See It Grow: A randomized evaluation of a digital innovation on demand for crop insurance and fertilizers in Kenya

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Motivation

- Climate change is increasing the incidence of extreme weather events.
  - Especially smallholder farmers' livelihoods are vulnerable to such events
  - Including droughts, floods, pests, diseases, etc.

- Shocks can reduce agricultural investments and use of inputs via 2 channels:
  - *After a shock:* Reduced savings, selling productive assets, and increased debt levels make it difficult to purchase modern inputs for the following season.

  - *Before a shock:* Anticipating a risk of losing their investments makes it (a) more difficult to obtain credit and (b) less attractive to invest for risk-averse farmers.
    - This will lower investments in profitable agricultural technologies / modern inputs, even after a season in which no shock occurred.

Challenges in providing agricultural insurance

Agricultural insurance to de-risk investments in agriculture?

- **Indemnity-based crop insurance**: asymmetric information (moral hazard, adverse selection) and high costs of verifying claims for a smallholder farmer
- **Index-based insurance:** addresses asymmetric information by settling claims based on an objectively verifiable index outside of a farmer's control
- Take-up of such insurance remains low, in part due to **basis risk:**
  - **Spatial**: risk exposure varies across space, especially in mountainous areas
  - **Temporal**: variation in planting dates, crop maturity, etc.
  - **Design**: models will never capture all risks or perfectly predict damage

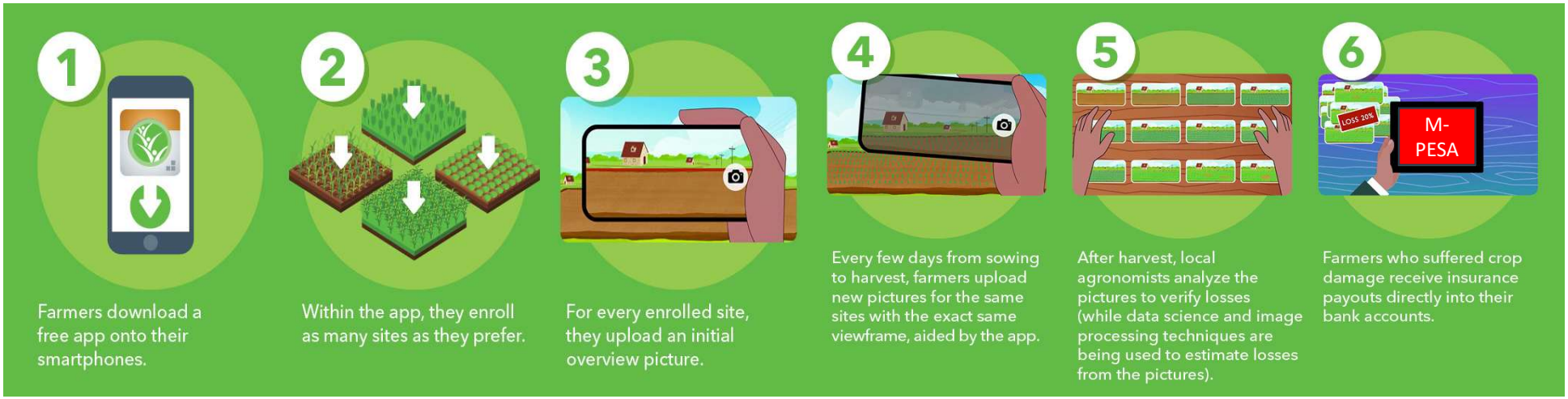
Digital innovations: Reduce both **asymmetric information** and **basis risk**

- Increase insurance take-up and strengthen impacts on fertilizer use?

Context & Methods

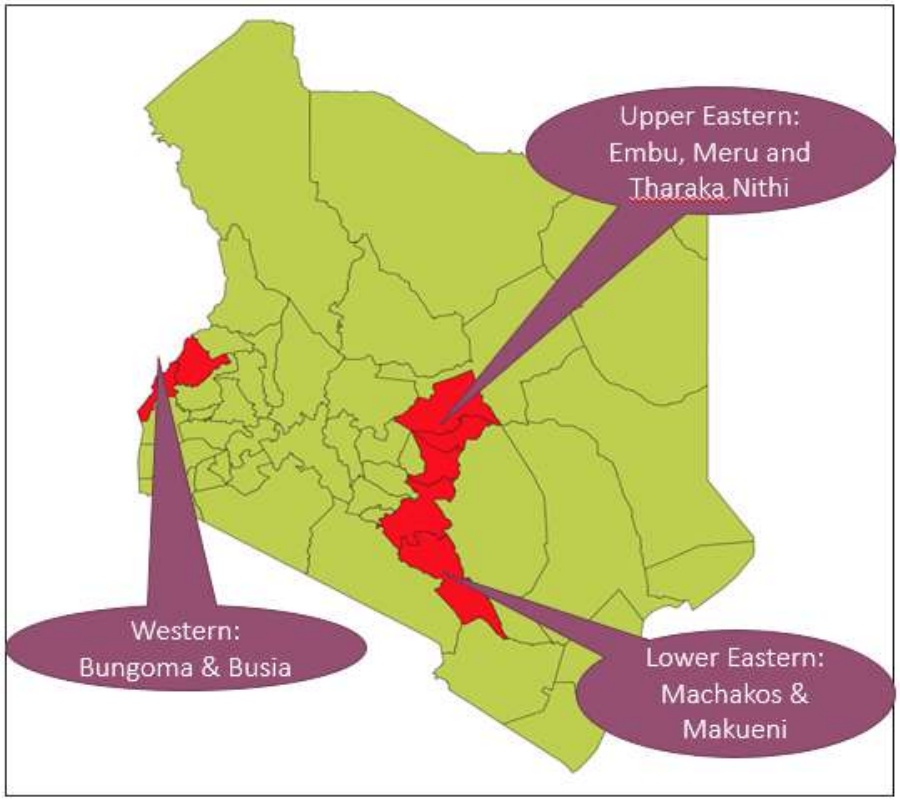
Digital Innovation: Picture-Based Insurance (PBI)

- Settles claims based on pictures of insured crops
  - Taken from sowing to harvest, of same portion of plot, to minimize tampering
  - Initially, agricultural experts inspect pictures to verify crop damage
  - Over time, development of deep learning to automate image processing
  - Formative evaluation in India demonstrated its feasibility (Ceballos et al., 2019)



Study Area: 7 counties from 3 regions in Kenya

- Insurance project led by ACRE Africa and implemented from 2019-2022
  - Especially arid and semi-arid lands (ASALs) suffered from a drought
  - Fertilizer use lowest in these ASALs
- Insurance product targeted maize, sorghum and green gram farmers
  - Offered through champion farmers
  - Sum insured equal to **cost of seeds**
  - Premium 10% of the sum insured
  - Payouts made via mobile money



Experimental Design

- ACRE Africa selected and trained 180 **champion farmers** (1 per village) across the 7 counties to send in pictures for about 20 project farmers per champion.
- We would expect **spillovers** within a village, but not across champions: hence, we randomly assigned champion farmers to one of the following 3 treatments:

Picture-Based Insurance (PBI) 40% of champions	Weather Index-Based Insurance (WBI) – 20%	Control group 40% of champions
Picture-based crop monitoring by champion farmer		
Free PBI policies for 3 seasons	Free WBI policies for 3 seasons	No free insurance trials

- After fertilizer application for the Long Rains 2022 (LR2022) season, survey with ~10 sampled project farmers per champion (based on power calculations)

Timeline

LR2020	SR2020	LR2021	SR2021	LR2022
Champions: Picture-based monitoring WBI & PBI champions: Free insurance	All: Picture-based crop monitoring WBI & PBI treatments: Free insurance	As in SR2020 End of season: insurance payouts from SR2020	As in SR2020 End of season: insurance payouts from LR2021	All: Picture-based crop monitoring Marketing of insurance products
Baseline registration (by champion farmers)		Midline survey (three phone survey rounds)		Endline survey (after fertilizer application)

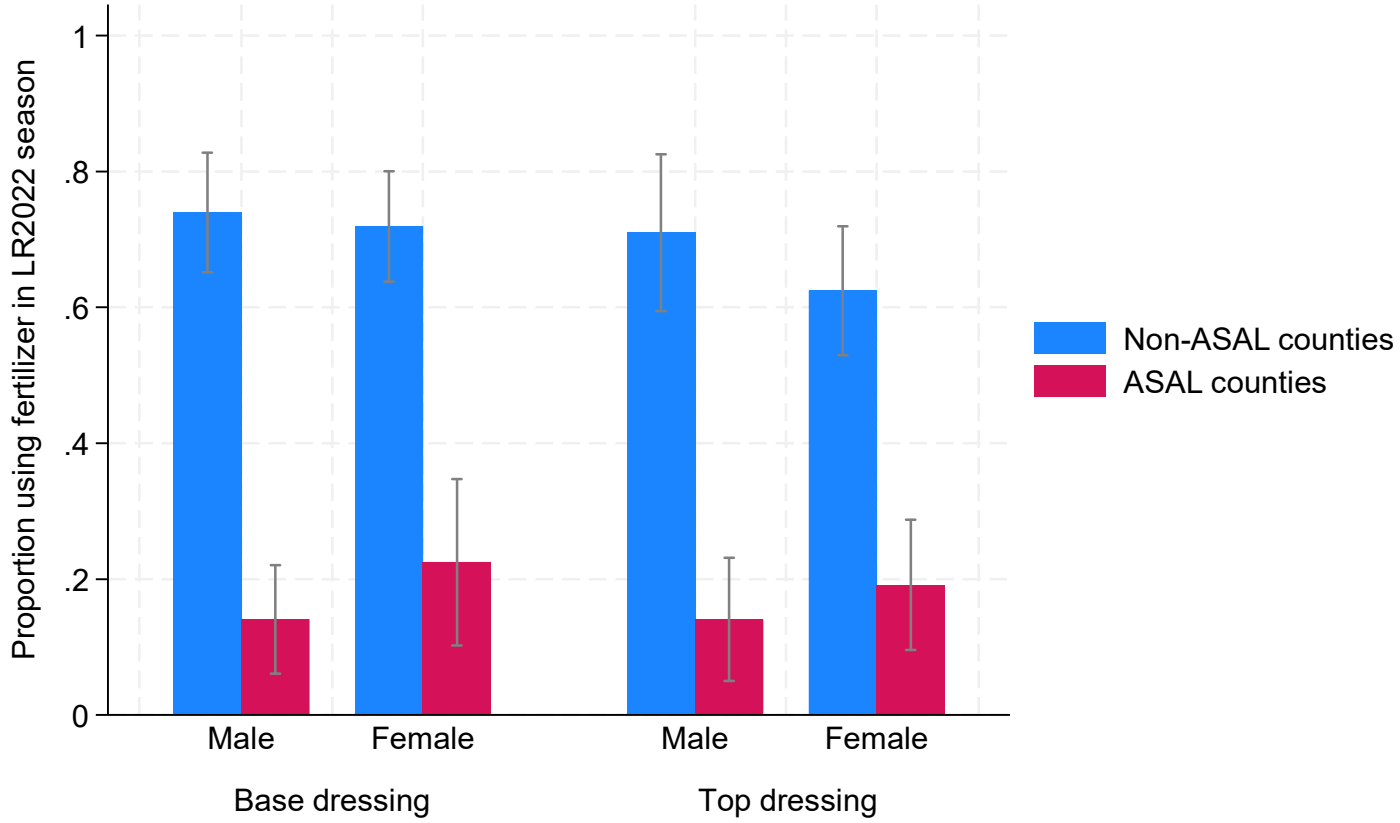
Internal Validity & Descriptive Statistics

Treatment balance at baseline

	(1) Control	(2) WBI	(3) PBI	(1)-(2)	(1)-(3)	(2)-(3)
				Mean difference		
ASAL county	0.375	0.345	0.316	0.030	0.059	0.029
Seed treatment	0.498	0.482	0.528	0.016	-0.029	-0.046
Female	0.600	0.593	0.646	0.007	-0.047*	-0.053
Has off-farm income	0.489	0.590	0.568	-0.100	-0.079	0.022
Owns a phone	0.956	0.967	0.966	-0.011	-0.009	0.002
Owns smartphone	0.336	0.265	0.316	0.070	0.019	-0.051
Trained on insurance	0.287	0.339	0.387	-0.052	-0.101	-0.049
Ever had insurance	0.162	0.147	0.176	0.015	-0.015	-0.030
Can read and write	0.750	0.691	0.743	0.060	0.007	-0.053
Age: Below 35 years	0.231	0.257	0.224	-0.026	0.007	0.033
Age: 35-55 years old	0.543	0.507	0.528	0.036	0.014	-0.022
Age: Above 55 years	0.226	0.236	0.248	-0.010	-0.022	-0.012
Education: None	0.078	0.116	0.101	-0.037	-0.023	0.014
Education: Primary	0.462	0.430	0.473	0.032	-0.011	-0.043
Education: Secondary	0.374	0.373	0.332	0.001	0.041	0.041
Education: Post-secondary	0.086	0.081	0.093	0.005	-0.007	-0.012
Marital status: Single	0.119	0.117	0.117	0.001	0.002	0.000
Marital status: Married	0.817	0.803	0.799	0.014	0.019	0.004
Marital status: Divorced	0.064	0.080	0.084	-0.016	-0.020	-0.005
Land: Has 1 acre or less	0.363	0.396	0.404	-0.033	-0.041	-0.008
Land: Has 1 to 2.5 acres	0.245	0.233	0.255	0.012	-0.010	-0.022
Land: Has 2.5 to 5 acres	0.201	0.197	0.192	0.004	0.009	0.005
Land: More than 5 acres	0.050	0.054	0.038	-0.004	0.012	0.016
Dietary diversity score	2.449	2.785	2.790	-0.336	-0.342	-0.005
Number of observations	1609	614	1340	2223	2949	1954

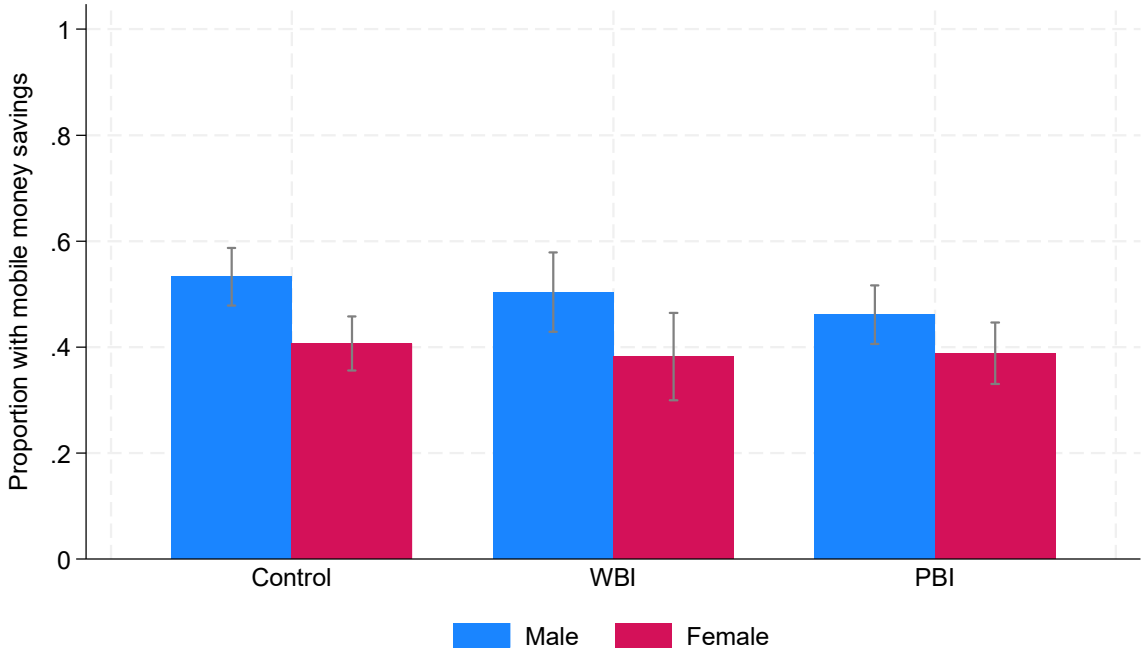
Notes. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.01$. Errors are clustered at the champion farmer level.

Use of fertilizer: Very low in ASAL counties



Notes: Based on endline survey data for project farmers in control group, excl. champions. N = 791.

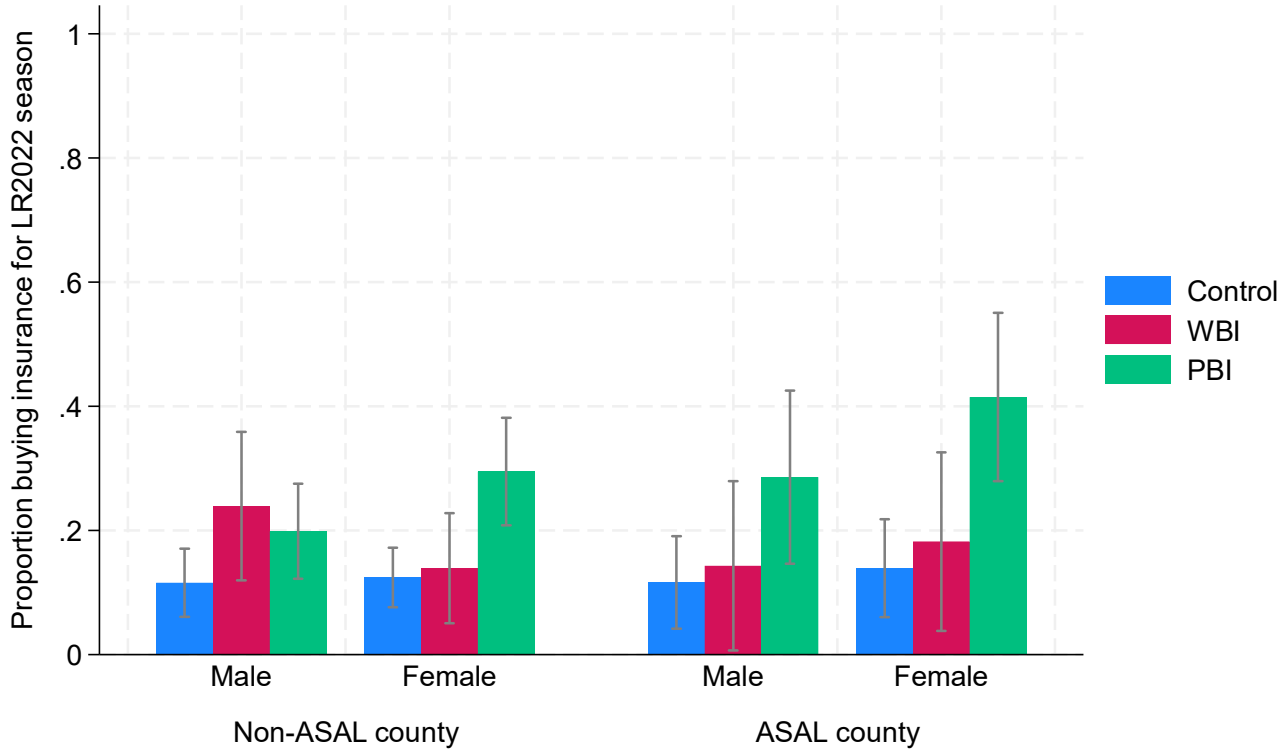
Financial inclusion: Lower at midline for women than for men



Could depress demand for insurance among women (Kramer, Malacarne and Waweru, “Control over future payouts and willingness-to-pay for insurance”, 2023)

Results

PBI increases insurance take-up especially among female farmers and in ASAL counties



Notes: Based on endline survey data for project farmers, excl. champions. N = 1,820.

Estimated effect sizes in a regression framework

$$Y_{ic} = \alpha + Ins_c\beta_1 + PBI_c\beta_2 + X_{ic}\gamma + \varepsilon_{ic}$$

Y_{ic}: Insurance take-up or fertilizer use

$\hat{\beta}_1$: Total effect WBI

$\hat{\beta}_1 + \hat{\beta}_2$: Total effect PBI

X_{ic}: Controls (county, crop, gender, seed treatment)

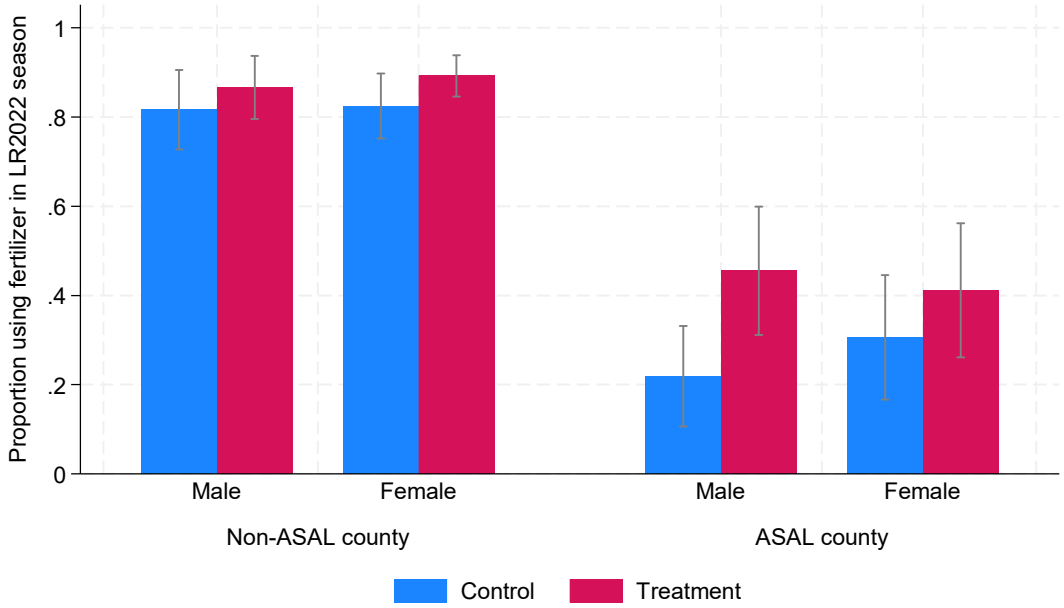
ε_{ic}: Clustered at the champion level.

	Buys insurance in LR2022 (LPM)
Total effect WBI	0.064
	(0.040)
Total effect PBI	0.183***
	(0.037)
N	1,820
Mean control group	0.125

Effect of PBI on uptake: Improved perceptions

	Agrees (strongly) with statement that insurance product offered…							
	Is easy to understand	Is easily available	Is cheap	Pays out in time	Pays in case of losses	Trust-worthy insurer	Is of high quality	Trust-worthy champion
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Offered insurance	0.057	0.031	-0.014	0.051	0.036	0.039	0.050	-0.018
(β_1)	(0.048)	(0.050)	(0.052)	(0.043)	(0.051)	(0.049)	(0.048)	(0.043)
Offered PBI (β_2)	0.078*	0.139***	0.122**	0.055	0.090*	0.114**	0.114**	0.098**
(extra effect of PBI)	(0.047)	(0.050)	(0.053)	(0.044)	(0.052)	(0.049)	(0.049)	(0.043)
N	1804	1804	1804	1804	1804	1804	1804	1804
Mean dep. variable	0.636	0.587	0.614	0.422	0.62	0.626	0.621	0.790
p-value $\beta_1 + \beta_2$	0.001	0.000	0.009	0.011	0.003	0.000	0.000	0.018

Insurance increases men's fertilizer use in ASAL counties



Notes: Based on endline survey data for project farmers, excl. champions. N = 1,785.

- Intent-to-treat: Increase among men in ASAL counties of 17% points

Treatment effects on fertilizer use

Ideally estimate Average Treatment Effect on the Treated (ATET), but insurance coverage is endogenous – including only insured farmers would introduce a **selection bias**.

- Farmers offered WBI or PBI at randomly assigned **high subsidy** more likely to buy insurance than those offered **low subsidy**: Use this to correct for selection bias in a **Heckman selection model**.

	Sample: Insured farmers (Heckman selection model)				
	All	***Male***	***Female***	***Non-ASAL***	***ASAL***
Total effect WBI	0.228***	0.282**	0.191*	0.130	0.431**
	(0.085)	(0.112)	(0.099)	(0.082)	(0.169)
Total effect PBI	0.121	0.105	0.131	0.063	0.227*
	(0.097)	(0.099)	(0.110)	(0.079)	(0.133)
N	1,803 (357/1,446)	1,803 (357/1,446)		1,803 (357/1,446)	
Mean control	0.673	0.673		0.673	

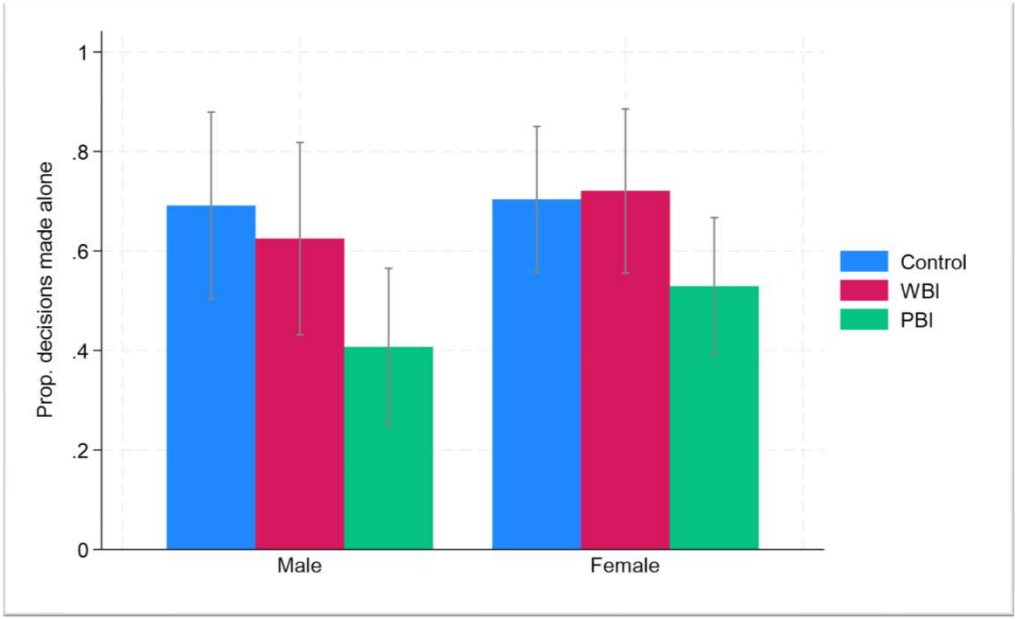
Baseline characteristics of insured farmers by treatment arm

Compared to farmers who enroll in the control group or the WBI treatment arm, farmers who enroll in PBI are on average:

- More likely to be female
- Less likely to have secondary education*
- More likely to be divorced/separated*
- Less likely to decide by themselves*

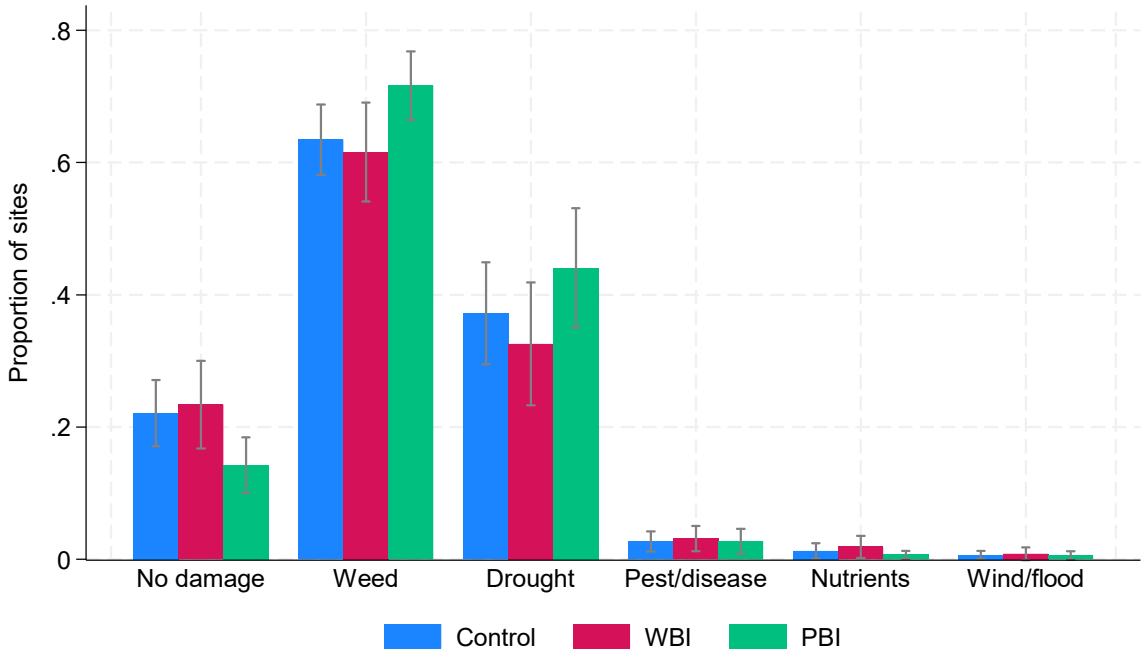
* Associated with lower fertilizer use.

Baseline empowerment of insured project farmers



Moral Hazard: Perhaps PBI makes farmers invest less in fertilizer?

Experts inspected all 10,455 images (from 2,472 plots) during prior Long Rains 2021 season (when WBI and PBI farmers had free insurance trials) for **visible crop damage** and its cause.



Champions sent in similar numbers of pictures across treatment arms.

Very little evidence of nutrient deficiencies across treatment arms.

PBI: More likely to have pictures with damaged crops (weed, drought)

- PBI farmers may have taken more risk than those with WBI or uninsured, thinking damage was covered.

Conclusion

- PBI improves uptake of insurance especially among women, because of improved perceptions of insurance product quality.
  - Highlights a way to make insurance more inclusive, despite using smartphone technology.
  - PBI not more expensive from underwriting perspective than WBI – main cost: image collection.
- Providing and purchasing insurance increases fertilizer use, especially in ASAL counties
  - Sum insured equal to estimated cost of seeds only – fertilizer purchases not even insured.
  - Insurance and fertilizer may be competing expenses for liquidity-constrained farmers.
  - Impacts most pronounced among male farmers – introducing, unintendedly, a gender gap
- Stronger effects on fertilizer use in the WBI treatment arm, despite higher PBI uptake.
  - PBI may not increase fertilizer use as much as WBI due to moral hazard concerns in PBI.
  - Compared to insured respondents in the WBI and control, those enrolling in PBI (women and men) have less decision-making power at baseline – and that, in turn, predicts fertilizer use at endline.

Thank You!

Baseline characteristics of insured farmers by treatment arm

	(1)	(2)	(3)	(1)-(2)	(1)-(3)	(2)-(3)
	Control	WBI	PBI	Mean difference		
ASAL county	0.450	0.303	0.383	0.147	0.067	-0.080
Female	0.650	0.545	0.755	0.105	-0.105	-0.210**
Owns a phone	0.920	0.924	0.989	-0.004	-0.069*	-0.065*
Age: Below 35 years	0.150	0.167	0.186	-0.017	-0.036	-0.020
Age: 35-55 years old	0.570	0.530	0.585	0.040	-0.015	-0.055
Age: Above 55 years	0.280	0.303	0.229	-0.023	0.051	0.074
Education: None	0.020	0.045	0.074	-0.025	-0.054**	-0.029
Education: Primary	0.414	0.439	0.527	-0.025	-0.112	-0.087
Education: Secondary	**0.485**	**0.470**	**0.319**	0.015	0.166**	0.151
Education: Post-secondary	0.081	0.045	0.080	0.035	0.001	-0.034
Marital status: Single	0.030	0.015	0.059	0.015	-0.028	-0.043*
Marital status: Married	0.939	0.924	0.856	0.015	0.083**	0.068
Marital status: Divorced	**0.030**	**0.061**	**0.085**	**-0.030**	**-0.055***	**-0.025**
Land: Has 1 acre or less	0.430	0.409	0.340	0.021	0.090	0.069
Land: Has 1 to 2.5 acres	0.210	0.303	0.287	-0.093	-0.077	0.016
Land: Has 2.5 to 5 acres	0.250	0.136	0.239	0.114	0.011	-0.103
Land: More than 5 acres	0.070	0.015	0.053	0.055	0.017	-0.038
Decides alone on seeds	0.717	0.712	0.511	0.005	0.207**	0.201*
Decides alone on finance	0.707	0.636	0.484	0.071	0.223**	0.152
Decides alone on selling	0.707	0.682	0.511	0.025	0.196**	0.171
Decides alone on income	0.667	0.667	0.500	0.000	0.167*	0.167
Number of observations	99	66	188	165	287	254

Notes. *** p<0.01, ** p<0.05, * p<0.01. Errors are clustered at the champion farmer level.