide the irrigation service in addition to the pump rental

How farmers pay for pump rentals

Lending or renting pumps doesn't have a fixed price and there are different factors that influence the pricing. One consideration is the connection or the relationship between people. Pump owners might decide to rent their pumps to people with whom they have a connection. This relationship could be influenced by living within the same village or on neighboring farms. One of the farmers we interviewed mentioned that he chose to lend his pump to a person whom he knows and trusts because their farms and homesteads are close. This relationship may contribute to favorable pricing of the rental. For example, in one village some pump owners who view sharing their pump as a favor choose not to charge a fee to their customers. Yet in another village in which sharing pumps is still considered a favor, pump owners charge a lending fee.

In our interviews we learned that pricing methods vary across districts (Figure 2). For example, in Nyagatare district, the farmers we spoke with who are growing corn said the renting price starts at 100,000 to 200,000 RWF/hectare/month and is based on the land size to be irrigated and the crop stage. An entrepreneur we met in Nyagatare also factors in the distance and elevation between the field and the water source in the price. This entrepreneur rented a pump to a tomato farmer for three months for a total of 200,000 RWF. The farmer who rented paid 100,000 RWF at the start of irrigation and the other 100,000 RWF after harvesting. Prices tend to be high in Nyagatare because farmers are generally wealthier, land sizes are larger, and distances to water are greater.

Main Points

Factors that affect rental costs:

1. Personal relationships
2. Land size
3. Type of crop/crop stage
4. Distance to water
5. Rental period
6. Fuel consumed

In contrast, in Kirehe district, the price is commonly based on the type of crop irrigated by a rental pump. The farmers we interviewed said it costs 25,000 to 30,000 RWF/month to irrigate cabbage and around 50,000 RWF/month for tomatoes, plus the cost of fuel used. In Bugesera district, in some areas like Mareba sector, farmers' rental pricing is proportionate to the consumption of fuel while using a rental pump. For example, if fuel costs 1,000 RWF/liter and a farmer consumes 1 liter of fuel, he will pay a rental fee of 1,500 RWF/day plus 1,000 RWF for fuel.

There are various degrees of formality in renting and pricing. One entrepreneur said that to rent a pump, a customer must sign a contract with conditions and detailed information. Some of the conditions that are included in the contracts include payment terms, use and operation of the pump, maintenance responsibilities, transport, and protocol in case of damage.

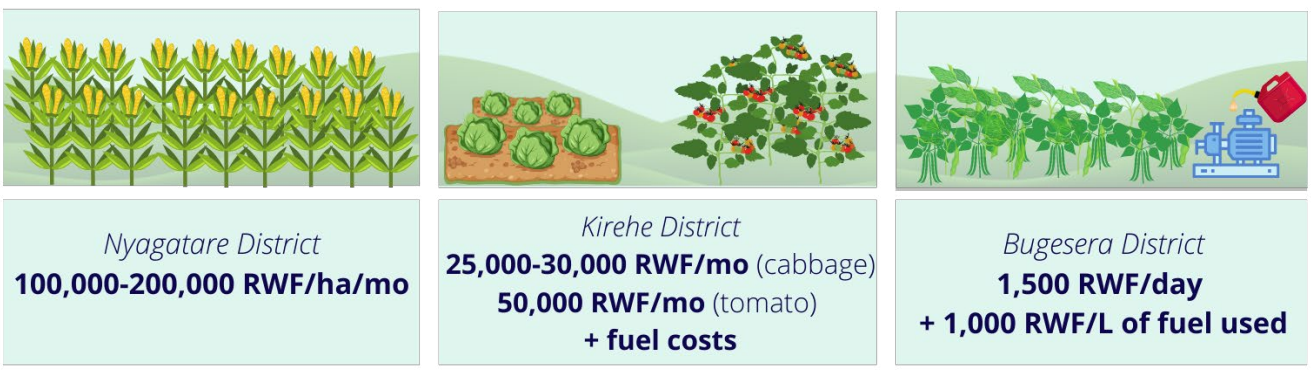


Figure 2

KEY INSIGHT 2

There are multiple business models within informal markets.

A business model describes the key components of a business, including value proposition, customer segments and relationships, channels for reaching customers, cost structure and revenue streams, and more. These components can be summarized in a Business Model Canvas (BMC).[3] We identified three unique IAAS business model types in Rwanda, which we call farmer-to-farmer lending, entrepreneur-to-farmer rentals, and water tanker trucks (Figure 3).

Farmer-to-farmer lending (Figure 4, Page 14) is an IAAS business model between a farmer who owns irrigation equipment and a farmer who does not. This transaction is often viewed as a favor and assistance for a neighbor.

Entrepreneur-to-farmer rentals (Figure 5, Page 15) is an IAAS business model between an entrepreneur and farmer. An entrepreneur is someone who exchanges service for money and who is willing to take risks and invest in irrigation equipment with the goal of growing their business. An entrepreneur may also farm, but their primary business is irrigation equipment.

Water tanker truck businesses (Figure 6, Page 16) use small pumps to pump water into large containers atop trucks. Trucks are then driven to farmer's dams and water is released into dams for storage. The entrepreneur who owns the water delivery business may or may not be the owner of the truck; they may themselves be renting the truck.

Key similarities and differences between these business types are discussed on page 17.

[3]*Osterwalder, A., Pigneur, Y. 2010. Business Model Generation: A handbook for visionaries, game changers, and challengers. Wiley.*

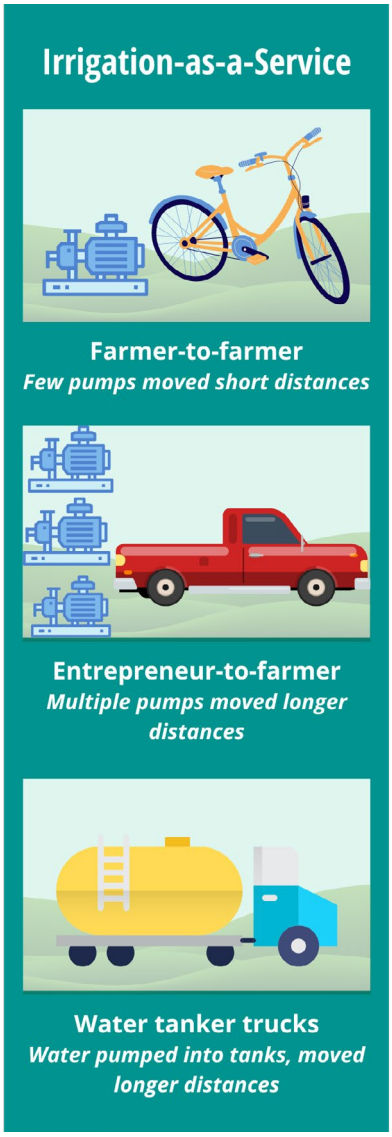


Figure 3

Our objective in studying irrigation-as-a-service is to understand how to increase access to irrigation and irrigated area for smallholder farmers, those farming less than 10 hectares. However, we include water tanker truck delivery services to livestock farmers (who use the water for their cows) in this report because all three business models occur in rural agricultural settings, serving similar and co-located customers, and these trucks may have unexplored potential to provide irrigation water to smallholder farmers.

For a detailed description of each Business Model Canvas, see "BMC Short Reports" at waterforfood.nebraska.edu/entrepreneurship.

FARMER-TO-FARMER

Business Model Canvas

Figure 4

Key Resources

Pumps, pipes, and accessories

Bicycle (or other means) to transport the equipment

Key Partners

District agronomists

Key Activities

Transporting equipment

Value Proposition

For smallholder farmers worried, anxious, and urgently needing a pump to irrigate because crops are wilting, farmer-to-farmer lending provides **quick and accessible access to irrigation**.

For smallholder farmers motivated to copy a neighbor's successful farming practices, and those determined and excited to grow more high-value crops, farmer-to-farmer lending offers a **low-cost and low-risk** entry point to irrigation and a **familiar seller and point-of-sale location**.

Customer Relationships

Village settings create physical and emotional bonds between the pump owner and customer.

Trust is established based on frequent availability of the pump to be rented.

Channels

The benefits of pump lending or renting pass by word-of-mouth and storytelling.

Pump inquiry is done face-to-face or via SMS/call.

Pumps are transported to and from the field by bicycle.

Customer Segments

Farmers living in the same village or with neighboring farms to the pump owner

Farmers who do not have the upfront cost to buy a pump but can afford renting

Cost Structure

Expenses for lending equipment to farmers include:

- Maintenance cost
- Communication cost
- Labor

Revenue Streams

Lending farmers can make profit through:

- Pump fee: the charge for borrowing/renting a pump on daily, weekly, or seasonal basis (may vary by crop and location)
- Service fee: the charge for a pump owner to perform an irrigation project

ENTREPRENEUR-TO-FARMER

Business Model Canvas

Figure 5

Key Resources

Pumps, pipes, and accessories

ATV, quad bike, or other vehicle to transport the equipment

Mobile phones

Key Partners

District agronomists

Key Activities

Field visits to study the terrain/farm layout before providing the service

Transporting and maintaining equipment and pumping water

Frequent communication among the pump operators on the field

Demonstrating to customers how to operate the pump

Value Proposition

For farmers worried and desperate because their crops or cattle are dying, and unable to access sufficient water, entrepreneur-to-farmer irrigation service provides **reliable and easily accessible water** during the dry season.

For farmers looking for less expensive or more efficient options to access irrigation, entrepreneur-to-farmer rentals or service can **fill dams quickly at a relatively low cost**.

Customer Relationships

Entrepreneurs do not favor personal relationships in business dealings; it's first come, first served.

Trust is built by reliability. Owners work even at night to meet demand.

Weekly face-to-face visitation with farmers that rent monthly.

Channels

Connections with entrepreneurs are made through word-of-mouth recommendations, SMS, and phone calls.

Customer Segments

Farmers with insufficient equipment to irrigate but who can afford the cost of service

Farmers with dams and fields far away from water, i.e. 1-2km

Livestock farmers in dry regions who need water for cattle

Cost Structure

Expenses for entrepreneurs include:

- Pump maintenance
- Communications
- Transport & fuel
- Labor

Revenue Streams

Entrepreneurs can make profit through:

- Rental fee: depends on duration and crop type
- Service fee: depends on distance to water source, number of irrigation pumps needed, and size of plot
- Customers pay for fuel used and transportation

WATER TANKER TRUCK

Business Model Canvas

Figure 6

Key Resources

Licensed drivers

Water trucks

Mechanics

Pumps and pipes

Fuel/diesel

Key Partners

Truck owners (often based in urban centers)

Key Activities

Renting the truck from the truck owners

Pumping water from the water source into the truck

Pumping water from truck into the dam sheet

Driving to and from the client/farmers

Value Proposition

For livestock farmers feeling hopeless because their cows produce less milk or die due to lack of water during the dry season, water trucks **fill dam sheets to keep cows alive and increase milk production**.

For livestock farmers frustrated because their cows contract illness from moving to shared water bodies, water trucks **keep cows healthy by providing water on the farm**.

Customer Relationships

Village settings and neighboring farms create connections between truck owner/operators and farmers.

Channels

Who has or can get a tanker truck is passed from farmer-to-farmer by word-of-mouth. Service inquiry is done in person or via SMS/call.

Customer Segments

Livestock farmers not close to water sources who have no access to water in the dry season

Livestock farmers who do not want to take their cows to water bodies but have dam sheets on their farms

Cost Structure

Business expenses include:

- Truck renting fees
- Truck/pump maintenance
- Fuel/diesel
- Drivers and laborers

Revenue Streams

Business owners can make profit through:

- Service fee: the charge for a round trip of the truck (from water source to farm)

For smallholder farmers who are worried, anxious, and urgently needing a pump to irrigate because their crops are wilting, or their cows are stressed due to lack of water, farmer-to-farmer, entrepreneur-to-farmer, and water truck business models provide quick access to irrigation and water for livestock. From the conversations we had with farmers using the mentioned irrigation-as-a-service businesses, they said they were content and grateful that they could irrigate or pump and store water easily, increasing crop yield and milk production.

The farmer-to-farmer and entrepreneur-to-farmer business models have a common goal of supporting smallholder farmers who are concerned about wilting crops and wanting to increase their yield but cannot access the needed irrigation equipment. Both businesses rent pumps to farmers or irrigate for them using motor pumps. This is different from the water truck business model that focuses on livestock production and works closely with livestock owners who are frustrated due to the dry season, discouraged by the distance to the nearest water source, and afraid that their cows might contract illness from other cows while traveling to water.

Entrepreneurs who rent pumps and water truck entrepreneurs are both business-oriented. They approach their business models as entrepreneurs by defining the problem, understanding the cause, and proposing the solution. In addition, they are willing to take their businesses to the next stage as soon as they get an opportunity. Pump and tanker truck entrepreneurs have the equipment, experience, and expertise to advise and serve even farmers far away from water sources. In comparison, farmers who rent their pumps to neighboring farmers usually do not provide extra services and are usually not willing to scale these services. The personal connections often required within this business model also present limitations to scaling up.

The entrepreneur-to-farmer model is unique because both crop and livestock farmers use the service. This business model is reliable and efficient especially for farmers who live far from the water source. The pump entrepreneur provides water for both irrigation and livestock by pumping water for up to two kilometers into dam sheets, or directly irrigating crops for the farmer. Compared to water trucks, rental pump entrepreneurs fill more water at a time into dam sheets and at a lower overall cost. It takes roughly a day to fill the dam sheets (the largest) with a pump, while a farmer using a water truck must receive water in multiple trips and dams are never completely filled at one time. Farmers are more comfortable using pumps rather than water trucks because the cost is lower, and pumps are more dependable in terms of supplying enough water to sustain a farmer throughout the season.

Although the entrepreneur-to-farmer model is successful and promising, it also has its challenges. If there is no proper follow up, this model can fail. A cooperative in Nyagatare district had a similar business model which has failed. Out of 14 pumps they used to rent out, only six were still functional two years later. In an interview, the president of the cooperative told us that the main reason for failure was lack of oversight. Since the equipment belonged jointly to the cooperative, there was no one person in charge to oversee the renting or maintenance of pumps and their accessories. The person who rented the pump was free to use it however they wanted, often carelessly.

The water truck model is different from other irrigation-as-a-service businesses because trucks are able to reach the farthest farms from water bodies. However, this is also a challenge because the farther they go, the more expensive it is for farmers and the fewer number of trips the truck can make in a day. The customers for this model must have dam sheets or water tanks for water storage. Most livestock farms are far from water bodies, and some water bodies dry up in dry seasons resulting in very high demand for water truck services, which is one of the main reasons this model works.

Livestock farmer: a farmer who raises cattle, often on a larger farm (15-25 hectares), and often with a dam sheet to store water.

KEY INSIGHT 3

Informal markets have an effect on the landscape that is unrecognized and important.

Loaning and renting pumps leverages investments in irrigation equipment to increase access to irrigation and irrigated areas.

The scope and impact of the rental market in Rwanda is not yet well recognized. Pump renting, especially from one farmer to another farmer or an entrepreneur (who is also a farmer) to a farmer is mostly considered as friendship or social activity, not as a business. Policymakers and government officials are aware that the sharing of pumps occurs among farmers, but when reporting the land irrigated, only the land of pump owners is reported. This misses the fact that informal lending and renting is increasing the land irrigated and the number of people irrigating. In addition, according to the Small-Scale Irrigation Technology (SSIT) subsidy program rules, farmers are not allowed to rent or make money from pumps purchased through SSIT; only free help and lending to other farmers is allowed.

Nonetheless, the rental irrigation pump market is extensive in Rwanda. Entrepreneurs who are renting out equipment to farmers say that there is higher demand than they can satisfy, and farmers are willing to pay as long as their crops do not wilt, or their cows die. Though some farmers rent because they do not have any other option, for other farmers, it was surprising to learn that they prefer renting rather than buying irrigation equipment, even if they can afford to buy the equipment.

Analysis of conditions under which an entrepreneur and a farmer can both be better off with a long-term rental than the farmer would be owning their own pump is beyond the scope of this report. However, if entrepreneurs have significant economies of scale around purchasing, operations, and maintenance cost, then long-term rentals can make economic sense to farmers.

Estimating Impact

Estimating how much land is being irrigated using pump rentals is difficult due to the informal nature of the transactions and the inconsistent scale of the market. Different regions have different ways of renting pumps, which are influenced by several factors. Such factors include how long the pump is rented out, what type of crops are being irrigated, the land area irrigated, and the time and distance to transport equipment to the field. If the pump is rented out daily to different people, multiple farms will be irrigated. However, if it is rented seasonally, only that field will be irrigated for that season. Some crops need to be irrigated frequently while others do not. Also, farmers have different land sizes. Some fields are large and require longer to irrigate, especially in Nyagatare, while others are small and can be watered quickly. This influences the number of people that can utilize a pump of a given size.

Due to the lack of data and uncertainty in assessing informal markets, we developed a methodology to estimate the impact of irrigation-as-a-service on irrigated area in Rwanda using a minimum number of input variables. The calculation seeks to determine a range of how much lending and renting has already

increased access to irrigation based on generalizing observed behavior of farmers during field interviews.

Key parameters used in estimation include the proportion of owners who rent, how many days a week they rent, and asset utilization rate (roughly speaking, how much time the pump is idled when it is not being rented or loaned out). Assuming high pump utilization rates on pump owners' own land, we estimate that lending and renting of pumps has increased actual irrigated area by 8-35% in Bugesera district and 3-21% in Nyagatare district. Lower pump utilization rates imply that pumps can be used to irrigate land relatively faster than higher pump utilization rates. Assuming low pump utilization rates, the estimated increase in irrigation area from loans and rentals is 31-138% in Bugesera district and 12-83% in Nyagatare district. The detailed methodology is available online at waterforfood.nebraska.edu/entrepreneurship.

Changes in knowledge, behavior, and condition

Despite uncertainty in quantifying the total impact of informal markets, based on interviews with farmers who rent pumps, the individual impact is positive. Many smallholder farmers are not equipped with knowledge or skills about irrigation, but after learning from their fellow farmers how irrigation could support their farming, they become interested in renting pumps and plan to buy their own as well. Borrowing or renting a pump can be a first step towards eventual pump ownership.

A farmer from Bugesera district told us that before purchasing his own pump, he learned how to use a pump by renting from his neighbor. Now that he has his pump, he grows French beans for export and his yield has increased. This is a common testimony among smallholder farmers. For farmers who struggled to afford the upfront purchase price, renting from their neighbors or cooperatives has been helpful to keep farming throughout the whole season. Farmers who rent from their fellow farmers believe that renting pumps saved them money. Eventually, this led to owning their own pumps, taught them how to operate pumps, increased their production yield, and encouraged them to cultivate high value crops.

Pump lending relies on and reinforces good relationships in the community, because neighbors have learned to trust and work together by sharing the risks and opportunities. One farmer mentioned that he rents a pump to four fellow farmers from cooperatives and when the pump has any technical issue, all four of them share the repair and maintenance costs.

Some farmers also found renting to be a great business opportunity and have taken it further to extend renting as their business and support other farms. An example of this is a person named Joseph (name has been changed). After realizing how many farmers and cattlemen from Nyagatare district were struggling to irrigate and feed their cows, Joseph started renting his one pump he had bought through the SSIT program. Years later, Joseph now owns and rents eight pumps that he bought with the profits he gained from renting. The mutually beneficial relationship between pump owners and customers can be described in the scenario below:

David (name has been changed) in Bugesera rents irrigation equipment from Joseph, another farmer who doesn't irrigate every day. David pays Joseph 3,000 RWF/day, three times a week. David buys his own fuel, and in case something happens to the pump when he is using it, he is in charge of the repairs. If Joseph is renting the pump only to David, he gets 9,000 RWF/week. If the pump cost 150,000 RWF, then the break-even point on the investment happens after just 17 weeks, without even considering the benefits of irrigation to the owner. When the pump owner rents, there is an additional financial benefit of the rental income which increases the return on investment of that irrigation pump. Then the pump owner can purchase more equipment in a short period of time, even if the equipment already owned depreciates faster. On David's side, the benefit of access to irrigation is increased yield, ability to farm additional seasons, and ability to grow high value crops, which all result in increased income.

RECOMMENDATIONS

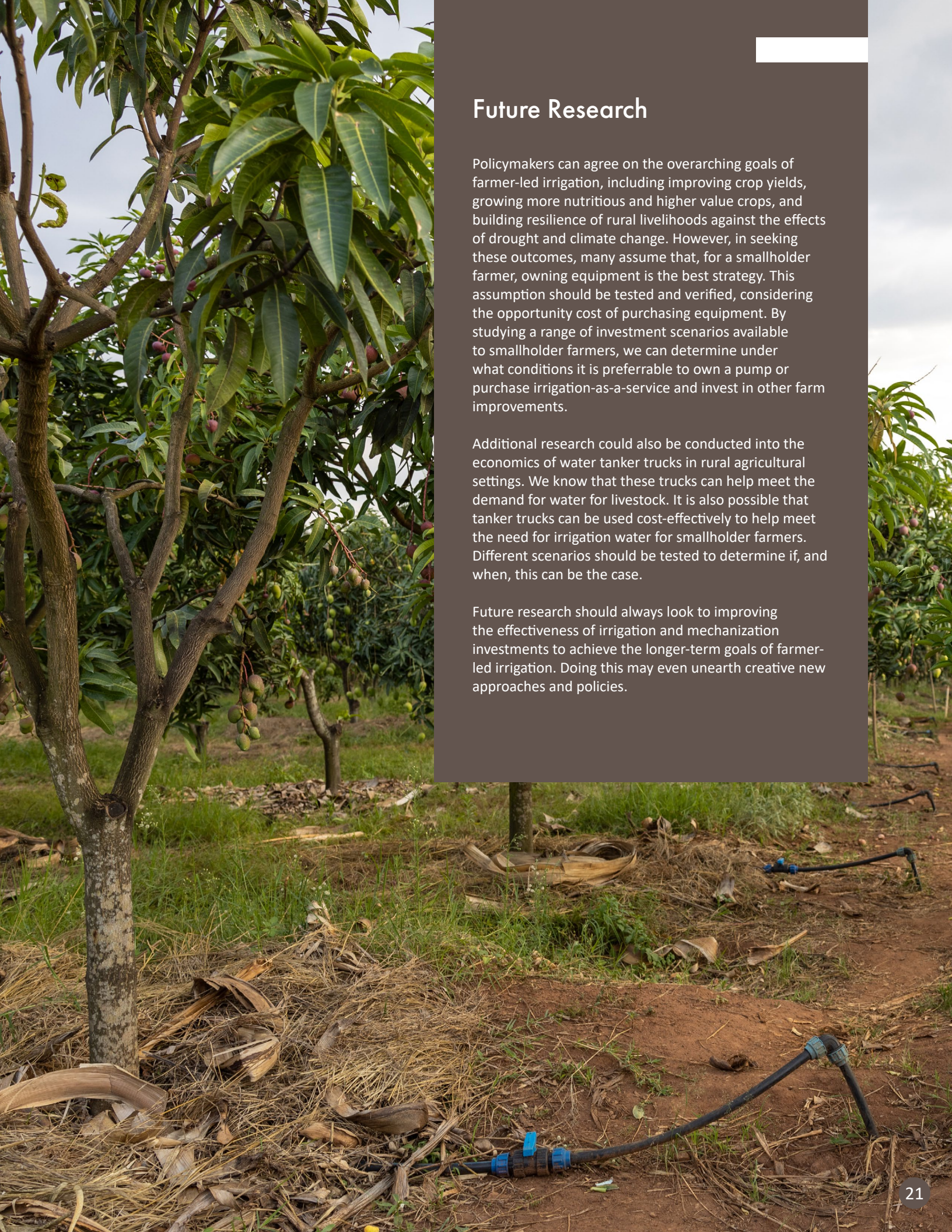
The SSIT program, which is the Rwandan government's investment in small-scale irrigation technology, aims to increase the adoption of irrigation by smallholder farmers and increase their yield and profitability. SSIT aims to irrigate 102,000 hectares by 2024.[4] If SSIT encouraged or facilitated sharing, investments in irrigation would have even more impact on the landscape. For example, SSIT agronomists could help connect farmers who were not eligible or could not afford to buy subsidized pumps to other farmers who had pumps available for loan. It can be cost effective to encourage more small pumps and allow farmers to lend or rent pumps to each other, especially if the goal is to increase irrigated acreage. Small pumps require significantly less investment per hectare than other irrigation technologies, and if these pumps are shared, the investment per hectare is even lower.

Our research shows that there are business opportunities for irrigation-as-a-service entrepreneurs, but there is still a gap in entrepreneur engagement to fulfill the high demand. To help scale-up IAAS business models, the government or NGOs could invest and engage investors in irrigation-as-a-service, such as by providing grants to entrepreneurs starting IAAS businesses. Currently, a large portion of government funding for smallholder irrigation in Rwanda goes to fewer than 20 SSIT-designated retailers. If the government also invested in irrigation-as-a-service entrepreneurs, this could spread out government funding more evenly to new business owners.

Additionally, the government or NGOs could support IAAS entrepreneurs with outreach and training, such as hosting engineering workshops about the latest irrigation technologies and methods, as well as about running service businesses.

Entrepreneurs seeking to start IAAS businesses can learn lessons from businesses that have succeeded and failed. Like other startup businesses, renting pumps can be challenging. For example, we encountered a cooperative pump rental business that failed due to poor equipment management and business planning. The cooperative rented four pumps to a customer who misused the equipment. All four pumps were damaged, and due to the poor follow-up system, the customer went missing and the cooperative lost all four pumps. Conducting customer discovery before starting a business helps in understanding the business ecosystem, how to manage the business operations, and how to reduce risk. For an entrepreneur interested in irrigation-as-a-service, we also recommend creating a sustainable operational system that is built on frequent communication and follow-up to avoid the same hardships.

[4]Rwanda Agriculture and Animal Resources Development Board. 2020. Rwanda Irrigation Master Plan. <minagri.gov.rw>. Accessed 6/2/2022.



Future Research

Policymakers can agree on the overarching goals of farmer-led irrigation, including improving crop yields, growing more nutritious and higher value crops, and building resilience of rural livelihoods against the effects of drought and climate change. However, in seeking these outcomes, many assume that, for a smallholder farmer, owning equipment is the best strategy. This assumption should be tested and verified, considering the opportunity cost of purchasing equipment. By studying a range of investment scenarios available to smallholder farmers, we can determine under what conditions it is preferrable to own a pump or purchase irrigation-as-a-service and invest in other farm improvements.

Additional research could also be conducted into the economics of water tanker trucks in rural agricultural settings. We know that these trucks can help meet the demand for water for livestock. It is also possible that tanker trucks can be used cost-effectively to help meet the need for irrigation water for smallholder farmers. Different scenarios should be tested to determine if, and when, this can be the case.

Future research should always look to improving the effectiveness of irrigation and mechanization investments to achieve the longer-term goals of farmer-led irrigation. Doing this may even unearth creative new approaches and policies.

See the DWFI website for more information at
waterforfood.nebraska.edu

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