What constrains smallholder farmers' sustainable adoption of irrigation?

Evidence from impact evaluations at scale

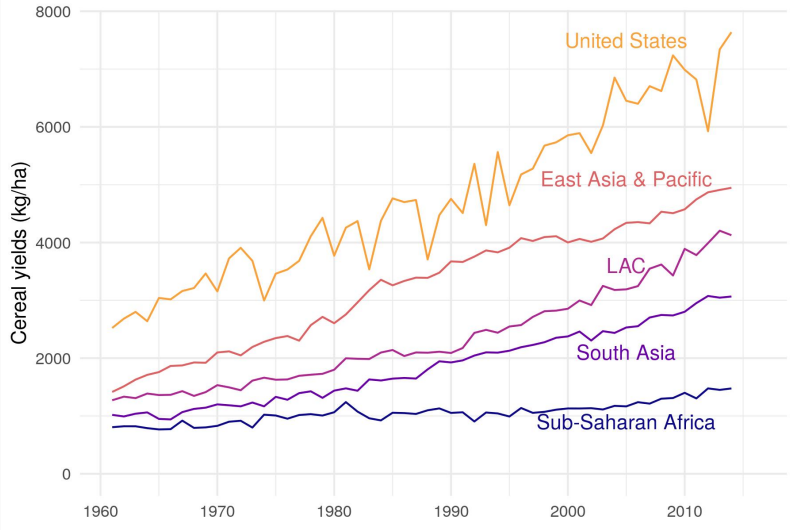
Florence Kondylis* and *very* many collaborators

RSMFP Lecture Series, May 12, 2022

*Development Impact Evaluation, World Bank

Motivation

Cereal yields



What has caused low yields in sub-Saharan Africa and parts of South Asia?

- Plausible hypothesis: constraints to adoption of profitable technologies contribute to yield gap
- Recent expansion of RCTs and policy targeting these constraints
  - Credit ($\Rightarrow$ MFI expansion)
  - Risk ($\Rightarrow$ PSNP/Index insurance)
  - Information ($\Rightarrow$ decentralized extension)
- and yet ...

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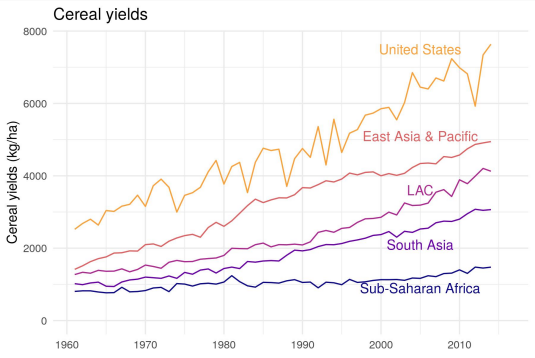
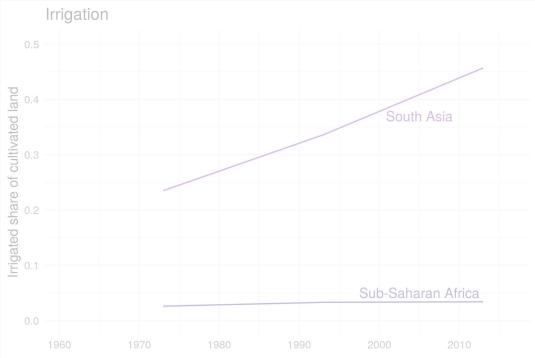
Expansion of irrigation access may be an important part of yield divergence





- 3.4% of cultivated land is irrigated in SSA vs 45.7% in South Asia
- Irrigation increases yields by 70% in India (Duflo & Pande, 2007); does the irrigation gap explain the yield gap?

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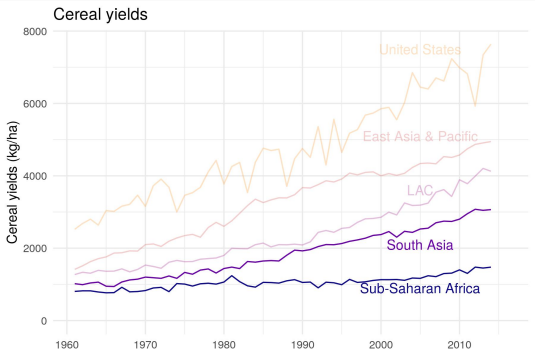

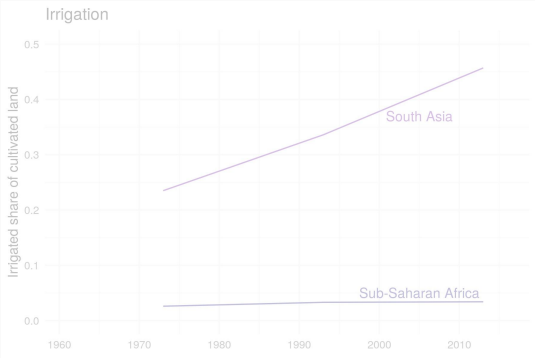

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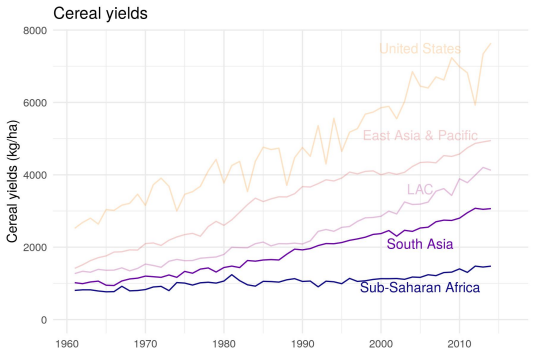

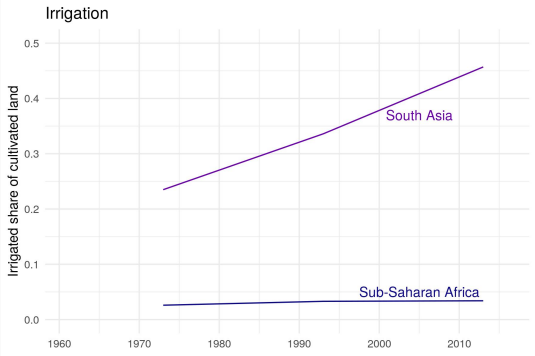

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Water scarcity and flooding are pervasive

What factors may prevent sustainable use of irrigation?

- Irrigation is a common pool resource: individual use of the water affects others' access (*externality*)
- Refers to different problematic across contexts
  - When sustainability relates to overuse
    - e.g., water tables are falling/salinity is rising
    - e.g., pressure in the system is scarce
    - $\Rightarrow$ use needs to be regulated
  - When sustainability relates to underuse
    - a critical mass of farmers need to adopt irrigation to cover Operations and Maintenance of larger irrigation schemes
    - $\Rightarrow$ requires sustained adoption of the technology

This talk: Addressing sustainable irrigation use across 3 contexts

Better water monitoring?

- Improving water availability through information on water needs and use
- Test different monitoring technologies (Mozambique)

Water-conserving crops?

- Reduce cultivation of water-intensive crops in dry season by promoting new seeds
- Test different dissemination strategies (Bangladesh)

Boosting adoption of irrigation?

- Evaluation to estimate the impact and sustainability of irrigation on farmer welfare in Rwanda
- 70% increase in cash profits for farmers adopting irrigation...
- ...but only 30% adopt

$\Longrightarrow$ Shed light on factors underlying the **efficacy and efficiency of irrigation adoption**

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Water Monitoring in Mozambique

Context

- In Mozambique, less than 10% of cultivated land is irrigated
- Recent droughts led **1.7 million people** in food crisis
  - The Government is planning to invest over $600m in surface water irrigation infrastructure over 10 years
  - In the dry season, surface water is scarce ⇒ Are we optimizing water use?

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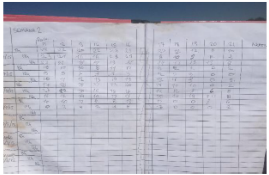
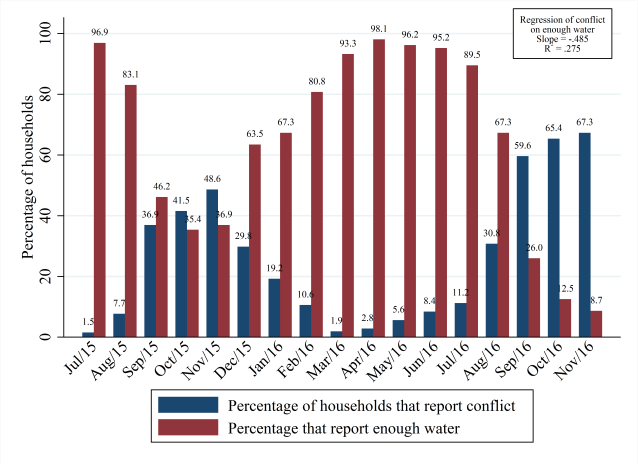
Measurement Experiment (Christian, Kondylis, Mueller, Siegfried, Zwager, 2021)

- Engineers train WUA members to collect flow and depth measures at calibrated points to estimate volumes

- Community data collectors record water depth **3 times per day**
- Extension service agents collect field data and report to central level

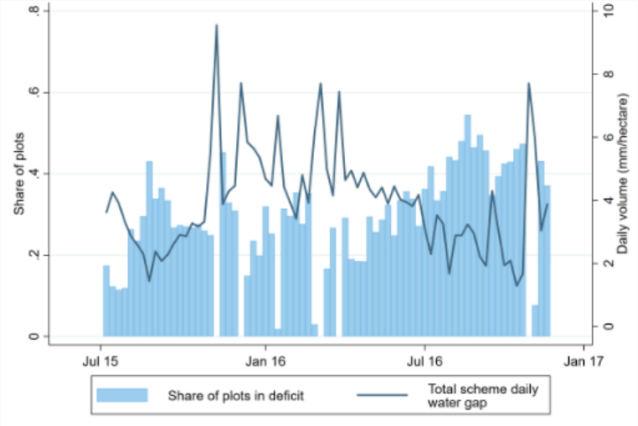


Conflict over water is rampant



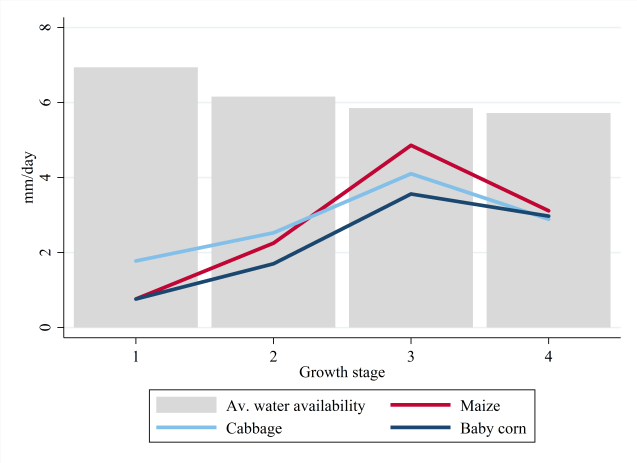
- But is this because:
  - Water is scarce?
  - Some overuse the water?

There is always enough water in the system!



- Yet, half of the plots don't get enought water ...
- Why?

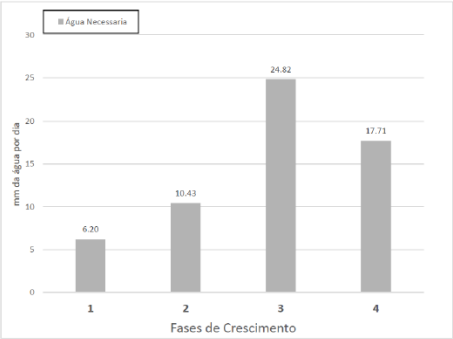
Farmers misallocate water across the crop cycle



- Farmers don't follow water requirements
- This inflexibility wastes enough water to create scarcity

Feedback experiment: Basic requirement vs Precise measurement

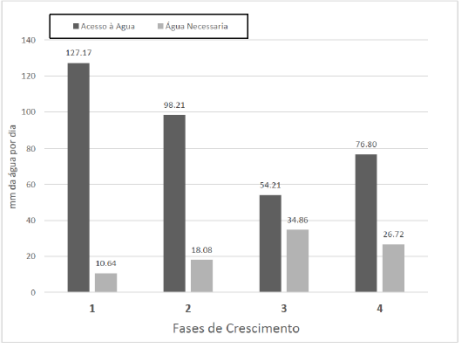
Nome da Cultura: Piri-piri



Dias em cada fase: 28 22 20 5

General Feedback: Specific only to crop

Nome da Cultura: Tomate



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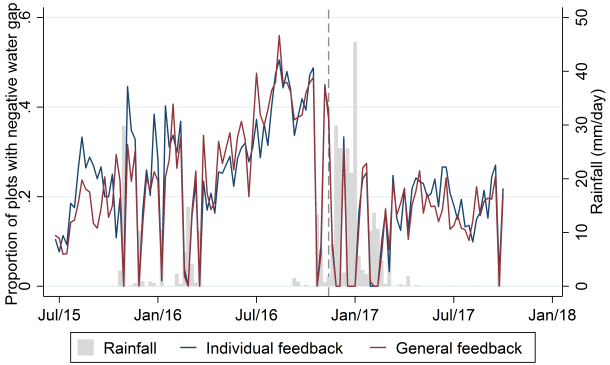
Individual Feedback: Every farmer's use measured

Sharing basic watering requirements worked just as well!



Notes: Observations are plot-crop-week. Lines show the proportion of plots in the week (x-axis) where water gap is negative (water availability<water requirements) given the crop cultivated and that crop's growth stage in the week. If plots have multiple crops cultivated simultaneously, the plot is represented once for each crop. The grey dotted line indicates the week in December 2016 when all farmers had received feedback. Grey bars measure rainfall in the week.

- Scarcity about 50% lower after treatment are implemented
- RCT shows no differences in water savings across treatments

Old Crops, New Seeds: Evidence from Bangladesh

Old Crops, New Seeds (Kondylis, Loeser, Mobarak, Jones, Stein, 2021)

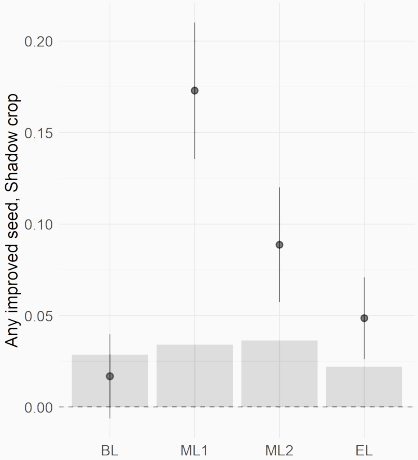
- Ministry of Agriculture is promoting diversification away from paddy in the dry (Boro) season to improve resilience and reduce dependence on groundwater irrigation
  - Promoted crops: mung, wheat, mustard, lentils and sesame
- Each village's demonstration package consists of improved seeds for 0.5 hectares ($\approx$avg land size in study sample)
  - First improved seed for these crops in Barisal
  - Improved seed targeted to this region must have high tolerance for flooding and salinity $\Rightarrow$ new varieties needed to be developed by BARI
- Demonstration packages are provided to farmer groups formed by the project, made up of 25 farmers

Experiment

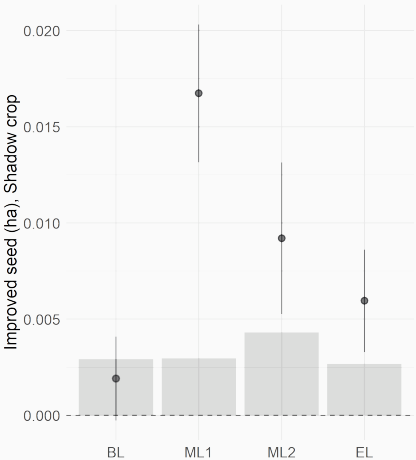
- We disseminate new seeds across 102 villages in Barisal
  - 75 demonstration villages receive 0.5 ha package of improved seed
  - 27 Control villages, which do not receive any demonstration interventions
- All villages (including control) receive extension services promoting use of the flood/salinity tolerant varieties and can purchase these varieties from local input suppliers

Demonstration triggers persistently higher adoption of improved seeds

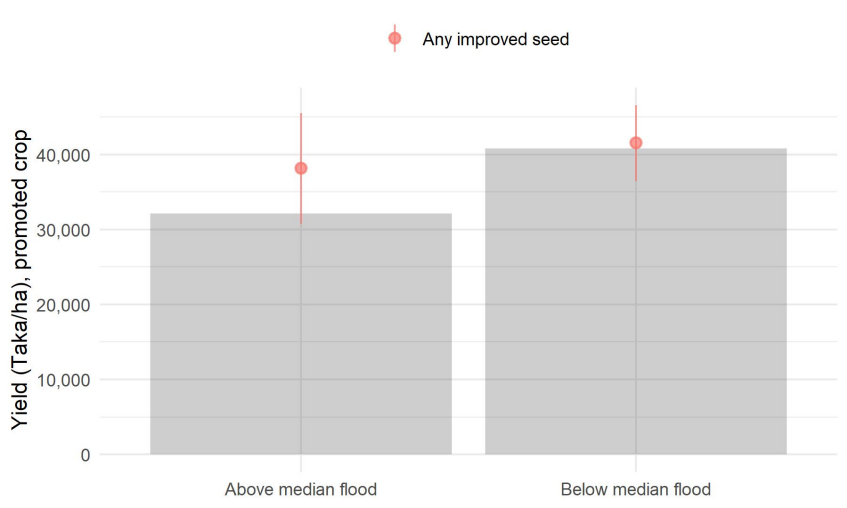
Impacts on adoption of improved seed



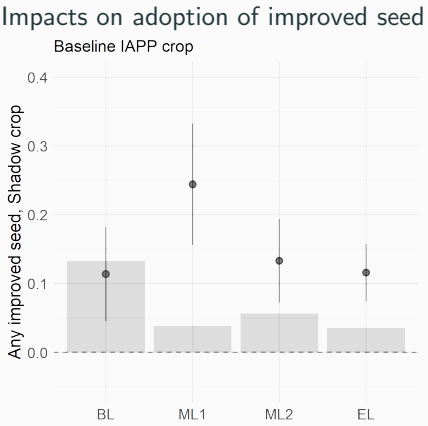
Impacts on area under improved seed (ha)

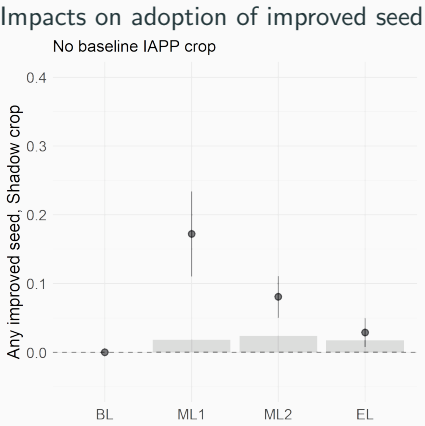


the new seeds eliminate losses from flooding



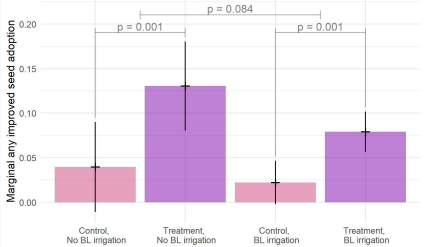
Baseline adopters of water-conserving crops keep using new seeds





Farmers who irrigated at baseline are less likely to adopt!

Impacts on adoption of improved seed



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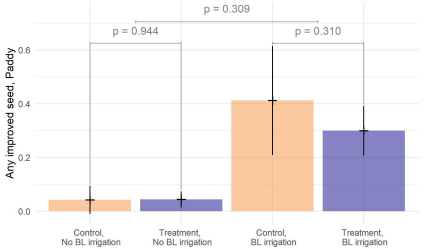

Key Takeaways

- **Medium run** Demonstration increases adoption of improved seed 5pp one year after demonstration
- **Long run** Impacts of demonstration fade to 3pp two years after demonstration, but impact are highly heterogeneous
  - Result suggest that farmers who already were cultivating non-paddy crops in the dry season at baseline were those most likely to keep using the improved seeds
  - Demonstration of a new seed was less successful in moving farmers away from a more profitable, less sustainable practice — cultivating irrigated paddy in the dry season
- Taken together, these results suggest the need to combine financial incentives with demonstration efforts to account for farmers' opportunity cost (e.g., payment for environmental services)

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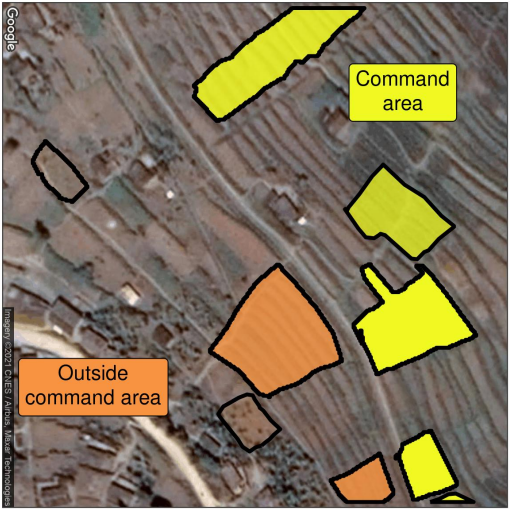
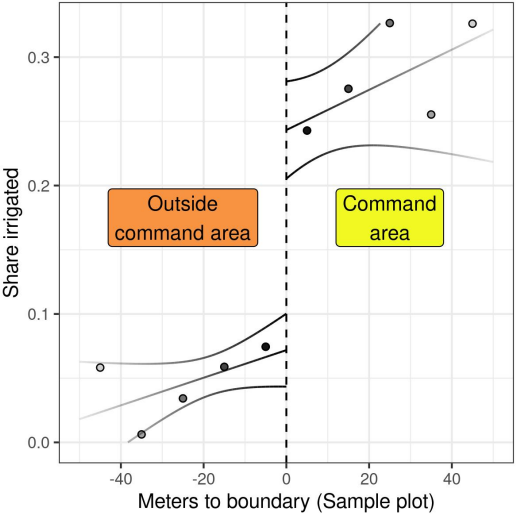
Adoption and Sustainability of Irrigation in Rwanda

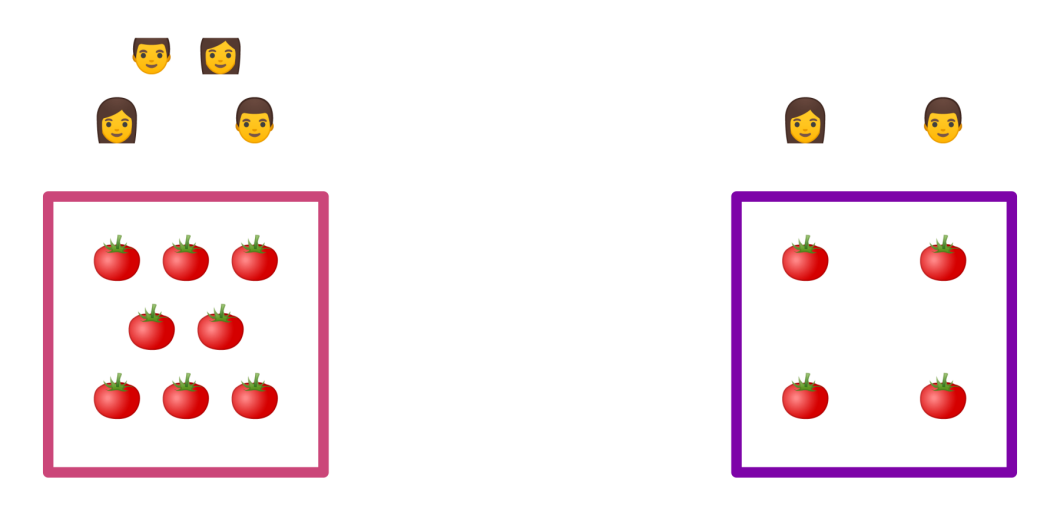
Agriculture and hillside irrigation in Rwanda

Discontinuity in access to irrigation

Farmers only irrigate 30% of plots (Kondylis, Loeser, Magruder, 2020)





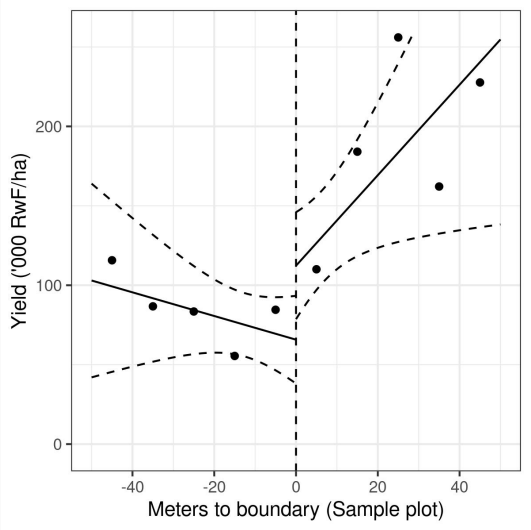


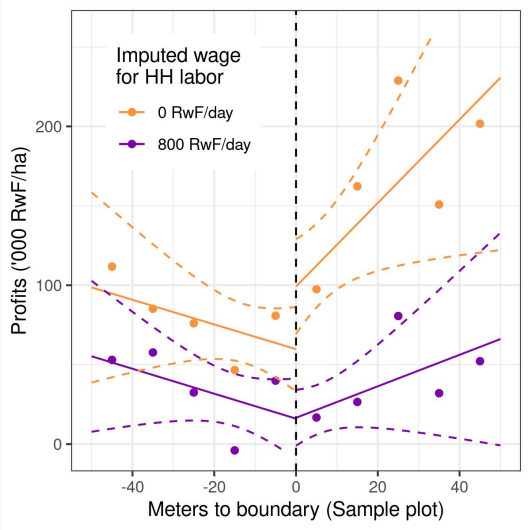
What limits adoption of irrigation?

Are returns heterogeneous, and adoption is efficient? (Suri, 2010)

Are households constrained, and adoption is inefficient? (Udry, 1997)

Irrigation increases yields, but impacts on profits depend on household wage





Key takeaways

Taking advantage of multiple rounds of surveys, we found

1. Irrigation is a productive technology, boosting profits by 43-62%
2. Yet, farmers only irrigate 30% of plots because of labor costs
   - These "stretched" farmers would benefit from **renting out plots** unused during the dry season
3. Distributing free minikits did not increase use of irrigation
   - Farmers who do not use irrigation did not take up free inputs
   - With other evidence (household labor dominant input, irrigation use spread throughout site), suggests that **information and access to finance are not currently primary barriers** to adoption of hillside irrigation
4. Smaller households struggle the most to irrigate multiple plots
   - Suggests that **thin labor markets** limit adoption of irrigation

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Thank You!

- 2018 Huye summer school, in partnership with the University of Rwanda

References (3 main papers used in this talk)

- Water Monitoring in Mozambique: Journal article
- Promoting New Seeds in Bangladesh: paper under construction (!), full slide deck upon request
- Adoption and Sustainability of Irrigation in Rwanda, Working Paper forthcoming at AER