Monitoring Water for Conservation: A Proof of Concept from Mozambique

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Water scarcity is a significant, and growing global constraint

- 1.2 billion people live in "severely water constrained areas agricultural areas"
- Agriculture accounts for 70% of global freshwater withdrawals (FAO, 2020)

Mozambique rapidly expanding irrigation

- Adoption of irrigation can expand cultivation season, promote resilience to droughts, enable cultivation of high-value water sensitive crops
- In Mozambique less than 10% of irrigable land is irrigated, but government is investing heavily in new irrigation infrastructure
- How to realize benefits of new irrigation without exacerbating water stress?

This study

- **Setting:** farmers cultivating plots receiving upgraded irrigation infrasctucture from the World Bank and Government of Mozambique
- **Novel Data:** High frequency water monitoring shows that in some weeks more than half of farmers face water scarcity, some farmers experience scarcity in nearly every week
- **Diagnosis 1:** Scarcity exists despite sufficient water at the scheme level (purely an allocation problem)
- **Diagnosis 2:** Mis-allocations arise because of rigid allocations over crop cyle
- **Feedback Experiment:** Introduction of water use feedback is associated with halving of water scarcity, but experimental test of feedback tools shows that individualized feedback was no more effective than general feedback.

Contributions

- Demonstrates the feasibility of a high frequency monitoring system that relies on local involvement rather than sensors (Little, Hayashi, Liang; 2015)
- Supports findings from other contexts that farmers sometimes rely on sub-optimal rules of thumb. (Maddox et al, 2008; Islam, 2016)
- Builds on literature from energy conservation to test the idea that metered information on resource use can create pressure to conserve (Ferraro and Price, 2013; Alcott and Rogers, 2014)
- Finds that in this context (without pricing) inefficiencies exist, but generalized low-cost nudges are as effective as high cost metered feedback.

Context

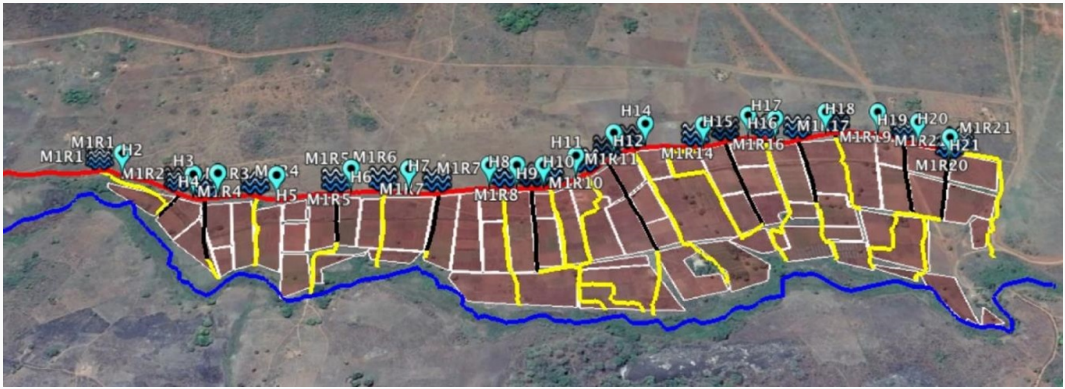
PROIRRI

- PROIRRI supported by the World Bank to equip modernized irrigation to 5,500 Ha
- Study Sample: 118 farmers in three outgrower schemes
- Major crops:
  - Maize (37%)
  - Baby-corn (27%)
  - Piri-piri (22%)
  - Cabbage (15%)
  - Collard greens (7%)
- Study Sample: 118 farmers in three schemes
  - Springs feeding water to canals or sprinklers
  - Average landholding in scheme = .6 Ha
  - Average landholding outside scheme = 3.8 Ha

Phase I: Lessons from water monitoring

Measurement

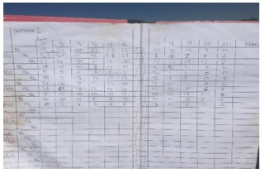
Each scheme is mapped and geo-tagged, allowing us to associated water discharged at measured points with plots



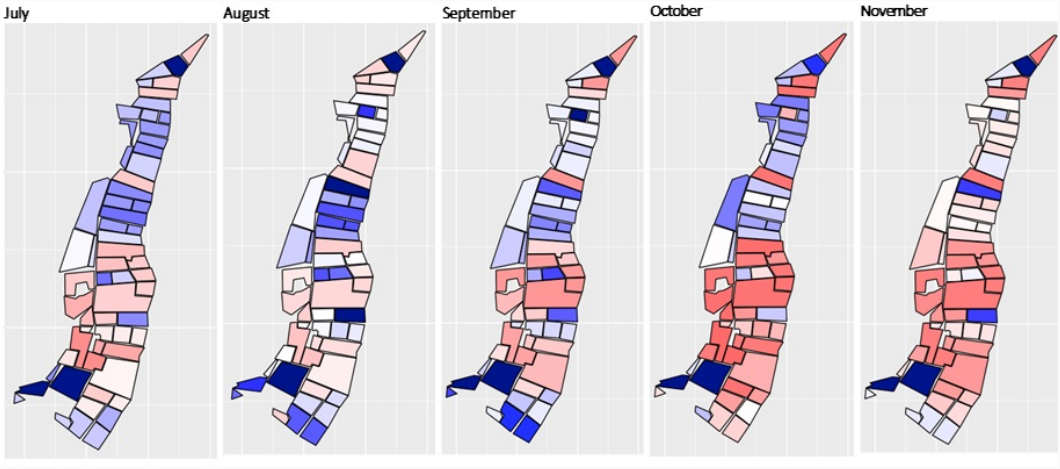
Community-based monitoring

- 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 and report to central level

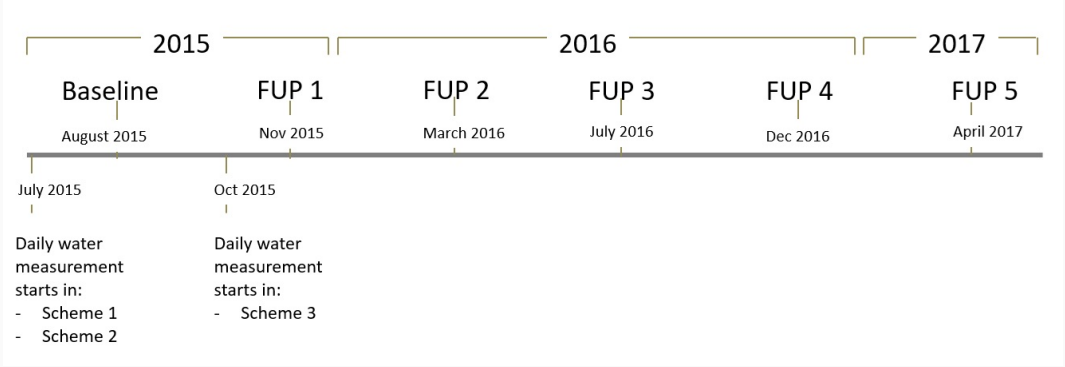


Measurement



Monitoring data allows us to assign water delivered to every plot for the period during the water monitoring.

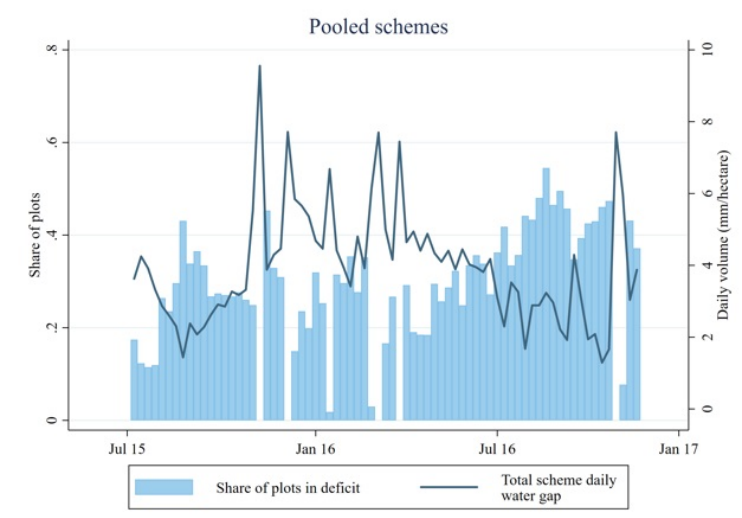
Household Surveys



Surveys allow us to know which crops are on very plot throughout the monitoring period. We can match these to watering recommendations to compare water allocations to how much water farmers would be advised to deliver to plots.

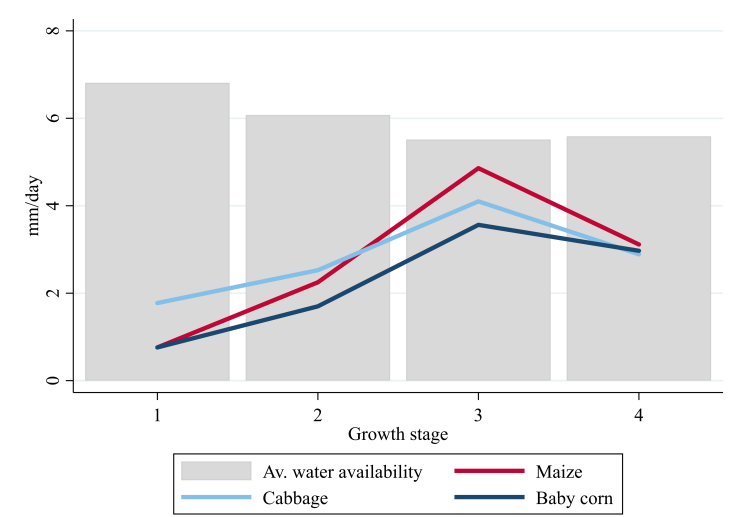
Finding 1: Water scarcity is common

- In most weeks, 20-50% of plots receive less water than the crops planted on those plots need in that growth stage
- BUT, in every week, scheme has enough water for needs of every plot



Finding 2: Scarcity arises from fixed allocation rules

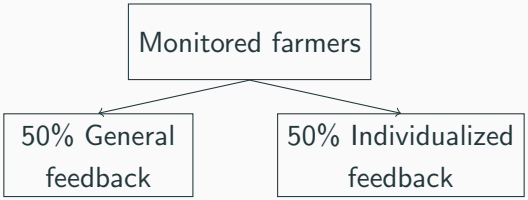
- Crop requirements vary a lot over crop lifecycle
- Water allocations do not



Phase II: Feedback experiment

Feedback experiment

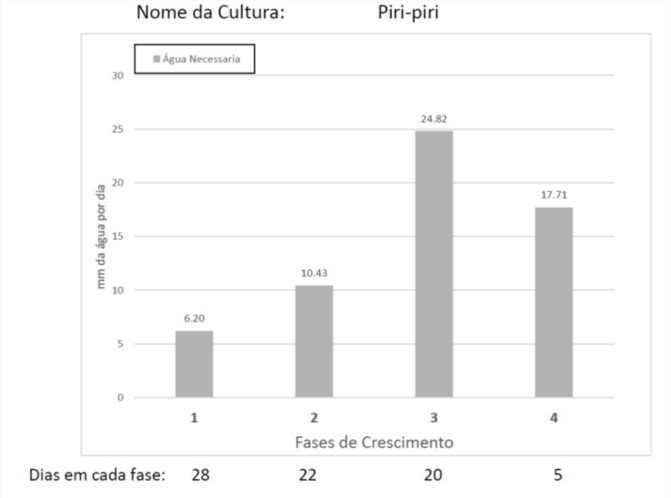
After one year of monitoring, all farmers got some type of reminder about watering over time:



- Matched pairs randomization
  - Pairs are created by matching on average depth of over-/under-watering

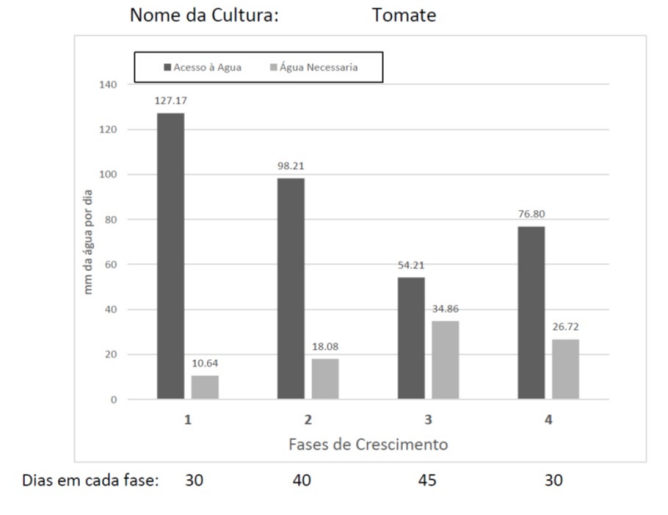
Generalized Feedback

- Visited by an extension agent
- Card shows water needs by stage for crops cultivated by farmer
- Same for all farmers with the same crops



Individualized Feedback

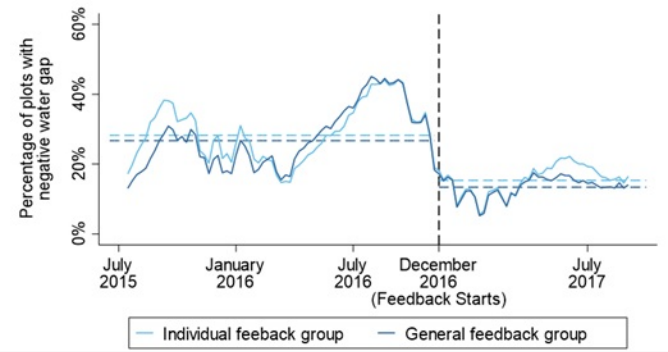
- Visited by an extension agent
- Includes Generalized feedback
- ALSO includes farmer's water allocation from same months in previous year.
- Much more expensive to deliver, because it requires monitoring every plot



Experimental results

Results from subsequent 1 year

- Share of plots facing scarcity after feedback about half what it was
- Experimental comparison shows individualized feedback was no more effective than generalized feedback



Fail to reject equality of feedback

	Dependent variable: water gap (mm/day)	
	(1)	(2)
Post-feedback	0.325***	0.353***
	(0.027)	(0.038)
Individual feedback		0.0623
		(0.067)
Individual feedback × Post-feedback		-0.0571
		(0.057)
Constant	0.153***	0.121***
	(0.033)	(0.038)
Observations	3720	3700
Adjusted R^2	0.206	0.206
Scheme fixed effects	Yes	Yes

Notes: Robust standard errors in parentheses, clustered at household level.

Lessons

Lesson 1: Monitoring can identify water use inefficiencies

- Demonstrates the potential for monitoring to uncover sources of inefficiency
- In this context, fixed allocation rules that do not vary delivery to different plots throughout the changing stages of crop water requirement lead to many farmers not having enough water
- Scale of inefficiency is large
  - In the first growth stage after planting, the average user is allocated 5.9 mm/day more than recommendation
  - Over all the area covered by the PROIRRI project, this adds up to over 3mil cu. m. of water per season (12.2% of all water used by industrial sources in Mozambique)
  - Assuming all irrigated area in the country is like the PROIRRI project, potential savings 9.4% of all water withdrawn in Mozambique

Lesson 2: Most expensive solutions might not be the most effective

- Individualized, metered feedback was no more effective than than generalized reminders
- Extension agents providing generalized information may be effective, as long as it is targeted to the right problem
- Need monitoring to inform extension (wouldn't have known to emphasize timing until we saw the mis-allocation pattern)
- But don't need to monitor everyone!
- "Sentinel sites" investing in measurement to monitoring practices and behaviors for a small number of farmer to inform targeted extension advice could be effective tools to eliminate water scarcity

Thanks!