

Releasing Economic Constraints to Get Irrigation Working

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Common Perceptions

Low adoption of productive technologies is a key reason for low agricultural yield in Sub-Saharan Africa. Productive technologies may be underutilized due to inefficiencies in the markets faced by farmers. In particular, these market failures distort technology adoption, most commonly through experimental manipulation of markets for risk, credit, and information.

Economic theory suggests that land and labor market failures reduce the adoption of productive technologies because they generate inefficient allocations of labor and land across farms. However, this theory has not been thoroughly tested.

Questions We Should Be Asking

Irrigation increases agricultural productivity by adding agricultural seasons, enabling the cultivation of water-intensive crops, and reducing uncertainty. However, irrigation is costly: it requires high construction and maintenance costs, and is associated with increased usage of complementary inputs such as labor, fertilizer, and improved seeds.

In the context of large irrigation schemes, infrastructure sustainability hinges on ensuring that the increased productivity associated with irrigation use is realized by farmers within the schemes so that maintenance costs can be recovered. In a recent DIME study,⁴ we show that failures in land

and labor markets may limit the adoption of this productive technology, putting the sustainability of these large investments at risk.

Irrigation is a key component of the Rwandan government's development agenda, per its goal of Rural Transformation (laid out in PSTA 4⁵ and NST1⁶). Land Husbandry, Water Harvesting, and Hillside Irrigation (LWH) is a flagship project with the goal of transforming hillside agricultural production sustainably. We conducted an impact evaluation of three hillside irrigation schemes constructed by the Rwandan government from 2009–14 in the Karongi and Nyanza districts. In all sites with irrigation access, sufficient water is available to enable year-round irrigation.

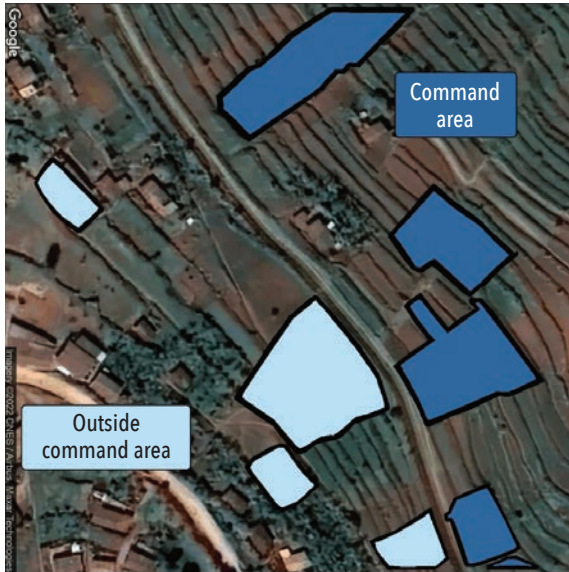
For farmers, the main cost of irrigating a plot is the labor associated with the actual irrigation, including maintaining furrows and using hoses to distribute water from the valves to their plots. Labor market failures create a wedge between household labor productivity and the market wage, meaning smaller households—who rely on hired labor to meet the labor demands of irrigated agriculture—may be unable to profitably irrigate their land. In addition, if these households face difficulty trading their land, labor

⁴ Maria Ruth Jones* et al. "Factor Market Failures and the Adoption of Irrigation in Rwanda," Policy Research Working Paper 9092, (Washington DC: World Bank Group, December 2019), <https://openknowledge.worldbank.org/handle/10986/33061>.

⁵ PSTA refers to the Strategic Plan for Agricultural Transformation. PSTA 4 "seeks the 'transformation of Rwandan agriculture from a subsistence sector to a knowledge-based value creating sector, that contributes to the national economy and ensures food and nutrition security in a sustainable and resilient manner.'" See: https://www.minagri.gov.rw/fileadmin/user_upload/Minagri/Publications/Policies_and_strategies/PSTA4__Rwanda_Strategic_Plan_for_Agriculture_Transformation_2018.pdf.

⁶ NST 1 refers to Pillar 1 of the Strategic Plan for Agricultural Transformation: Economic Transformation, per above.

■ **Figure 1.1** Plots Inside and Outside the Irrigation Scheme (“Command Area”)



Note: The “command area” in dark blue shows the irrigated plots, while the light blue area shows plots that are not part of the irrigation scheme.

market failures can cause inefficient adoption of this profitable technology.

Our impact evaluation compares plots located just above the canal (not irrigated) to those just below (with irrigation access)(see figure 1.1). We randomly selected plots within 50 meters of the irrigation scheme boundary, and then identified the associated households to interview. Households answered survey questions about the sampled plot and any other plots they cultivate. In total, the evaluation includes four years of data on 3,000 plots.

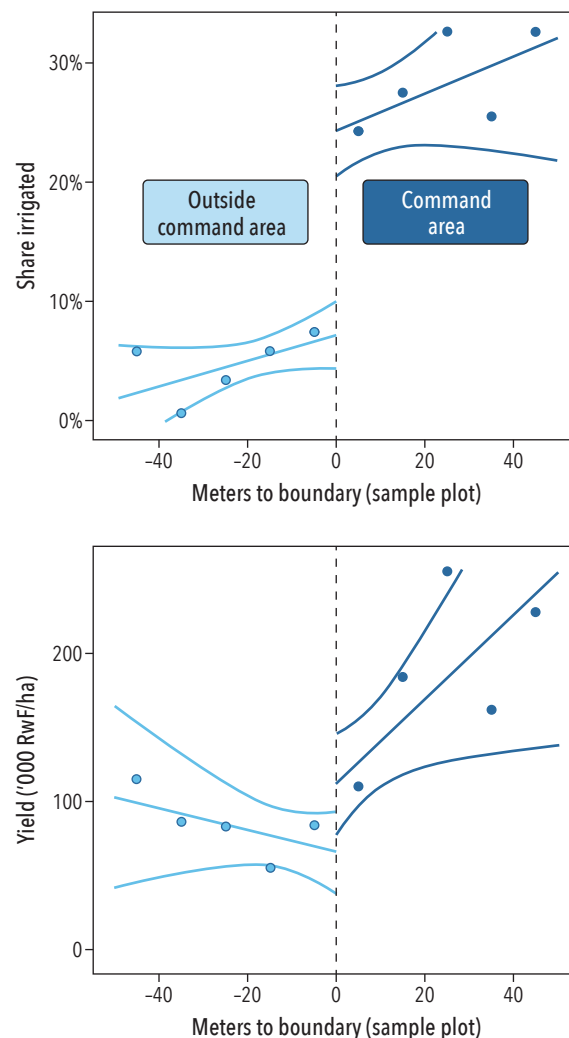
Challenging Perceptions

Our evaluation produced three key results:

1. Irrigation enables dry season horticultural production, which boosts on-farm profits by

43–62 percent (see figure 1.2). These profits are generated by changing cropping patterns from perennial bananas to a more input-intensive rotation of dry-season crops that command higher prices, for example cabbages, tomatoes, and onions, as well as rainy-season staples.

■ **Figure 1.2** The Impact of the Irrigation Scheme on Share Irrigated and Yield



Note: Each solid dot represents the average proportion of irrigation and yield for sample plots grouped in 10-meter bins of distance compared to the command area boundary. The curved lines represent 95 percent confidence intervals. The plots inside the command area are associated with both higher irrigation levels and higher yields.

2. **Irrigation adoption is constrained.** Farmers were only irrigating 30 percent of plots four years after the introduction of the irrigation initiative. Access to irrigation requires farmers to substitute labor and inputs away from their other plots. Eliminating this substitution would increase adoption by at least 34 percent.

3. **Labor substitution is largest for smaller households and wealthier households.**

Households with two additional members substitute 37–78 percent less than average-sized households, while households that are one standard deviation wealthier substitute 45–90 percent more than average wealth households. Land markets are constrained, limiting land transactions between both farmers who have extra land in the irrigation scheme that they cannot irrigate, and other farmers close by who would irrigate but have no land within the irrigation scheme. Only labor market failures, combined with failures in the land market, can explain irrigation access on one plot leading to greater substitution across plots for richer households, and decreased substitution across plots for larger households.

Randomized controlled trials carried out within these schemes, which aimed to address information and credit constraints, demonstrated that farmers' adoption of irrigation is not limited by their knowledge of the irrigated crops or by limited access to finance to purchase non-labor production inputs.

One important caveat: these findings apply only to smallholder agriculture—the prevailing cultivation arrangements on these schemes. While constrained access to markets cannot explain our

results, we cannot reject that a move away from smallholder agriculture toward other cultivation arrangements, such as contract farming or other out-grower arrangements, would increase the adoption and sustainability of irrigation investments. This is currently on the World Bank policy agenda, supporting investments across the rural development portfolio.

Policy Implications

The impacts of farmers' access to irrigation documented in the context of the flagship Land Husbandry, Water Harvesting, and Hillside Irrigation project have informed complementary investments at scale, as well as the national sector strategy (PSTA 4) toward efficient use of irrigation, establishing a link between rigorous research and policy design.

A new grant and International Development Association (IDA)-funded investment in the sector will address market inefficiencies. Within these new operations, experiments designed to manipulate land and output markets, as well as trials of labor-saving irrigation technologies, are underway to maximize returns on irrigation development.



This case study is based on an impact evaluation conducted within DIME's Economic Transformation and Growth research program. See: Jones, Maria, Florence Kondylis,* John Loeser,* and Jeremy Magruder. 2019. "Factor Market Failures and the Adoption of Irrigation in Rwanda." Policy Research Working Paper 9092, World Bank, Washington, DC. This paper is forthcoming in the American Economic Review.*

REFERENCES

Jones, Maria,* Florence Kondylis,* John Loeser,* and Jeremy Magruder. 2019. "Factor Market Failures and the Adoption of Irrigation in Rwanda." Policy Research Working Paper 9092, World Bank, Washington, DC. <https://openknowledge.worldbank.org/handle/10986/33061>.

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