Policy brief
38313 | August 2018

Florence Kondylis, Maria Ruth Jones, Jeremy Magruder, and John Loeser

International Growth Centre

Impacts and sustainability of irrigation in Rwanda

In brief

- Economic growth in Rwanda relies critically on agricultural growth, yet Rwanda's agricultural sector faces critical constraints such as fragmentation, dependence on erratic rainfall, and challenging geography.
- As the country's agriculture is mostly rain-fed, production is exposed to climatic variation and unreliable rainfall. As such, irrigation presents a mechanism to intensify Rwanda's agricultural production.
- This brief estimates of the impacts of irrigation on farmers' welfare, and tests the mechanisms designed to address concerns about the sustainability of irrigation investment.
- The initial findings highlight large short-term effects of irrigation, and offer promising early evidence of impact of complementary interventions.
- The researchers call for future research into the area of irrigation in future seasons and highlight how this study has implications for future agricultural policy in Rwanda.

This project was funded by IGC Rwanda

Context

Economic growth in Rwanda relies critically on agricultural growth. Yet, Rwanda's agricultural sector faces critical constraints: fragmentation, dependence on erratic rainfall, and challenging geography. Population patterns and small landholdings (with an average of 0.2 ha of arable land available per rural resident) necessitate intensification of production. As Rwanda's agriculture is mostly rain-fed, production is exposed to climatic variation and unreliable rainfall. As such, irrigation presents a mechanism to intensify Rwanda's agricultural production.

Irrigation investments have enormous potential to improve the lives of smallholder farmers who otherwise depend on rain-fed agriculture, through improving yields, increasing cultivation in the dry season, and reducing risk. Yet, hillside irrigation requires massive infrastructure investment, and only 1% of arable land is irrigated. Operation and maintenance (O&M) costs of this class of systems are also high, and sustainability of investment will require a shift from staple crop to high-value export crop production.

The Land Husbandry, Water Harvesting and Hillside Irrigation (LWH) is a flagship project of the government of Rwanda that aims to transform hillside production, increasing productivity in an environmentally sustainable manner. This impact evaluation focuses on three LWH irrigation schemes. Hillsides in and around these schemes are terraced. These irrigation schemes share similar design features: a main canal is directed from the water source along contours of the hillside. Groups of approximately 20 households (range of 5-50 at baseline; median of 19) will rely on a secondary canal to irrigate their terraces. These households are organised into Water User Groups (WUGs). Along the secondary canal, there is a tertiary inlet with a flexible pipe on every third terrace. Working on the terraces, farmers dig (temporary) tertiary canals in the soil to draw the water from the flexible pipe and irrigate the terrace.

There are three agricultural seasons in Rwanda: two rainy seasons (A and B) and one dry season (C). In season A, rainfall is sufficient for production in most years. In season B, rainfall is sufficient in an average year but insufficient in dry years. In season C, rainfall is insufficient for most agricultural production. Thus, we expect irrigation to directly affect production the most in season C, and to a lesser extent in season B. There may be additional effects throughout the year if farmers alter their investment strategies. For instance, farmers are expected to switch to higher value crops that require steady water intake throughout the season (e.g., horticulture).

Figure 1: Primary canal in one of the studied hillside irrigation sites, Karongi District

Study design

The impact evaluation will provide estimates of the impacts of irrigation on farmers' welfare, and test mechanisms designed to address concerns about the sustainability of irrigation investment. The key research questions are:

1. What are the impacts of irrigation on smallholder welfare?
2. Does empowering a monitor within a WUG improve maintenance outcomes? Does the placement of a monitor within the irrigation scheme affect resource sharing?
3. Do self-demonstration kits encourage experimentation and long-run adoption?

The baseline survey was conducted from August-October 2015, while the schemes were still in demonstration phase. Interventions started in the field during the first rainy season of 2017 (September 2016-January 2017). A follow-up survey was conducted from May-July 2017, measuring the short-term impacts of the interventions. This brief summarises those short-term impacts.

Impacts of irrigation

We estimate the impacts of access to irrigation using a spatial regression discontinuity design, comparing the plots just above the canal (not irrigated) to those just below (with access to irrigation). Construction of the schemes completed in 2015. All farmers in the irrigated area have access to water. Water usage fees are charged to all households that irrigate. To afford the water usage fees, and to make the schemes viable, farmers will need to transition to high value crops, such as horticulture, and away from the staple crops of maize and beans.

Figure 2: Example maintenance issue for the irrigation infrastructure

Operations and maintenance

We used a randomised control trial to measure the impact of empowering monitors on maintenance outcomes. We also tested whether the placement of a monitor within the irrigation scheme affect resource sharing. In 76 randomly-selected WUGs, the WUG elected a monitor from any of its members. The position, however, was reserved for a farmer cultivating land close to the main canal (counterintuitively, these are the farmers most exposed to collective action problems, since they cannot draw water while farmers below them are using the water). The remaining 100 groups have an employee of LWH monitoring their water use (the status quo).
Monitors complete a worksheet once every week, in which they record: number of days in which there was water available for irrigation, occurrence of 11 events related to routine maintenance, and water sharing issues. Monitors started their new tasks in November 2016, and have collected weekly data since.

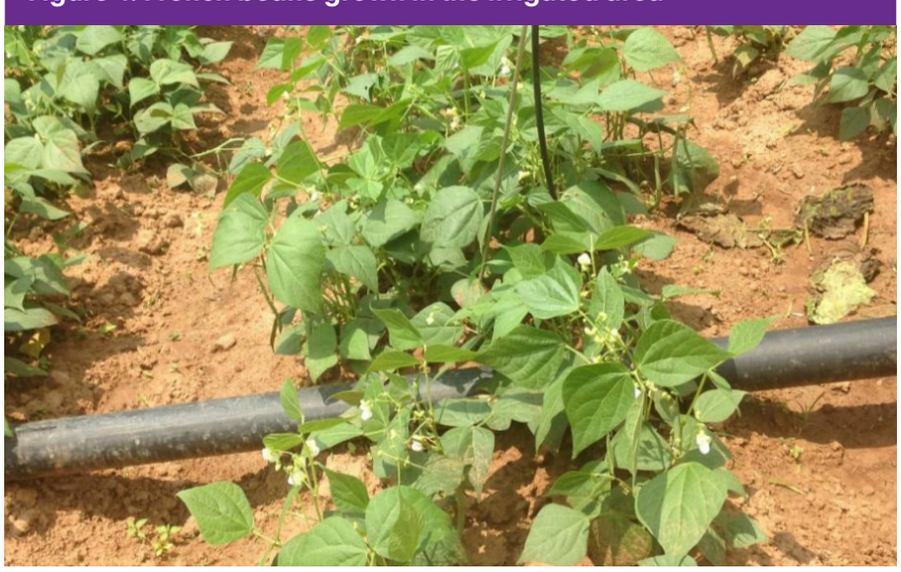
Mini kits

We used a randomised control trial to test whether mini-kits for self-demonstration effectively encourage experimentation with high value crops, and whether that experimentation leads to long-term adoption. We expect important coordination issues to be resolved as we encourage more farmers to experiment and, therefore, adopt a new crop within a WUG. As crops have different watering schedules, and farmers along a terrace need to coordinate watering, there are strong complementarities to all adjoining farmers growing the same crop. This is mechanical: at the terrace level, water moves through ditches and furrows, so it is easiest to water all plots at once.

Figure 3: Training WUG monitors

A virtuous cycle occurs when farmers begin to experiment with high value crops: productivity improves as farmers learn how to cultivate high value crops, farmers use the irrigation system because it is necessary for cultivation of these crops, and they properly maintain the irrigation system because their production becomes dependent on it. Additionally, this constant use of the irrigation system allows LWH to collect enough fees to make the irrigation scheme sustainable.

Figure 4: French beans grown in the irrigated area



Policy implications

This project builds on an ongoing programme of impact evaluation of Rwanda's Land Husbandry, Water Harvesting and Hillside Irrigation (LWH) Project. The partnership between the World Bank's Development Impact Evaluation (DIME) and the Ministry of Agriculture (MINAGRI) began in 2012, and over the past five years, MINAGRI has a demonstrated commitment to using impact evaluation results to inform policy design and scale-up. LWH, a flagship MINAGRI programme, uses a modified watershed approach to introduce sustainable land husbandry measures for hillside agriculture on selected sites, and develops hillside irrigation for sub-sections of each site. The first generation of trials focused on the rural finance and agricultural extension components of the LWH project, as the physical infrastructure for the irrigation component of the project required significant construction time. Each trial was conducted over the course of 1-2 years, with results informing the project design as it scaled up to new watersheds.

Now that the irrigation scheme construction is completed in three of the watersheds, the LWH team is interested in turning similar attention to the irrigation component. As the irrigation schemes were very costly to construct, MINAGRI is keen to rigorously measure their cost-effectiveness, and to maximise the sustainability of that investment by learning how to effectively implement water user fees and ensure proper maintenance. The Rwandan government is midway through a multi-year project to complete about seven hillside irrigation schemes with a potential for more. The research team is working closely with the government to produce rigorous evidence that will guide the scale up decisions, as well as strategies to improve the performance of irrigation schemes.

Irrigation is a policy priority for the region more broadly. As of 2010, only 6% of total cultivated area in Africa was irrigated; all other production was rainfed (IFPRI 2010). This impact evaluation will contribute data on the returns to hillside irrigation and lessons for scheme management, critical to informing the discussion on how to smartly invest in irrigation infrastructure to boost agricultural productivity and manage increasing climate variability.

Results

The initial findings highlight large short-term effects of irrigation, and offer promising early evidence of impact of complementary interventions.

Short-term impacts are large and positive. In the first dry season of irrigation adoption (16°C):

- Plots just inside the command area are 16% more likely to be cultivated,
- 9-38 percentage points more likely to be growing horticultural crops, and
- 8-27% more likely to use DAP, CAN, or urea fertilisers.

In line with these changes in crop choice and input use, **value-weighted yields increase by 31-77%, and sales per hectare increases correspondingly.** Taking into account that only about 1/3 of farmers choose to cultivate in season 16°C, the point estimates suggest that **Season C revenues go up by 210,000-300,000 RWF for cultivating farmers.** We also see evidence of more land transactions (rentals and sales) in the irrigation area. This makes sense, as farmers who prefer not to cultivate in the dry season or grow horticultural crops may choose to rent or sell their land to those who do wish to cultivate.

We additionally used randomised control trials to document the impact of complementary interventions that have the potential to increase the returns and sustainability of irrigation. Unfortunately, the timing of our interventions relative to this first mid-term survey do not allow us to measure their full impact. Future survey rounds will be needed to have definitive results. However, we find clues in our monitoring data that these complementary interventions may indeed increase adoption of horticultural crops and enhance farmers' access to irrigation water. For the monitoring intervention, we find that having a monitor has a substantial positive effect on days a group is able to irrigate. For the demonstration kits intervention, we see that 38% of farmers who were offered a demonstration kit choose to use it, and kit recipients are slightly more likely to be using irrigation. In future seasons, we will examine whether the use of these kits led to persistent take-up of horticultural crops.

Dissemination

While the findings highlighted in this report are preliminary, the results have already shaped policy at three levels. First, at the local level, this work has enhanced the capacity of district officials to design monitoring systems and empower farmer monitors for irrigation schemes. The training material generated to implement the operations and monitoring intervention can be retooled for different schemes, with little customisation. In the absence of this evaluation, local capacity for this class of intervention may not have been built.

Second, this research programme has affected policy at the project (LWH) level. Indeed, early findings from this work have motivated the continuation and scale up of these interventions to new irrigation schemes being overseen by MINAGRI's single project implementation unit (SPIU). This is a key result for this work, which will allow for further testing and, thus, broader policy impact for this research work.

Third, dissemination has already taken place to affect policy decisions beyond the project and at the level of Rwanda's national strategy for the agricultural sector. The research team, led by a World Bank Task Team Leader (TTL), disseminated the early results presented in this mid-term report in high-level forums in Rwanda early October 2017. These events induced communications with high-level policymakers in Rwanda, up to

Permanent Secretary level in MINAGRI and Director General Planning level at MINECOFIN, with a view to affect budget allocation to irrigation schemes moving forward. Further dissemination activities will be scheduled as new results come in.