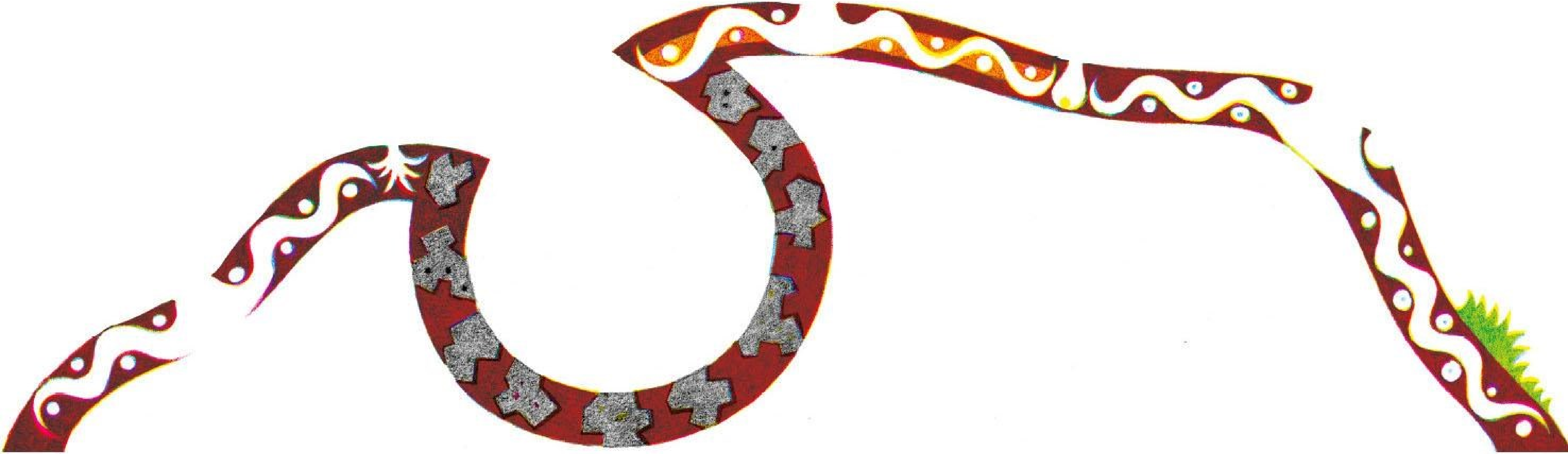
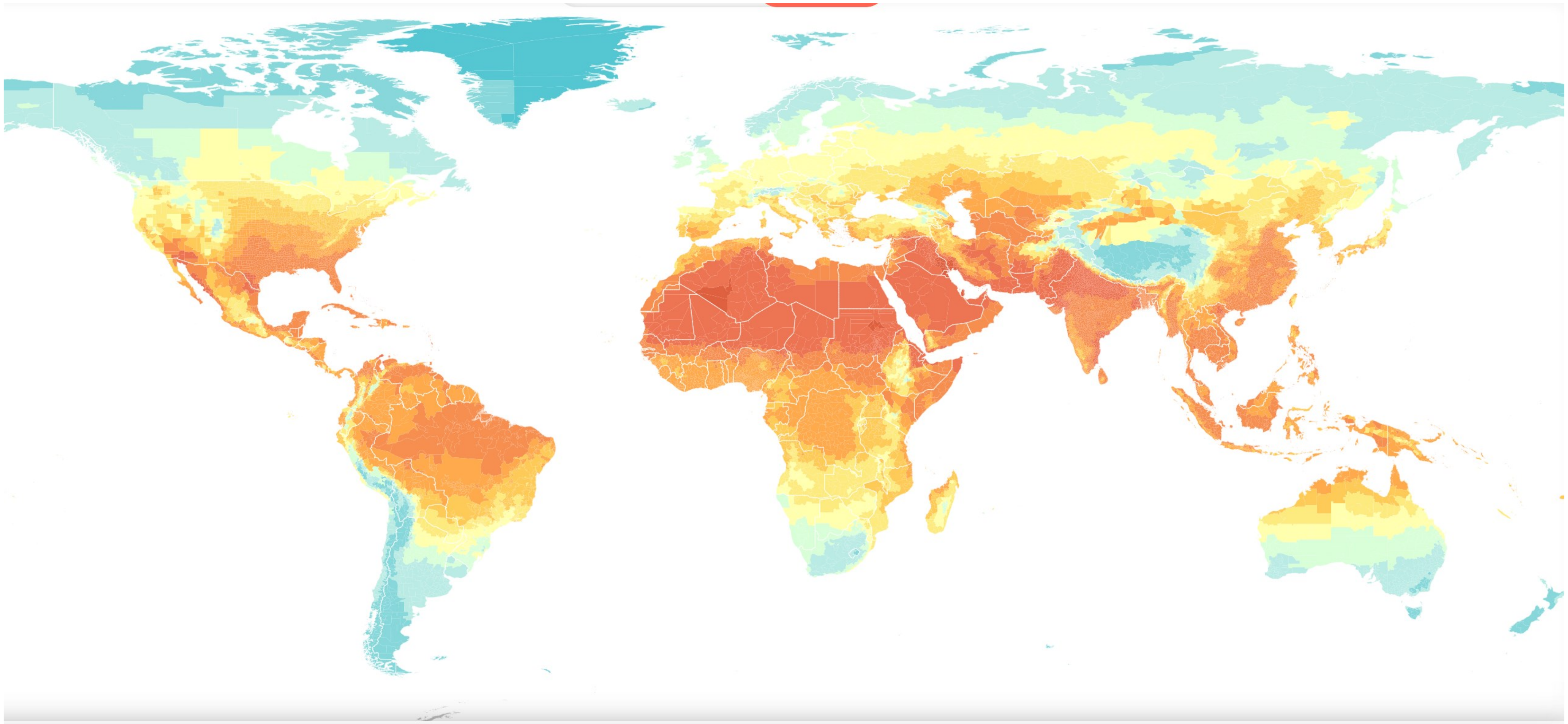
Adaptation to Climate change

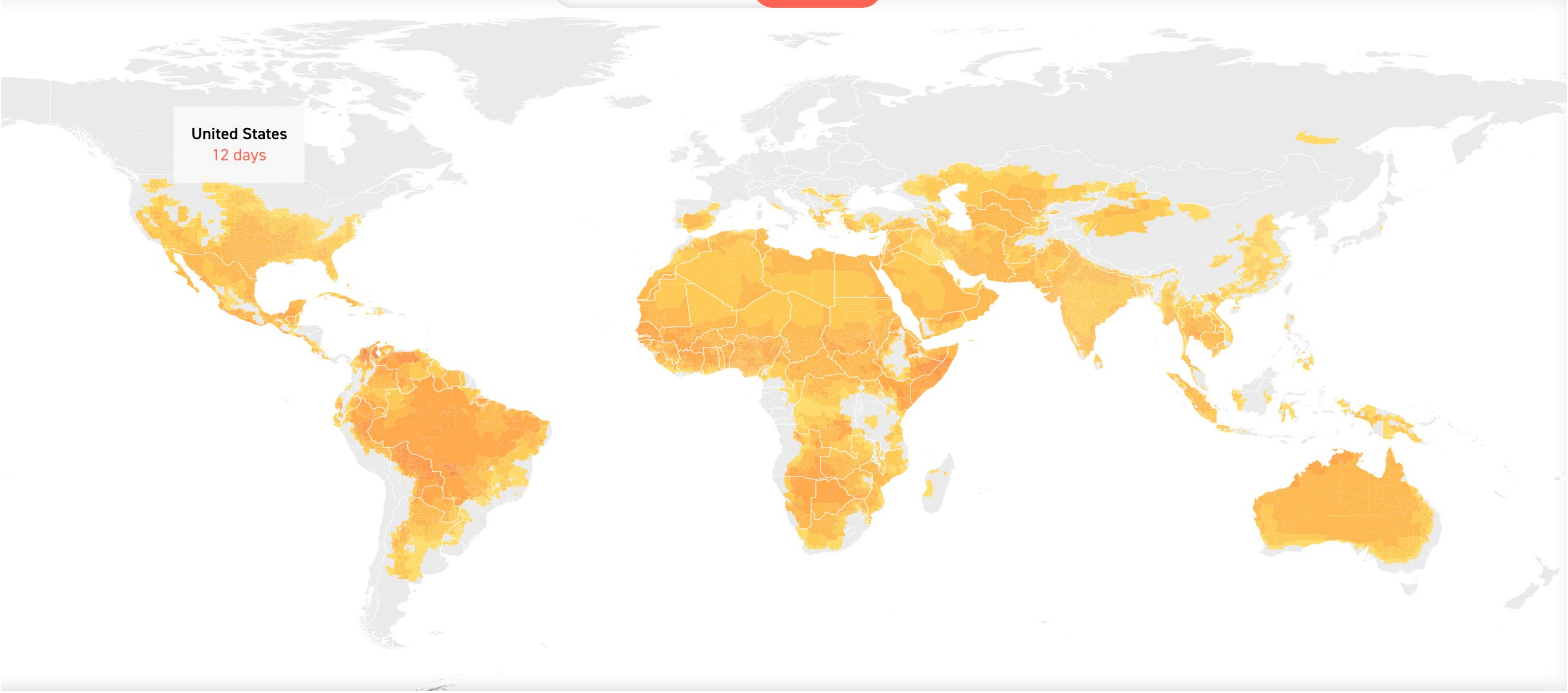
BREAD-IGC September 2023

Esther Duflo

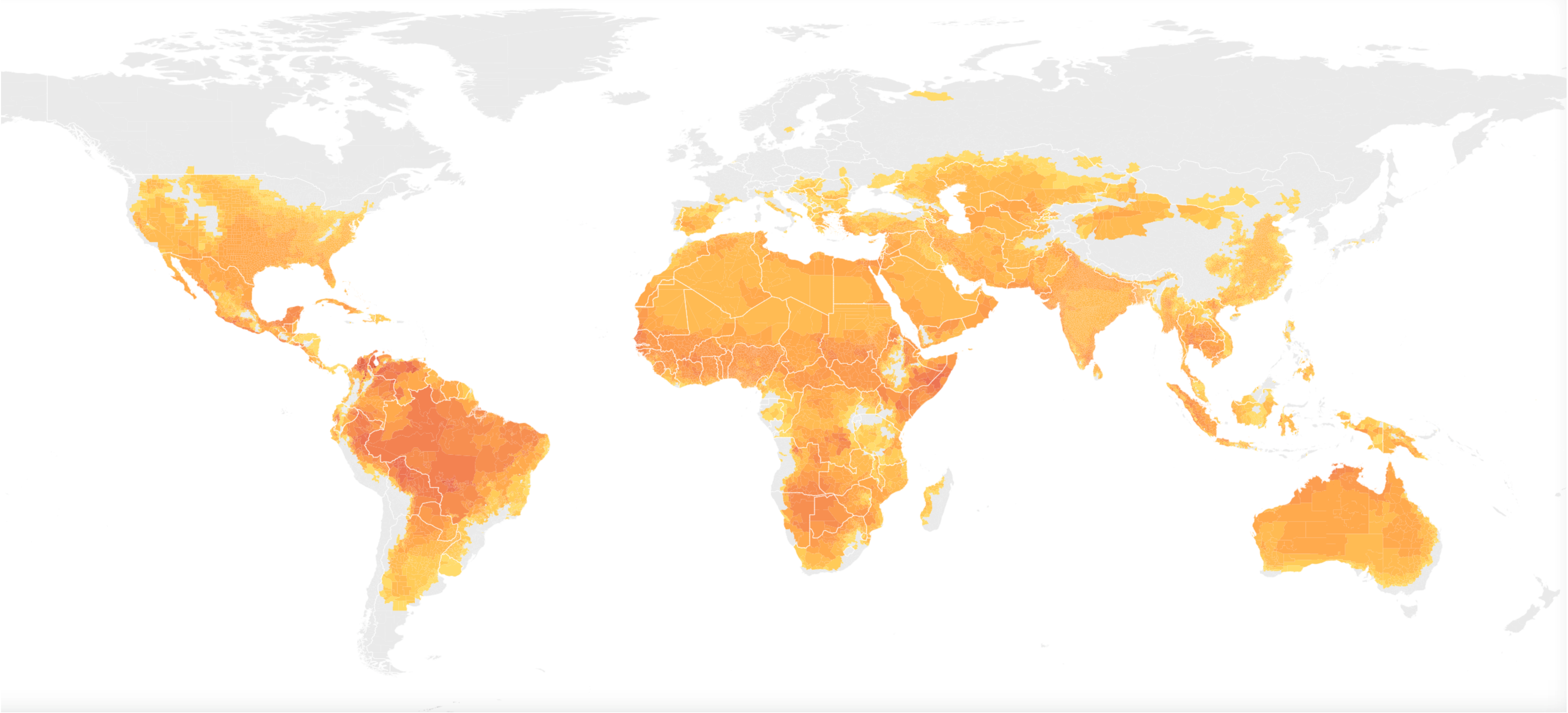




LMIC are in countries where it si already hot



So they will experience more hot days in the next 20 years



And still more by 2100

Human Health /Mortality

Increased Risks linked to disasters

Less social safety nets (private and public)

Large coastlines: Flooding

Agricultural/industrial Productivity : Greater impact on GDP

Poorer income and less access to protective technologies

Cost of climate change that are likely to be higher in poor countries

- No great counterfactual for climate change
- Similar empirical challenges in high and low income settings
  - Integrated assessment models (Weyant 2017)
  - Short run fixed effects estimates (e.g., Deschenes et al. 2007, Carleton et al. 2022)
  - Long differences (e.g., Burke and Emerick 2016)
  - Longer differences (Waldinger 2022)

Measuring climate impacts

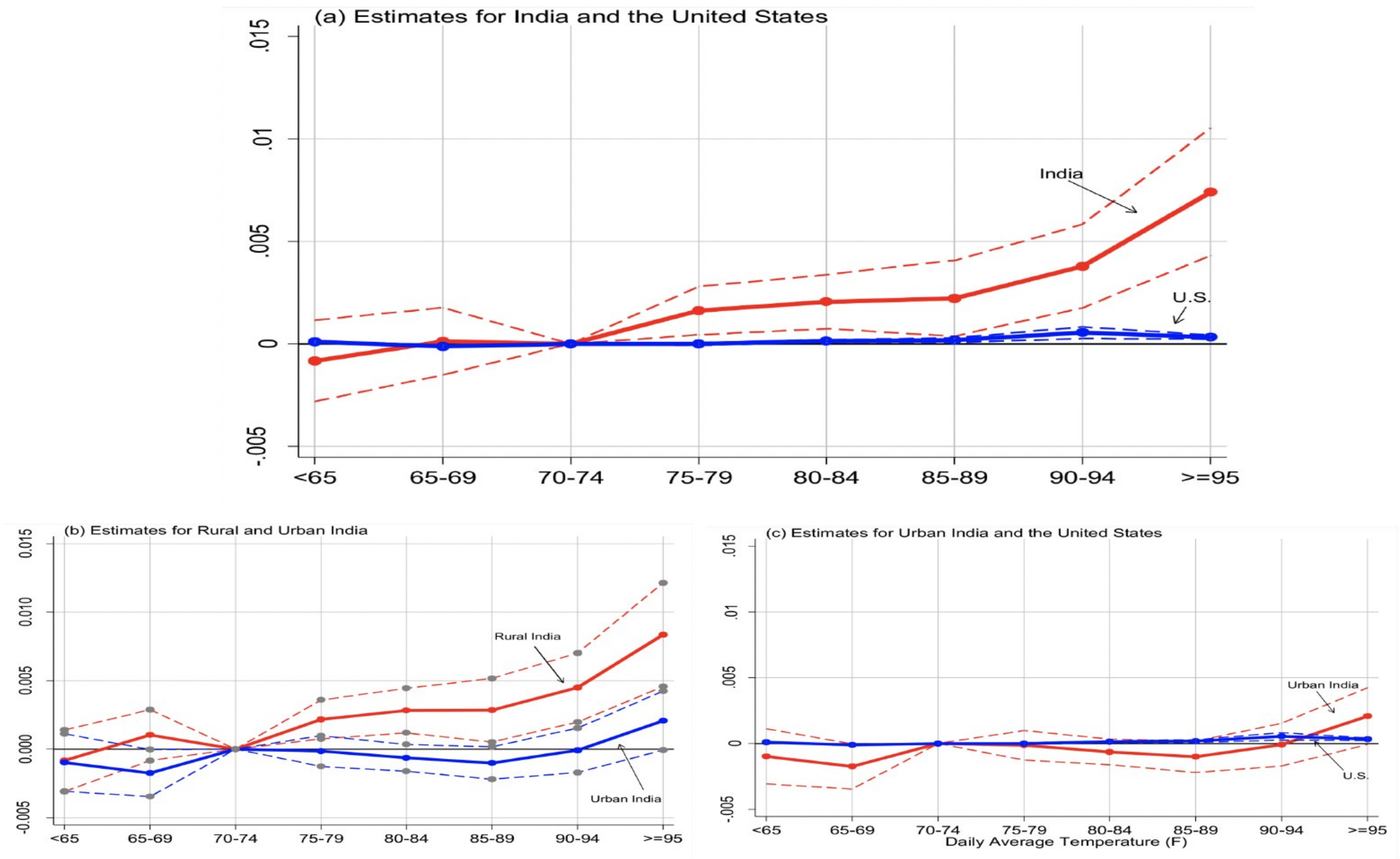
Two way fixed effects

Y can be: productivity, test scores, mortality, etc.

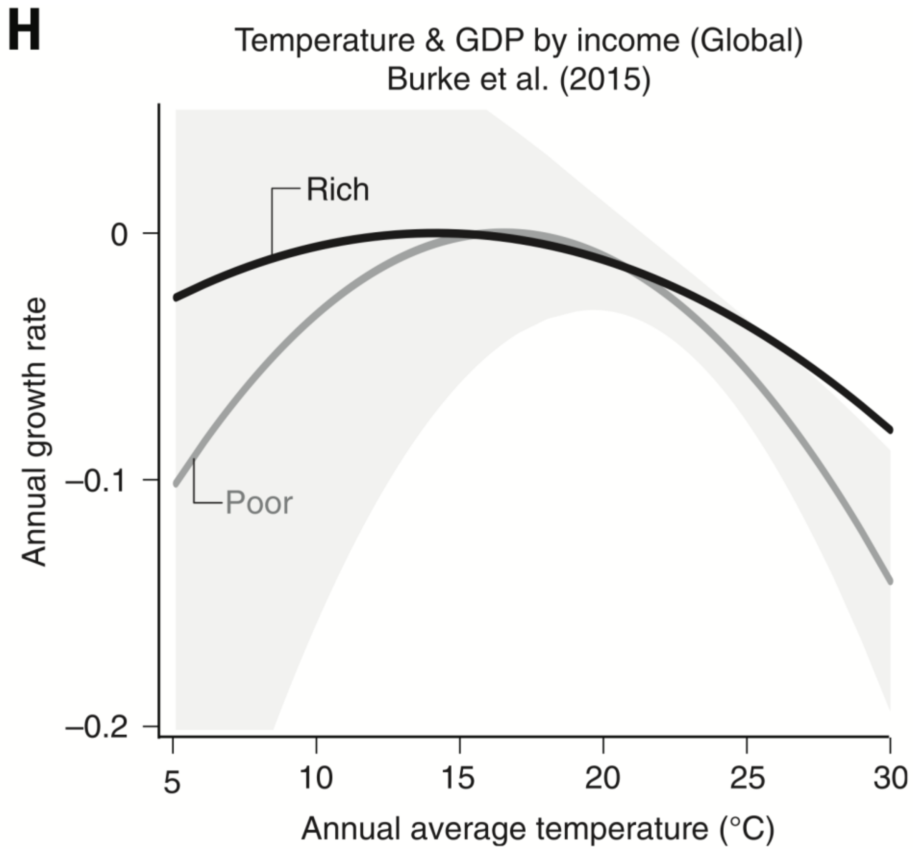
$$Y_{it} = \sum_{j=1}^{8} \theta_j TMEAN_{itj} + \sum_{k} \delta_k \mathbf{1}\{RAIN_{it} = k\} + \alpha_i + \gamma_t + \lambda_r^1 t + \lambda_r^2 t^2 + \epsilon_{it}$$

The workhorse short-term impacts model (Pioneered by Greestone)

Impact of weather on mortality in India (Burgess, Donaldson and Greenstone)



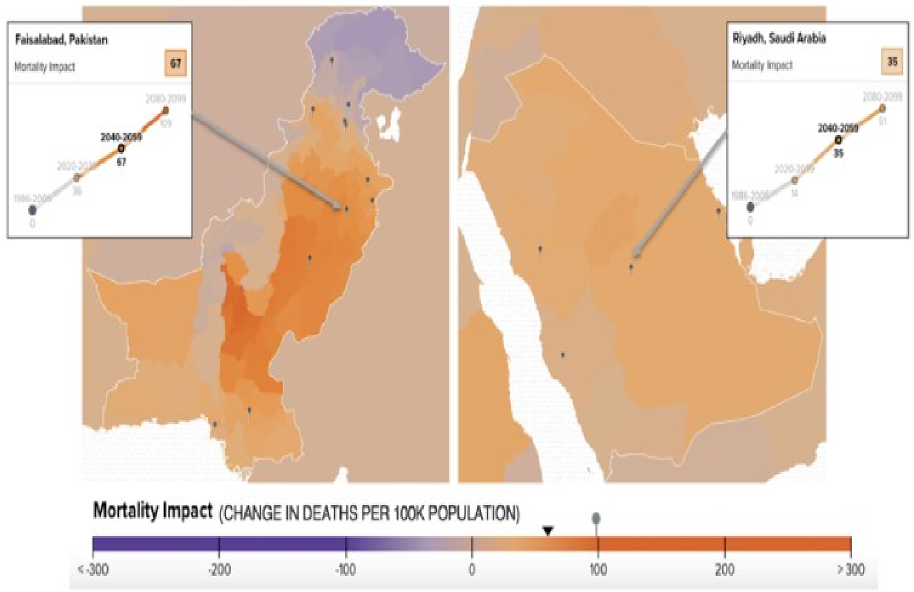
The short run impact of weather on mortality is heterogenous



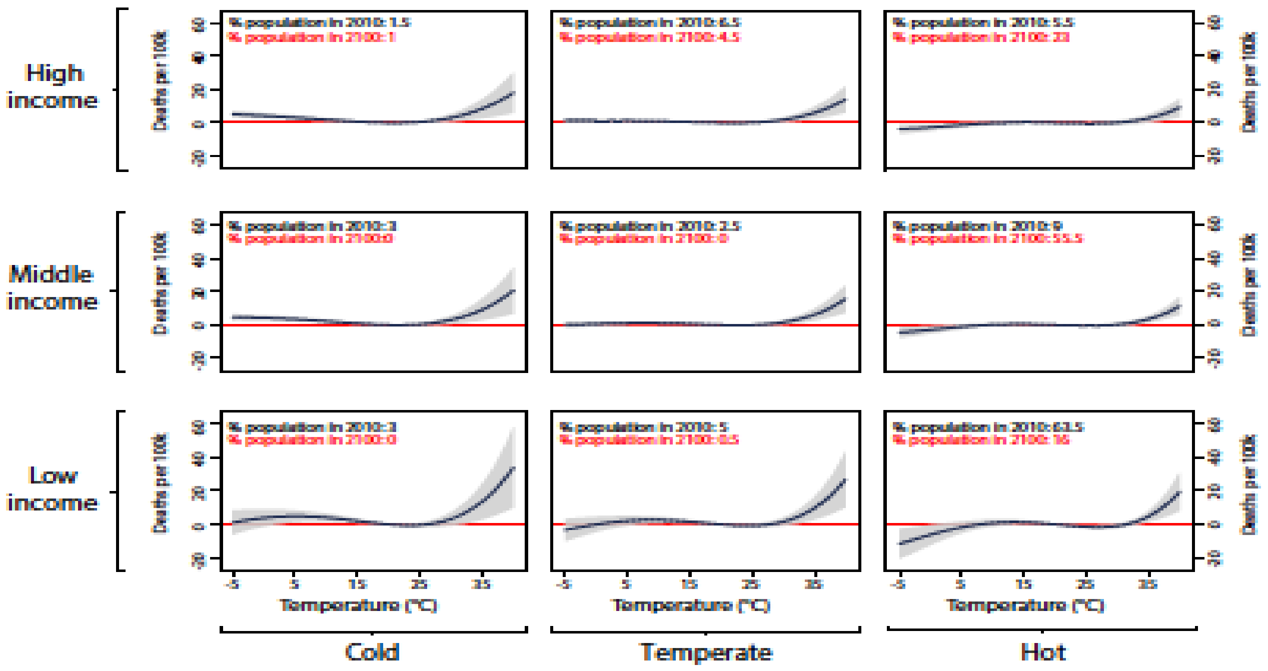
Source: Burke et al. (2015) “Global non-linear effect of temperature on economic production,” Nature

Similarly for GDP

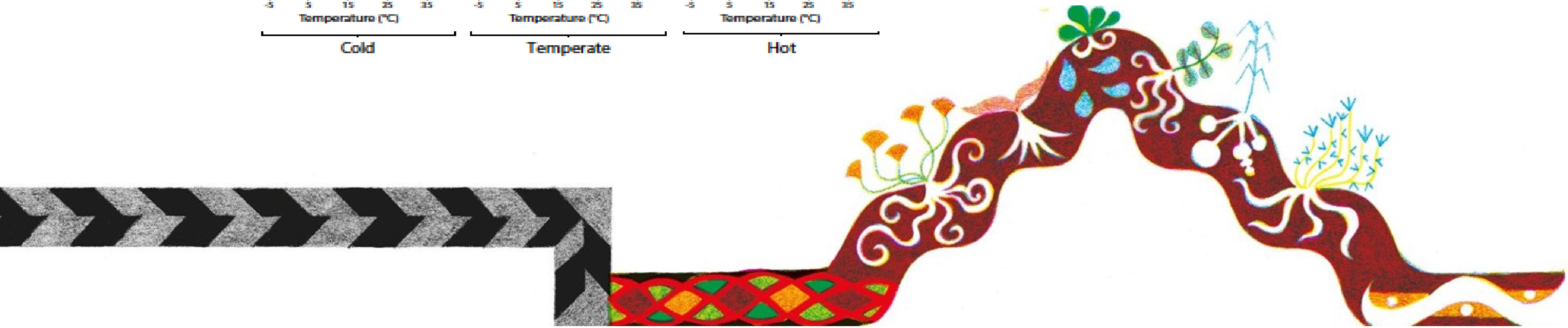
Projected Mortality Impacts to Pakistan and Saudi Arabia by Midcentury (2040-2059), Under Moderate Emissions Scenario (RCP 4.5), Mean Outcome



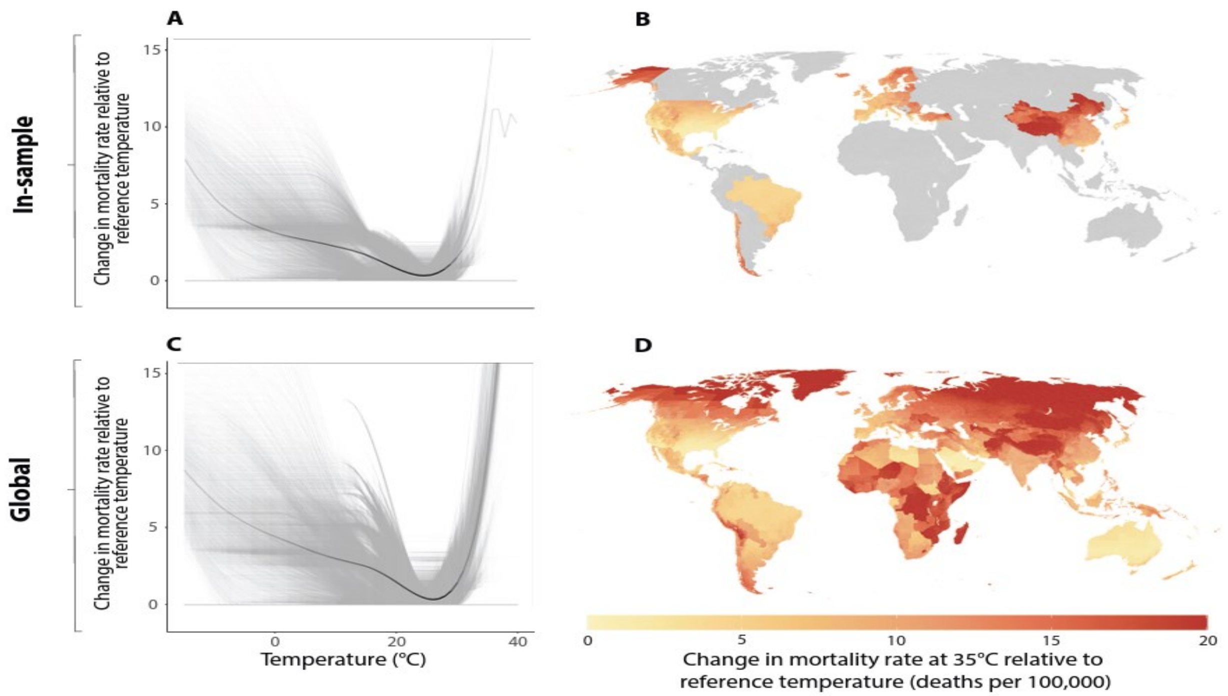
- Adaptation Costs money:
  - Air conditioning
  - Working outside vs inside
  - Importing food
  - Etc.



Estimation of effect of a hot day from two ways FE in 25,000 micro-regions



Carleton et al (2022). Mortality damage of hot days around the world



Cost of a hot day, in different regions of the world

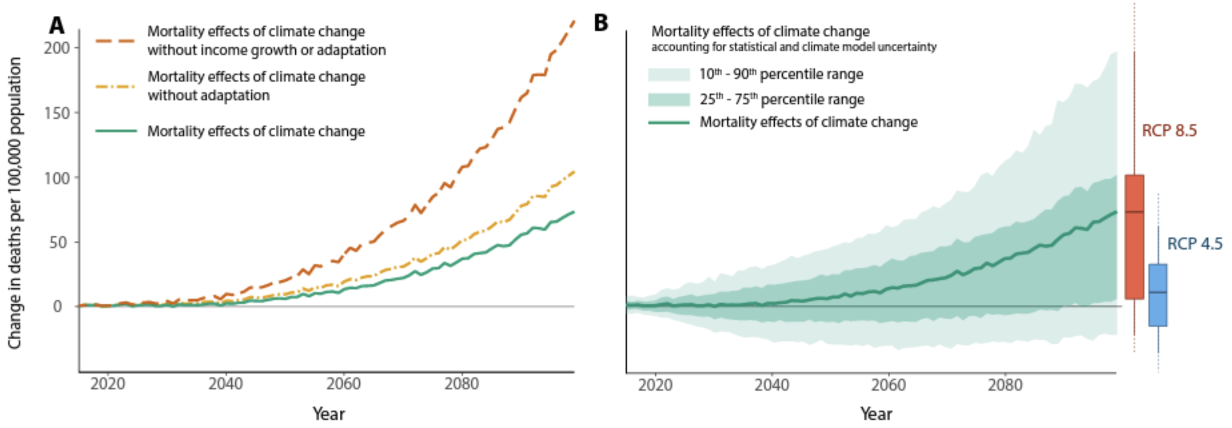
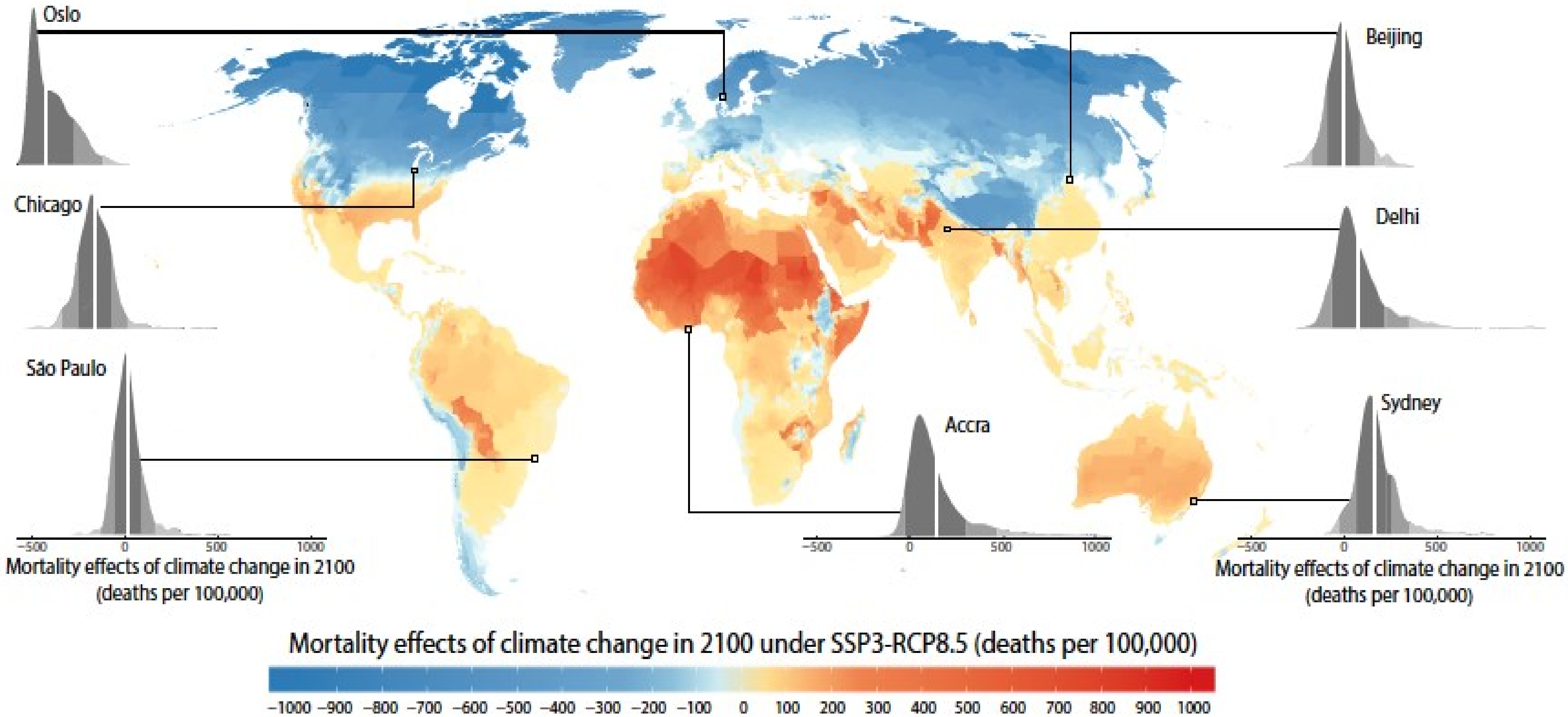
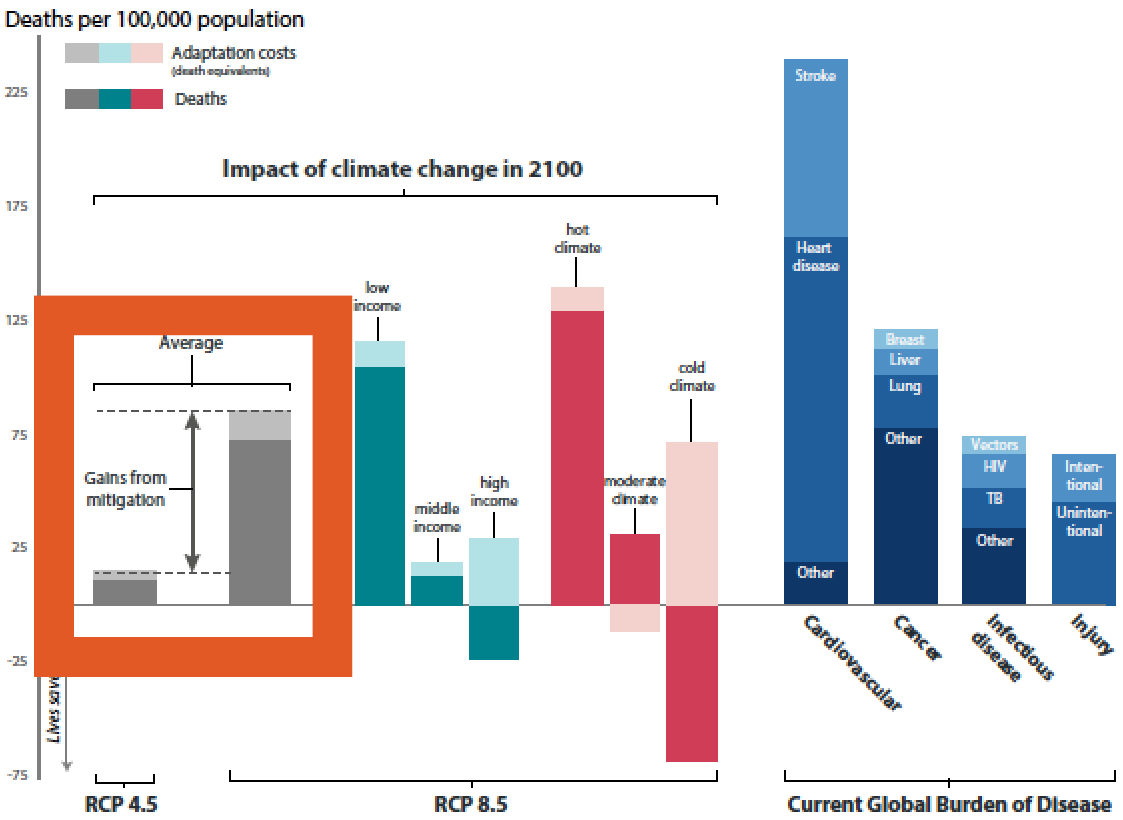


Figure 5: Time series of projected mortality effects of climate change. All lines show projected mortality effects of climate change across all age categories and are represented by a mean estimate across a set of Monte Carlo simulations accounting for both climate model and statistical uncertainty. In panel A, each line represents one of three measures of the mortality effects of climate change. Dashed (Equation 2a'): mortality effects of climate change without income growth or adaptation. Dashed-dotted: (Equation 2b'): mortality effects of climate change without adaptation. Solid (Equation 2'): mortality effects of climate change. Panel B shows the 10^{th}-90^{th} percentile range of the Monte Carlo simulations for the mortality effects of climate change (equivalent to the solid line in panel A), as well as the mean and interquartile range. The boxplots show the distribution of mortality effects of climate change in 2100 under both RCPs. All line estimates shown refer to the RCP8.5 emissions scenario and all line and boxplot estimates refer to the SSP3 socioeconomic scenario. Appendix Figure F.7 shows the equivalent for SSP3 and RCP4.5.

Adaptation plays a key role



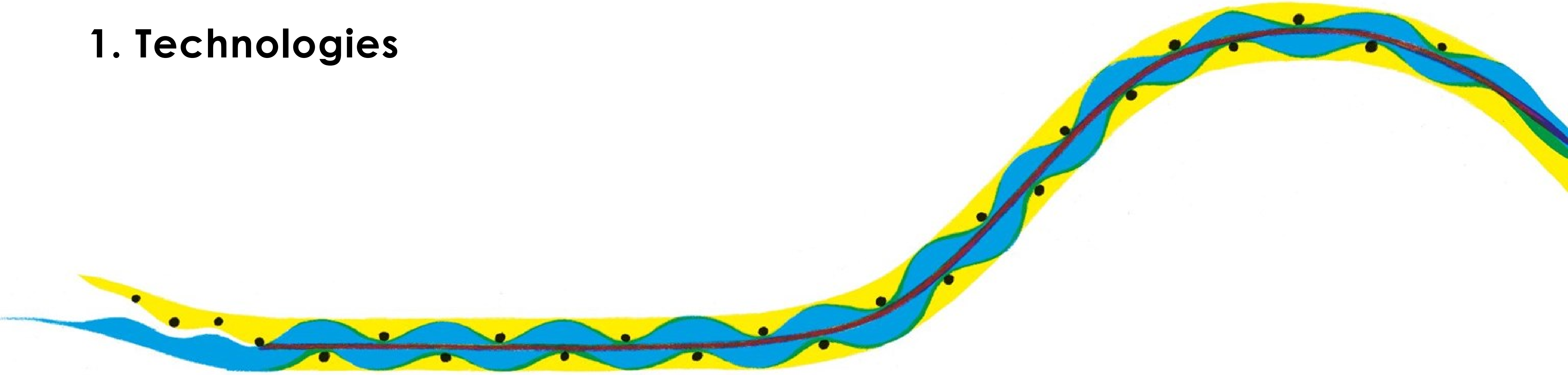
Coûts en termes de mortalité, 2100

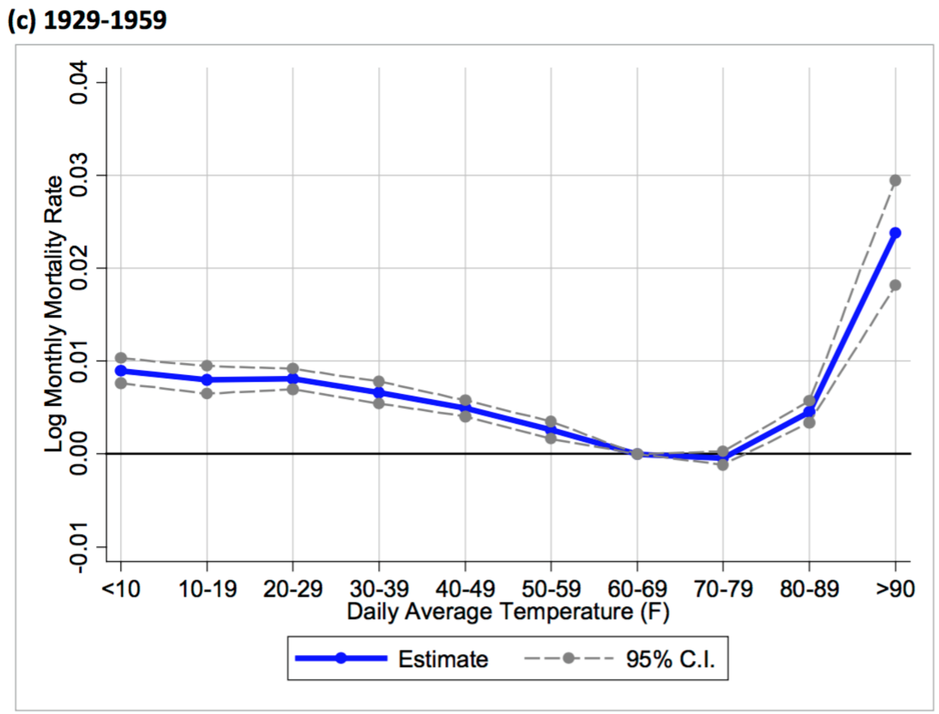


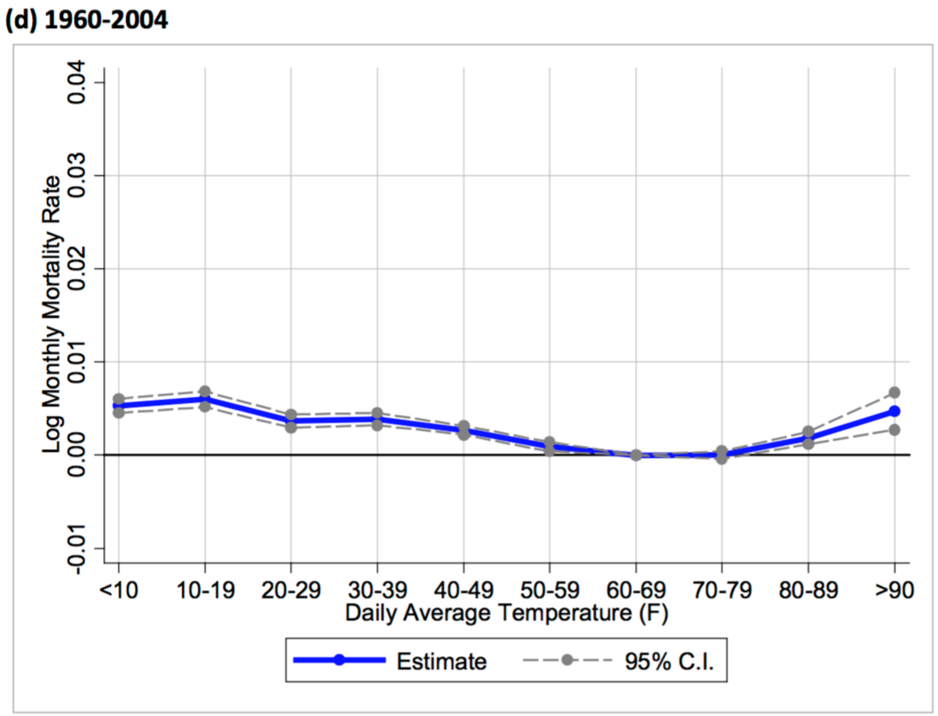
Deaths and adaptation costs (Carleton et al.)

So how do we adapt?

1. Technologies







Source: Barreca et al. (2016) "Adapting to Climate Change," Journal of Political Economy

Technology: Air Conditioning
Bareca et al (2016)

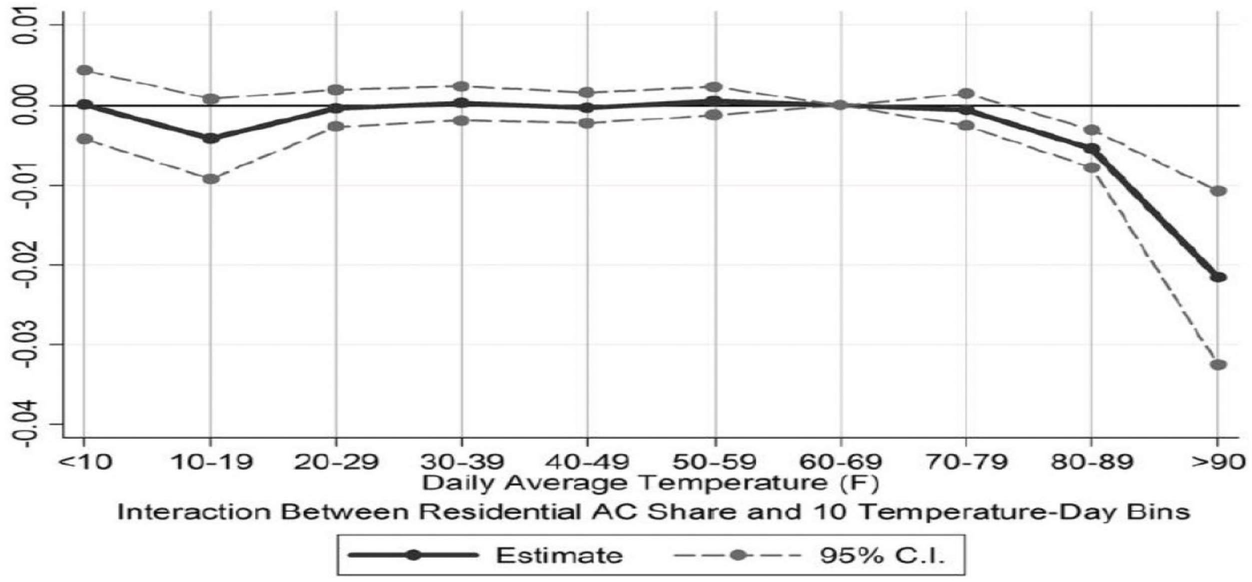
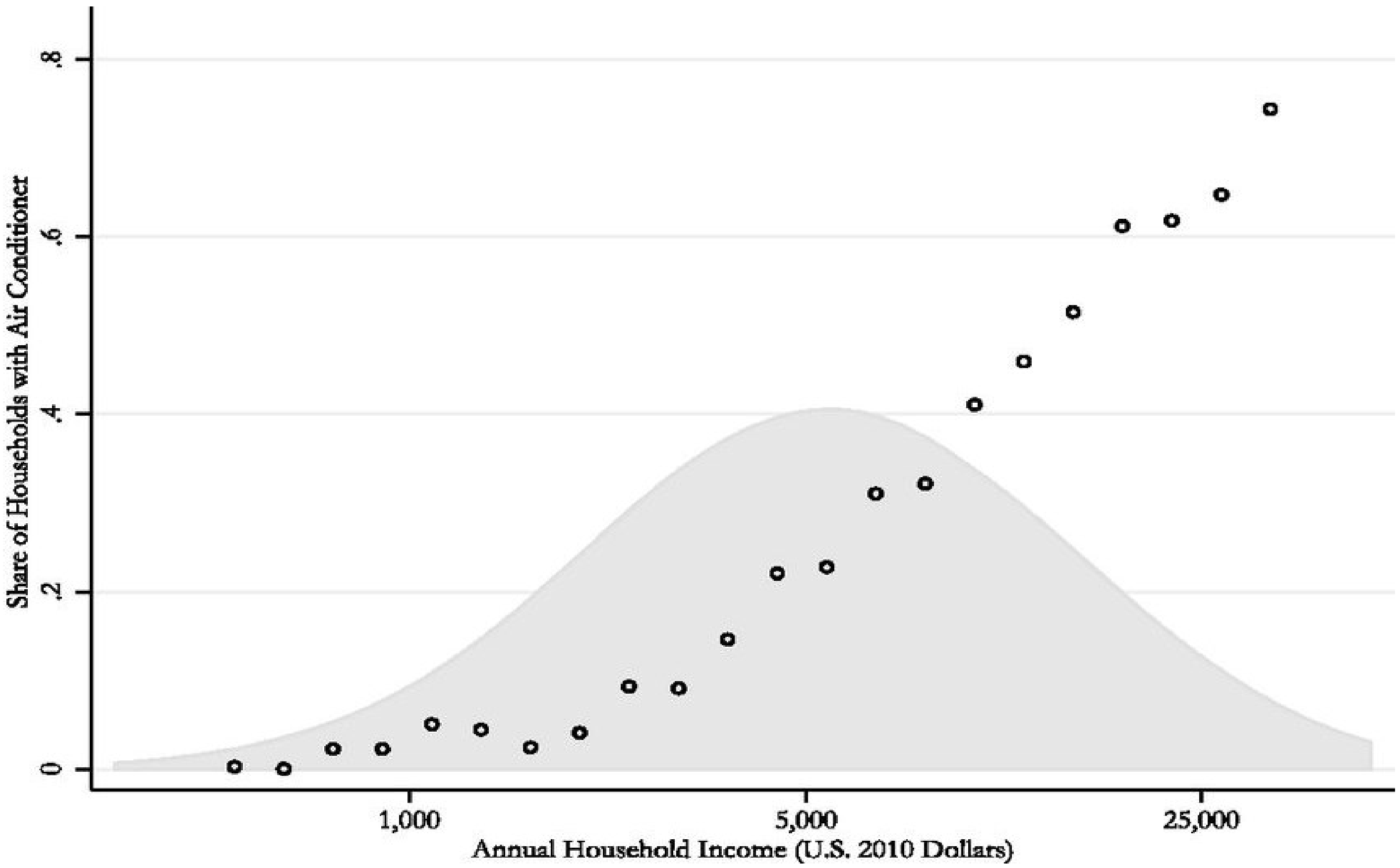


FIG. 4.—Impact of residential air conditioning on the mortality-temperature relationship, 1960–2004. The figure plots the δ_j coefficients associated with the interactions between the share of the population with residential AC and the nine temperature-day bin variables from the fitting of equation (2) to 1960–2004 data. The dependent variable is the log monthly mortality rate, and the specification includes the baseline set of covariates. Standard errors are clustered on state. See the text for additional details.

$$
\begin{aligned}
log(Y_{sym}) \quad = \quad & \sum_j \theta_j TMEAN_{symj} + \sum_j \delta_j TMEAN_{symj} \times MOD_{sy} + MOD_{sy}\phi \\
& + \pi_L LOWP_{sym} + \pi_H HIGHP_{sym} + X_{sym}\beta + \alpha_{sm} + \rho_{ym} + \varepsilon_{sym}
\end{aligned}
$$

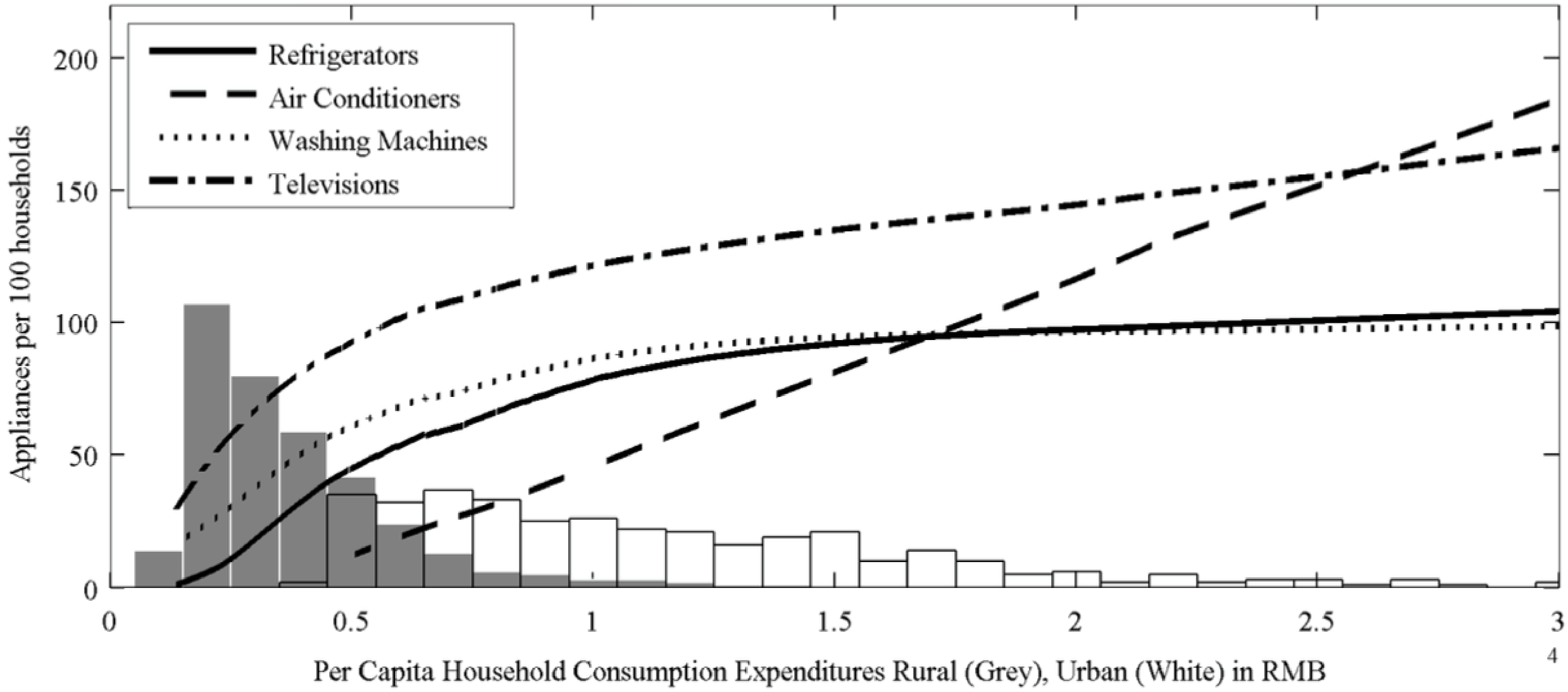
- MOD_{sym} = modifier variables (health care / electricity / AC)

Not just for the US!



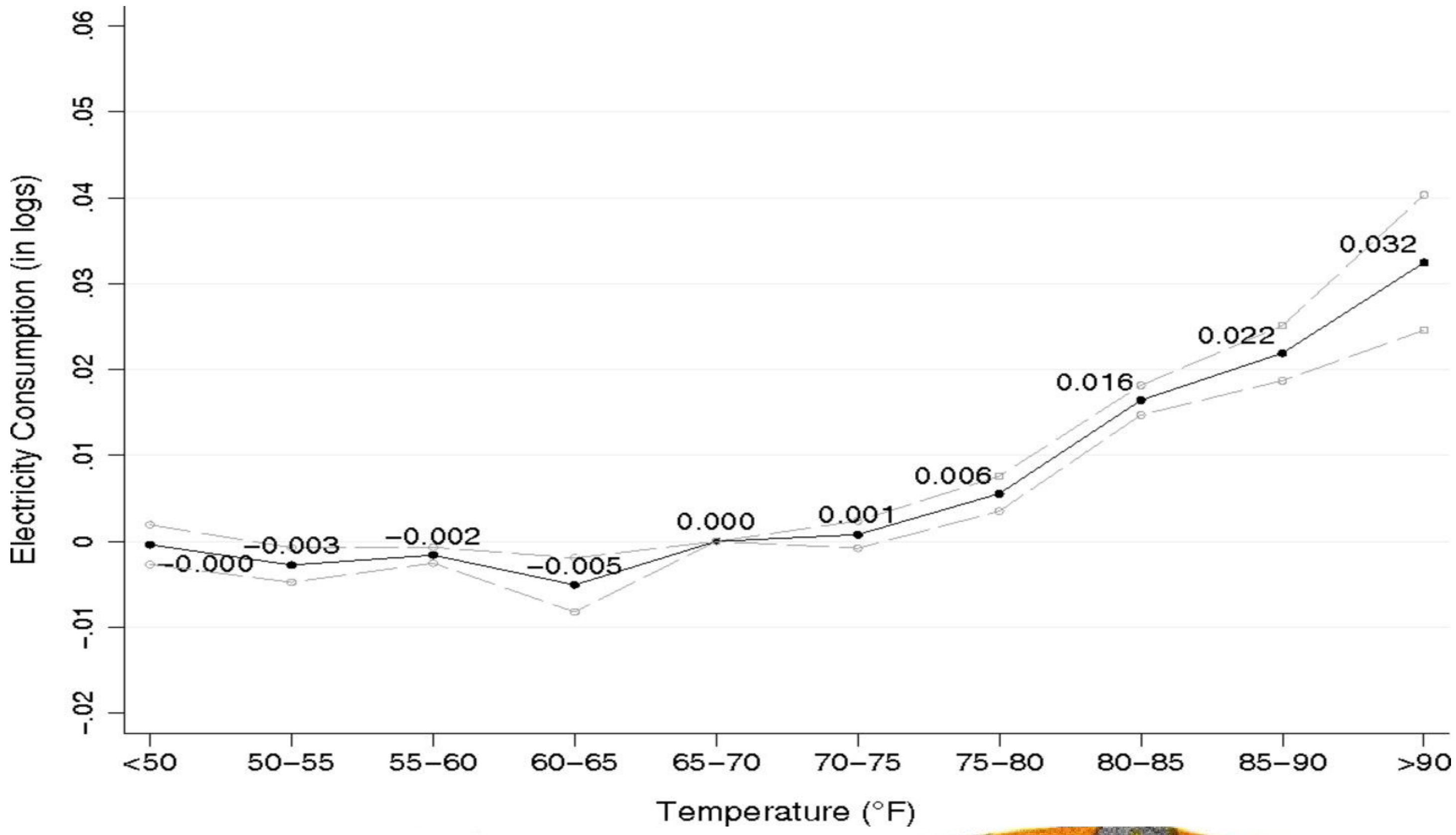
Source: Davis and Gertler (2016) "Contribution of air conditioning adoption to future energy use under global warming" PNAS

As countries become less poor they will want more AC



Source: Auffhammer and Wolfram (2014) “Powering up China” AER P&P

Income and adoption of other appliances

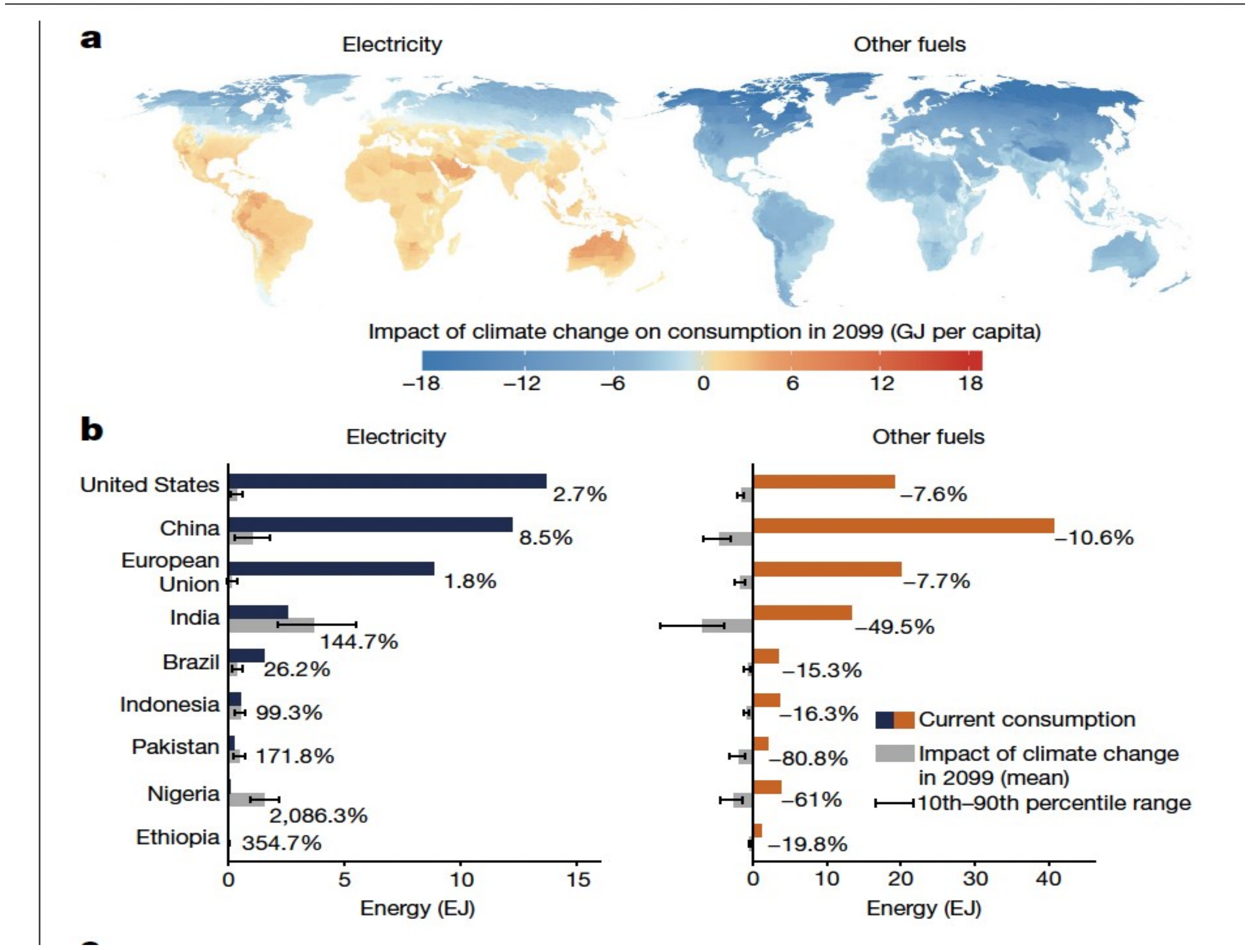


Source: Davis and Gertler (2016) "Contribution of air conditioning adoption to future energy use under global warming" PNAS

And those who have AC will use electricity when it is hot

- Until 2100, Middle cinome country will use lots more of electricity

- Depending how it is produced it can contribute to aggravate climate change problems



Downside of adaptation through Air Conditionning…. Electricity use exploses

Better crops
(Dar et al, 2013)

Irrigation
(Tarraz, 2017)

Crop diversification
(Auffhammer and
Carleton, 2013)

New ways of planting
(Aker and Jack)

Other technologies

How to increase adoption of the adaptation technologies?

Zaï/Tassa	Banquettes	Demi-Lunes
		

Agronomic trials show RWH techniques restore degraded land, increase yields and increase resilience

- Yet across the Sahel, adoption levels remain low

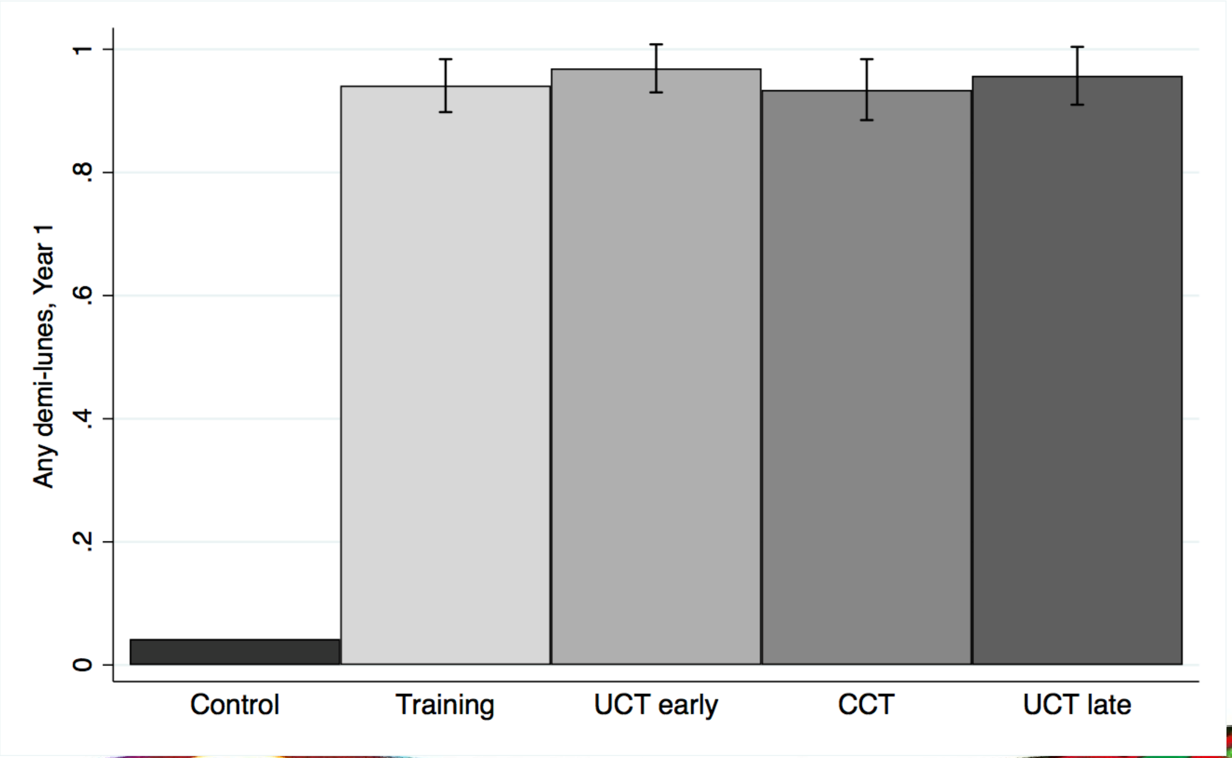
Increasing adoption of rainwater harvesting in Niger

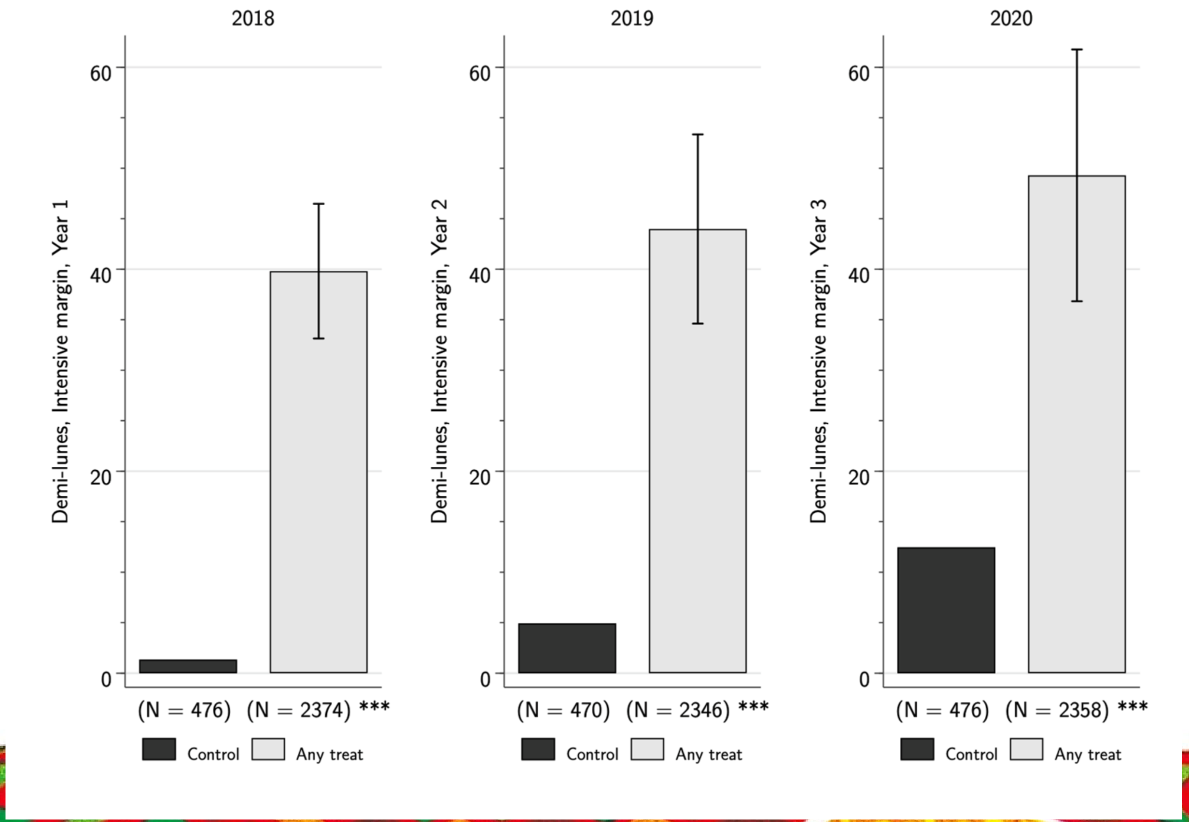
Zaï/Tassa	Banquettes	Demi-Lunes
		
Photo: M. Nuradeen Danjuma	Photo: A. Mills	Photo: J. Aker

Agronomic trials show RWH techniques restore degraded land, increase yields and reduce crop failure

- Yet across the Sahel, adoption levels remain low

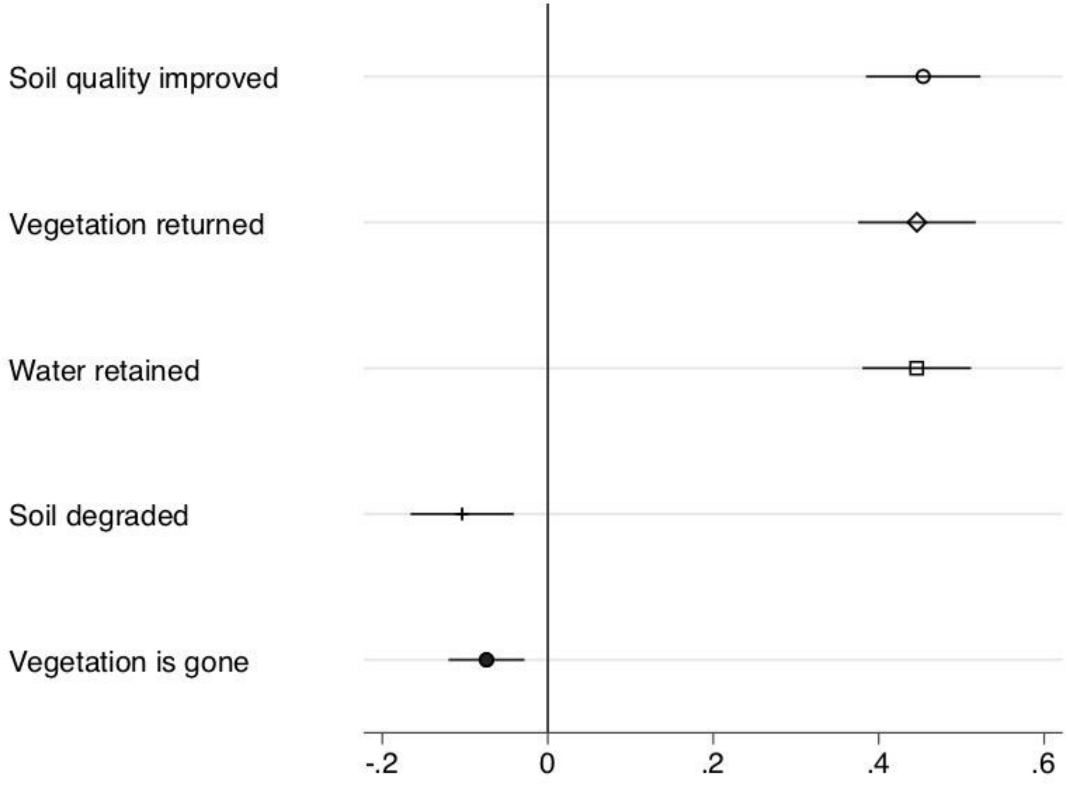
Result: Training alone resulted in widespread adoption (>95% take up), sustained for at least 3 years





impacts and cost effectiveness

Year 3: Self-reported improvements in land quality

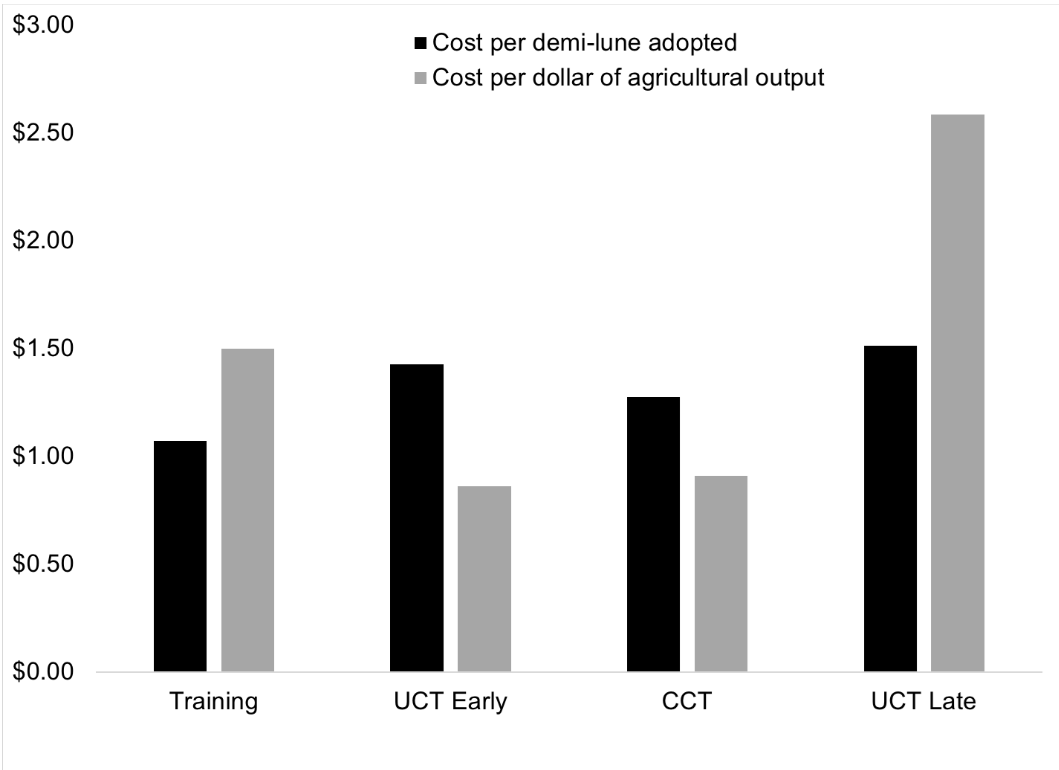


Other impacts:

- 12-14% increase in crop income
- 2x as likely to bring land back into production
- 1/3 less likely to retire land from production

Step 2: Measure impacts and cost effectiveness

Measure impacts and cost effectiveness



Training is most cost effective for increasing adoption

UCT-early is most cost effective for increasing production

Scale up what works

Take lessons from RCT and collaborate with govt. on scale up

- Test how to streamline program for scale
- Compare adoption of different RWH techniques
- Learn more about why trainings are so effective

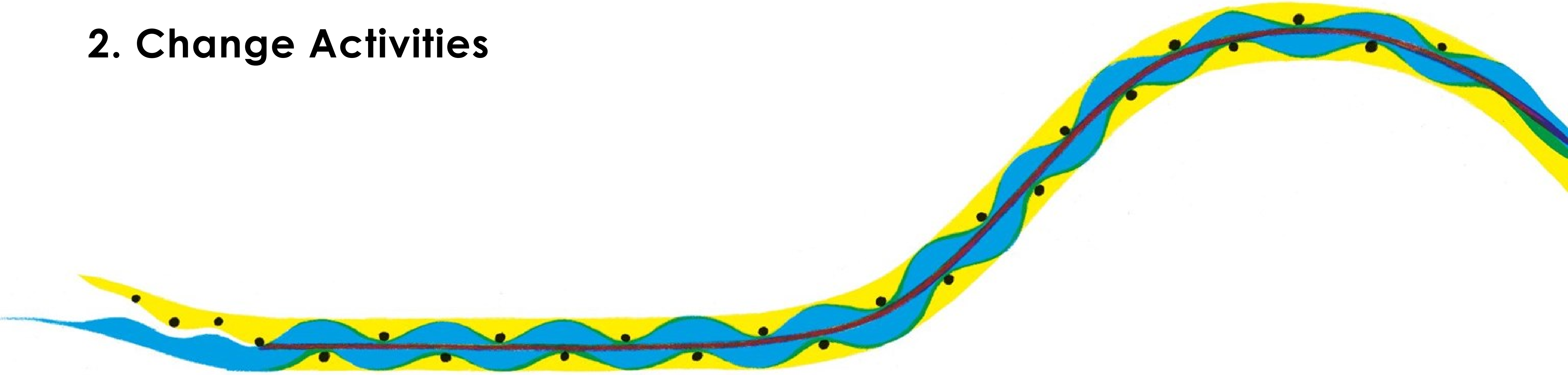
Timeline: Start in early 2023, timed with growing season

Researchers: Jenny Aker, Kelsey Jack, Malam Assane Maigari

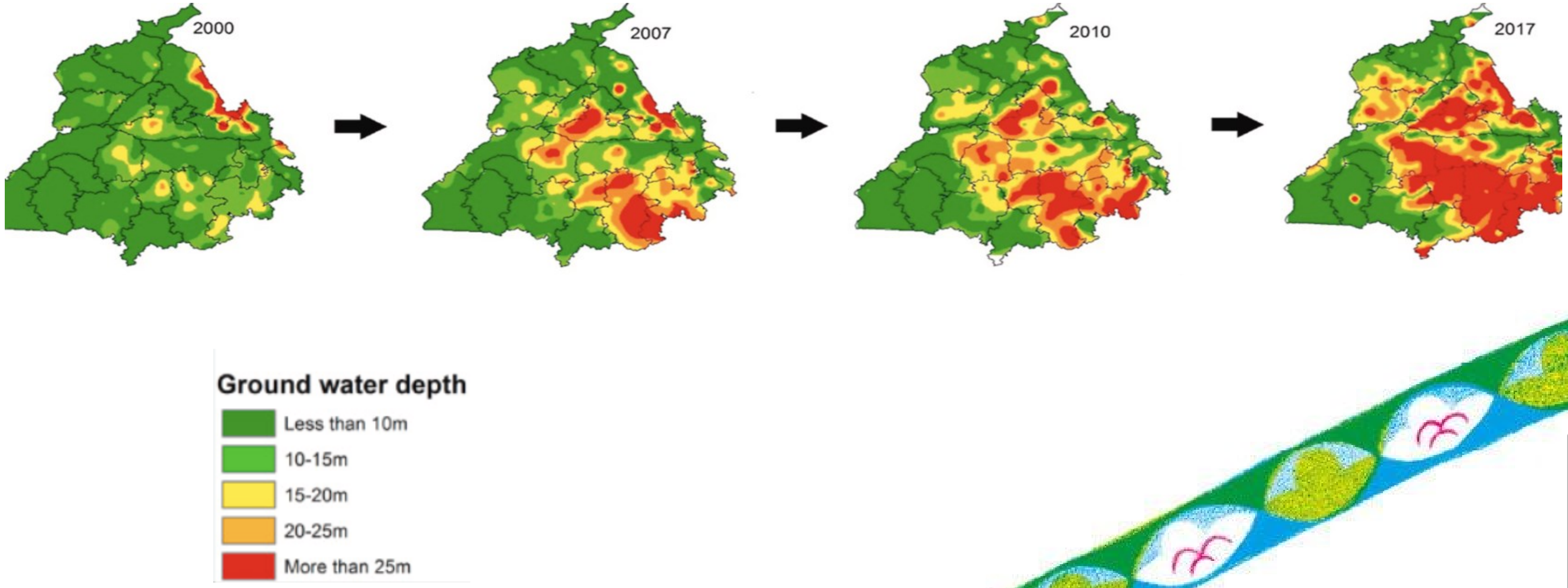
Policy Partners: Ministry of Environment of Niger

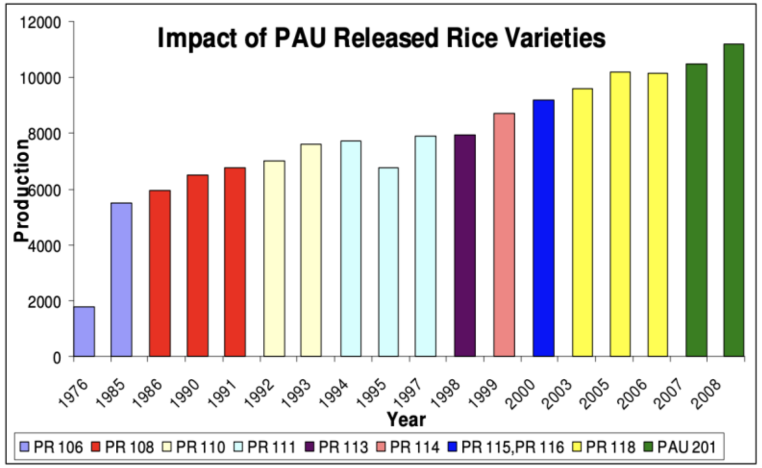
So how do we adapt?

2. Change Activities



Groundwater get depleted 1.5 times faster than it fills up



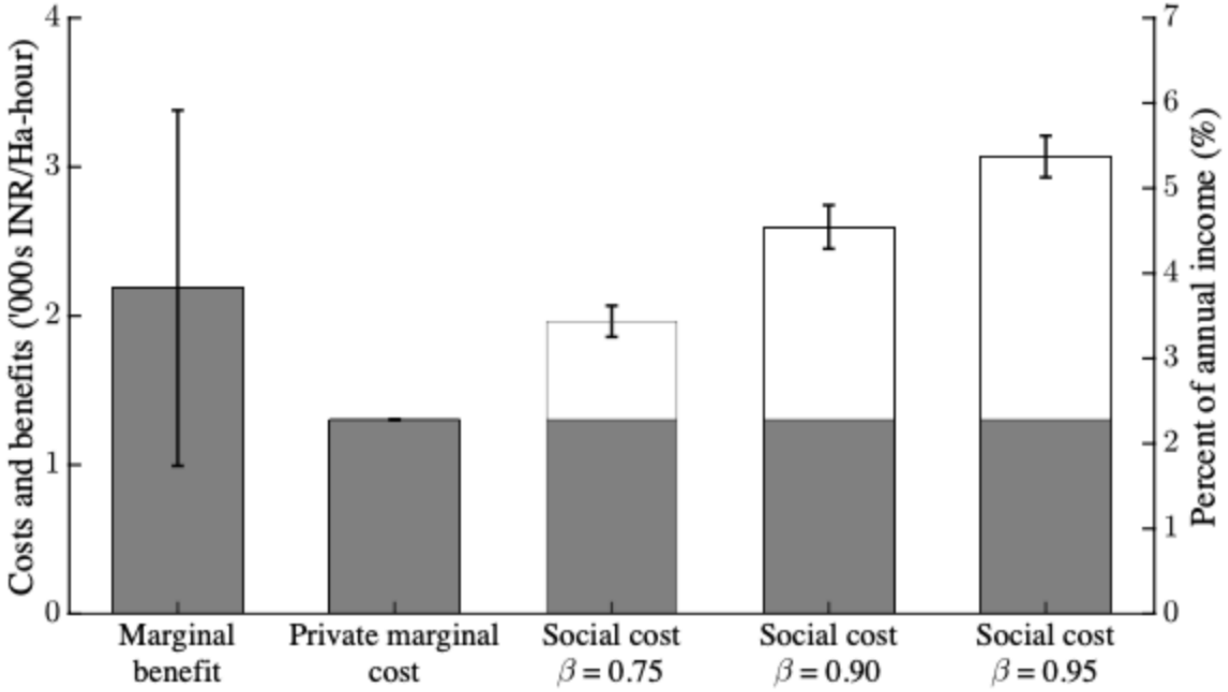


Production de riz (100% irrigué)

Rice and Water in Punjab

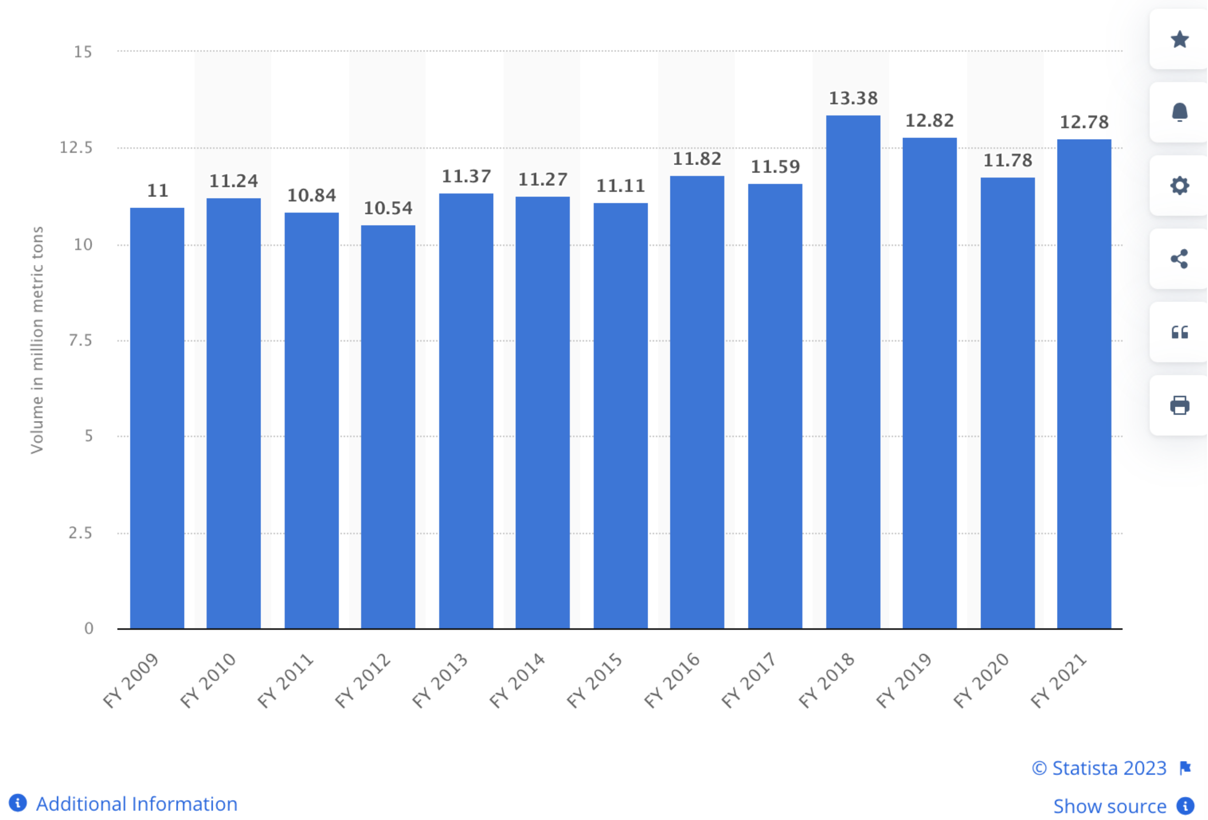
- Farmers get free electricity, but it is ratioonned
- They don’t waste electricity statically: they need it!

Figure 2 Marginal benefits and costs to increasing the electricity ration by one hour



- What they need to do to adapt is to stop growing rice. Do they?
- Social value of rice production <<0 (just from pollution)

In addition they contribute to climate change and choke Delhi



Rice production in Punjab

Not in Punjab

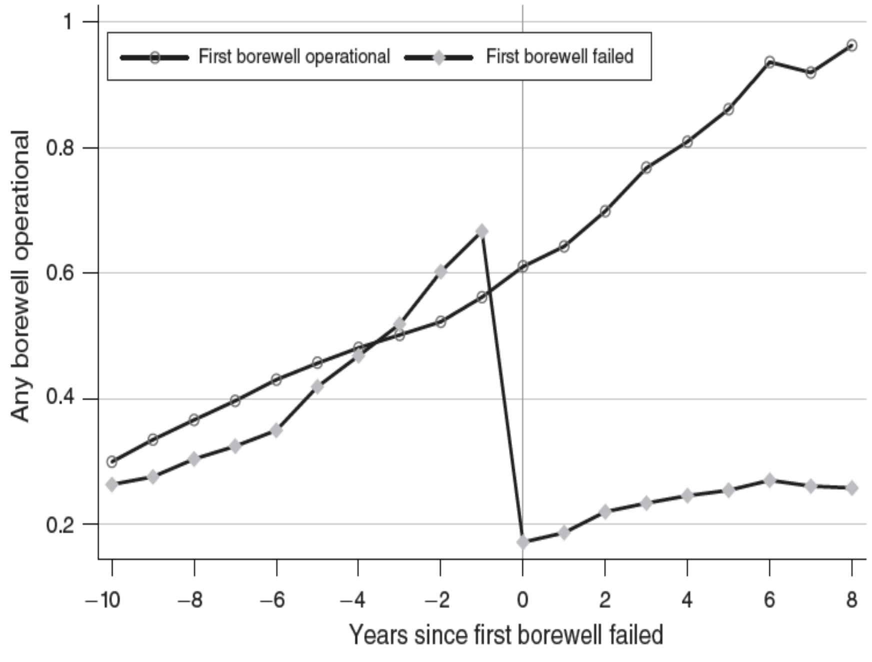


Figure 4. Borewell Failure and Access to Water over Time

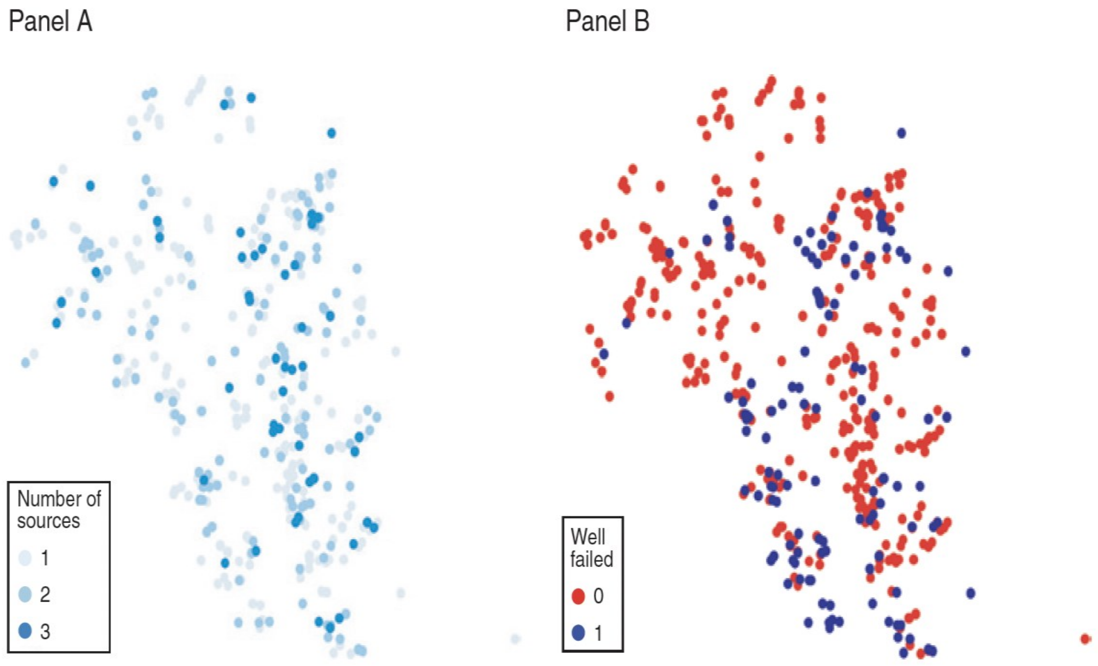


Figure 3. Hydrogeological Data

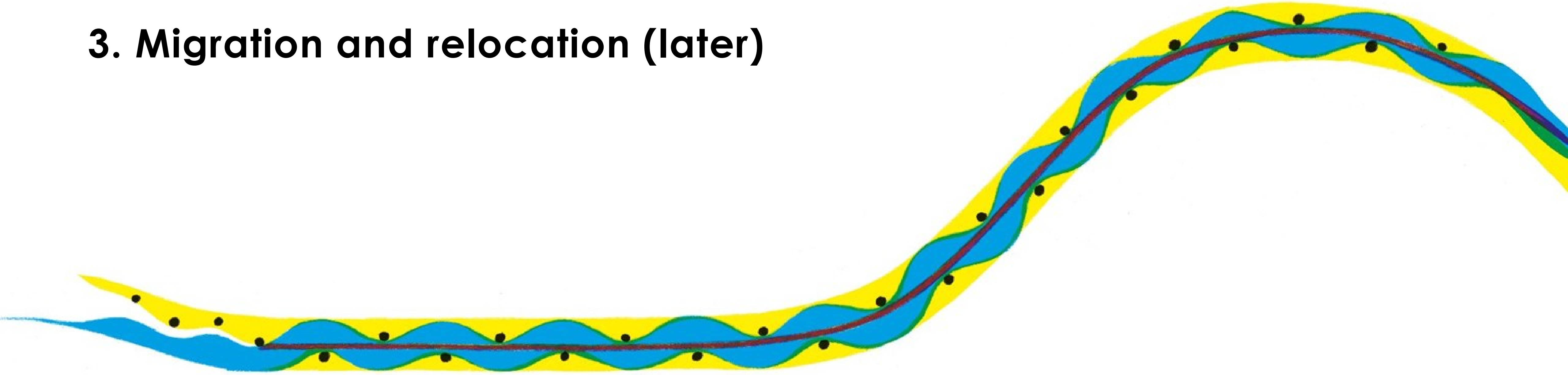
But when wells fail (Blakslee et al.)

	Control mean	Impact of BW failure	
	(1)	(2)	(3)
Any income			
On-farm	0.800	0.002	0.003
		[0.024]	[0.026]
Government transfers	0.204	0.004	0.028
		[0.031]	[0.033]
Business	0.039	−0.004	−0.010
		[0.012]	[0.012]
Remittances	0.062	0.002	0.009
		[0.019]	[0.020]
Off-farm employment	0.291	0.084	0.118
		[0.038]	[0.038]
Income (1,000 Rs.)			
On-farm	59.141	−16.684	−14.083
		[5.854]	[6.325]
Off-farm	21.850	8.623	12.182
		[5.549]	[6.017]
Total	80.991	−8.061	−1.900
		[8.773]	[9.500]
Village fixed effects		Yes	Yes
First-BW year-drilled fixed effects			Yes

No adjustment of on farm activities but Off farm employment compensates

So how do we adapt?

3. Migration and relocation (later)



So how do we adapt?

4. Financial products (insurance, loans, etc)

TABLE 3—AVERAGE TREATMENT EFFECTS: LABOR

	Any ganyu sold (1)	Hours sold (2)	Any ganyu hired (3)	Hours hired (4)	Family hours on-farm (5)
Panel A. Year 1: pooled treatment arms					
Any loan treatment	−0.048	−1.137	0.039	2.003	4.953
	(0.026)	(0.551)	(0.015)	(1.231)	(2.618)
Panel B. Year 2: pooled treatment arms					
Any loan treatment	−0.021	−0.799	−0.006	0.455	11.467
	(0.042)	(0.489)	(0.030)	(1.507)	(5.658)
Treated in Y1	0.045	0.708	0.001	0.325	7.908
	(0.036)	(0.520)	(0.026)	(1.098)	(3.827)
Loan × treated in Y1	−0.058	−0.605	0.020	−1.210	−14.367
	(0.051)	(0.646)	(0.040)	(1.765)	(6.765)
Loan + Y1 + loan × Y1	−0.034	−0.696	0.015	−0.430	5.008
	(0.033)	(0.419)	(0.029)	(1.061)	(4.194)

Fink, Jack, Masiye, 2020

Access to capital lead to less sale of labor in lean season

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Fink, Jack, Masiye, 2020

Access to capital lead to less sale of labor in lean season

TABLE 6—AVERAGE TREATMENT EFFECTS: CONSUMPTION AND FOOD SECURITY

	Months with enough food (1)	Food security (*z*-score) (2)	Meals per day hungry season (3)	Meals per day harvest season (4)
Panel A. Year 1: pooled treatment arms				
Any loan treatment	0.331	0.305	0.100	0.012
	(0.133)	(0.079)	(0.045)	(0.014)
Panel B. Year 2: pooled treatment arms				
Any loan treatment	0.073	0.174	0.079	0.011
	(0.132)	(0.123)	(0.029)	(0.025)
Treated in Y1	−0.055	−0.016	0.046	0.006
	(0.132)	(0.100)	(0.033)	(0.019)
Loan × treated in Y1	0.141	0.285	−0.037	−0.002
	(0.173)	(0.149)	(0.041)	(0.031)
Loan + Y1 + loan × Y1	0.159	0.442	0.087	0.015
	(0.120)	(0.099)	(0.031)	(0.020)

And more production and food security

Floods in Pakistan

The problem is not just levels, it is volatility and disasters (including floods and coastal damages)

- People help each other when faced with idiosyncratic shocks (Towsend, etc.)
- However less good for aggregate schock
- Mobile money help households cope with more shocks by diversifying source of help (Suri and Jack)
- Still, unlikely to be enough for large schocks caused by increased volatility.

Informal sharing

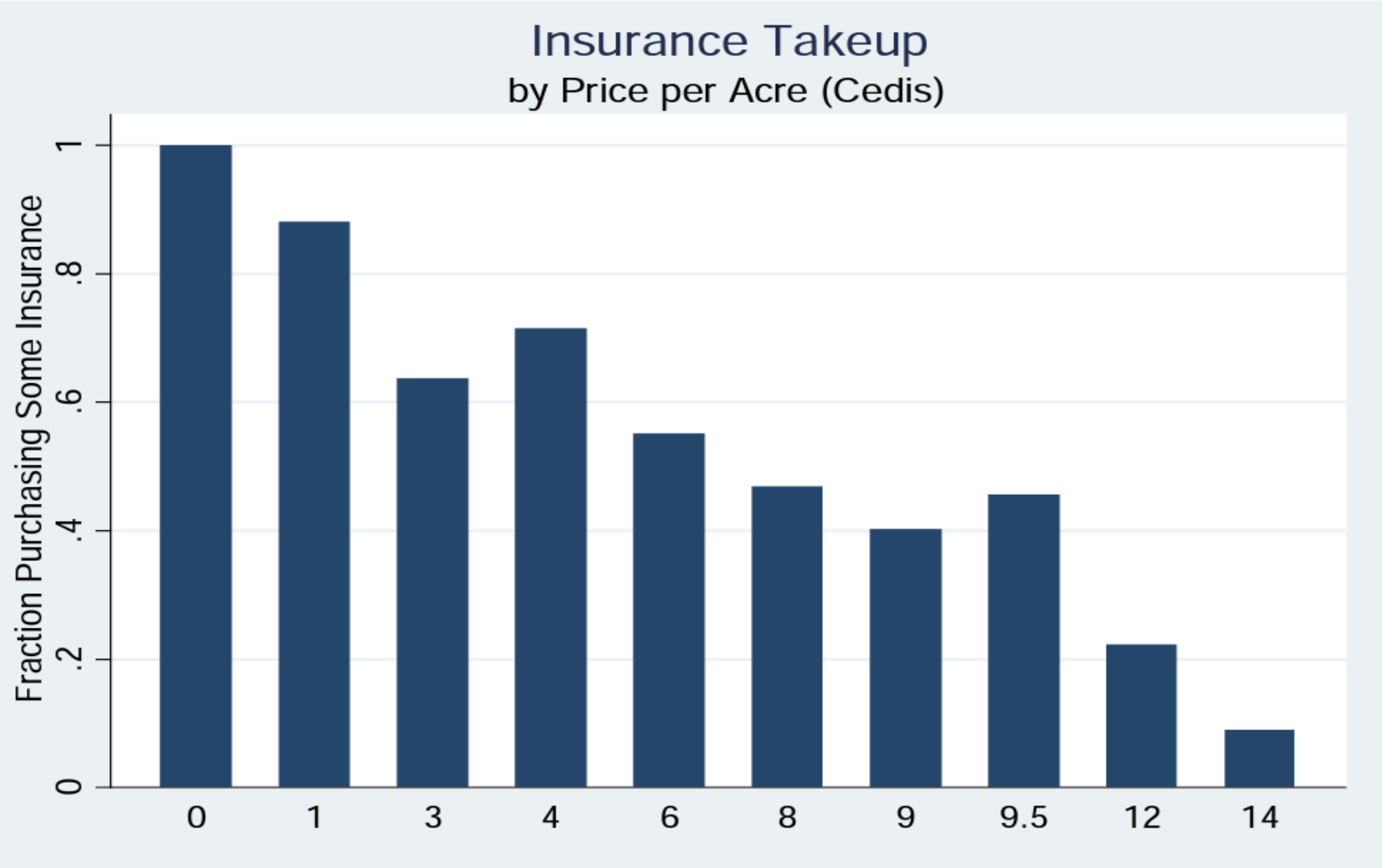
Table 3: Impact on Investment and Harvest

IV

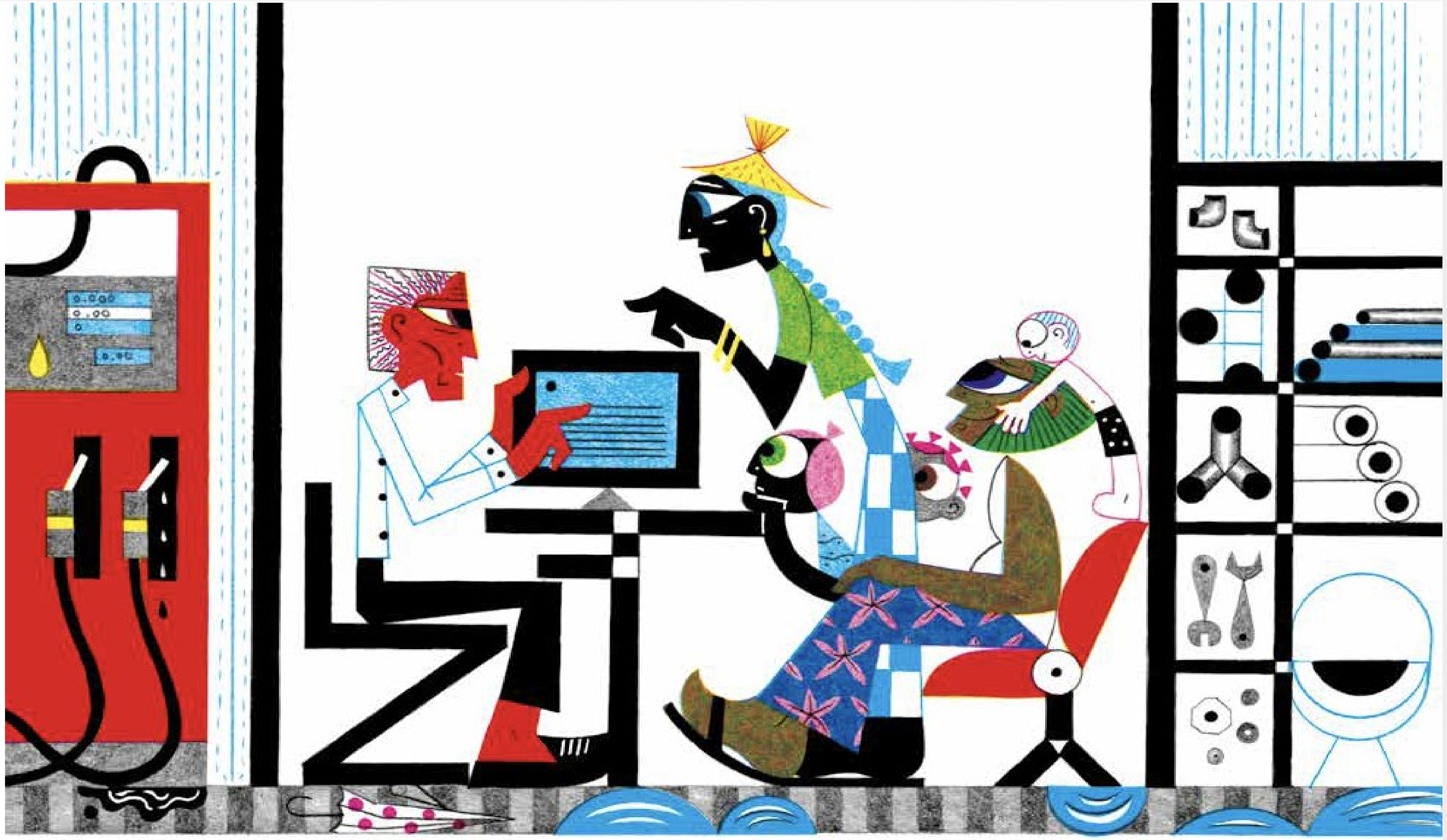
Dependent variable:	(1) Land Preparation Costs	(2) # of Acres Cultivated	(3) Value of Chemicals Used	(4) Wages Paid to Hired Labor	(5) Opportunity Cost of Family Labor	(6) Total Costs	(7) Value of Harvest
Insured	25.53**	1.02**	37.90**	83.54	98.16	266.15**	104.27
	(12.064)	(0.420)	(14.854)	(59.623)	(84.349)	(134.229)	(81.198)
Insured * Capital Grant Treatment	15.77	0.26	66.44***	39.76	-52.65	72.14	129.24
	(13.040)	(0.445)	(15.674)	(65.040)	(86.100)	(138.640)	(81.389)
Capital Grant Treatment	15.36	0.09	55.63***	75.61	-130.56	2.44	64.82
	(13.361)	(0.480)	(17.274)	(68.914)	(92.217)	(148.553)	(89.764)
Constant	169.38***	8.12***	171.70***	201.88***	1,394.58***	2,033.11***	1,417.52***
	(10.603)	(0.399)	(13.804)	(45.383)	(84.786)	(124.294)	(90.635)
Observations	2,320	2,320	2,320	2,320	2,320	2,320	2,320
R-squared	0.017	0.143	0.041	0.005	0.006	0.009	0.012
Mean for Control	189.1	5.921	158.3	327.9	1302	2058	1177
Chi2-test of Insured and Insured + Capital Grant Treatment	8.889	7.125	36.15	3.136	0.239	5.091	6.618
p value	0.003	0.008	0.000	0.077	0.625	0.024	0.010

Robust standard errors in parentheses. "Insured" instrumented by full set of prices (Table 2, Column 1 presents first stage regressions). Total Costs (Column 6) includes sum of chemicals, land preparatory costs (e.g., equipment rental, but not labor), hired labor, and family labor (valued at gender/community/year specific wages). Harvest value includes own-produced consumption, valued at community-specific market value. All specifications include controls for full set of sample frame and year interactions. *** p<0.01, ** p<0.05, * p<0.1

Karlan, Udry, Osei (2014)
Weather insurance can improve investment and profit

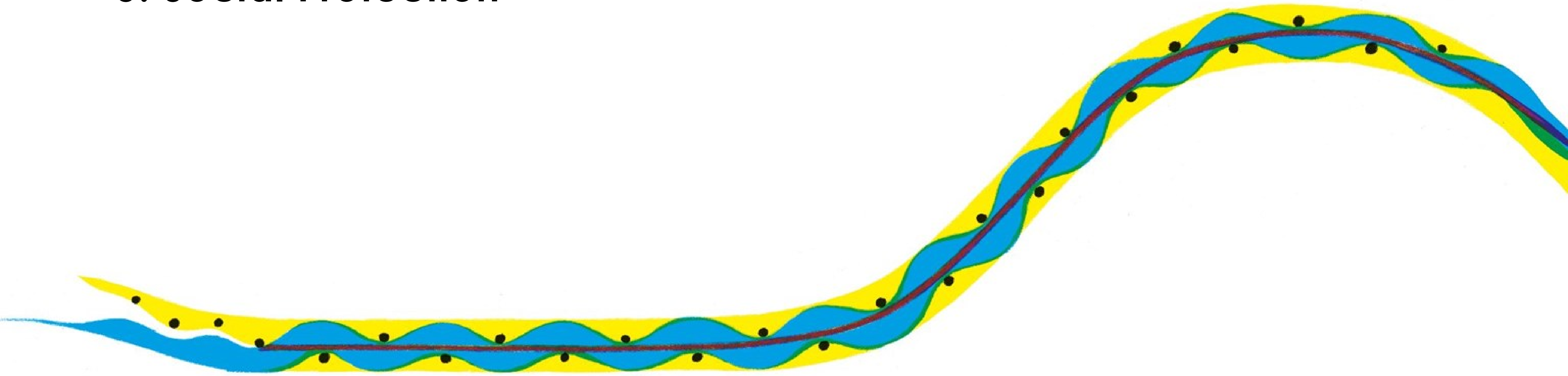


But insurance take up is very low at actuarially fair price



So how do we adapt?

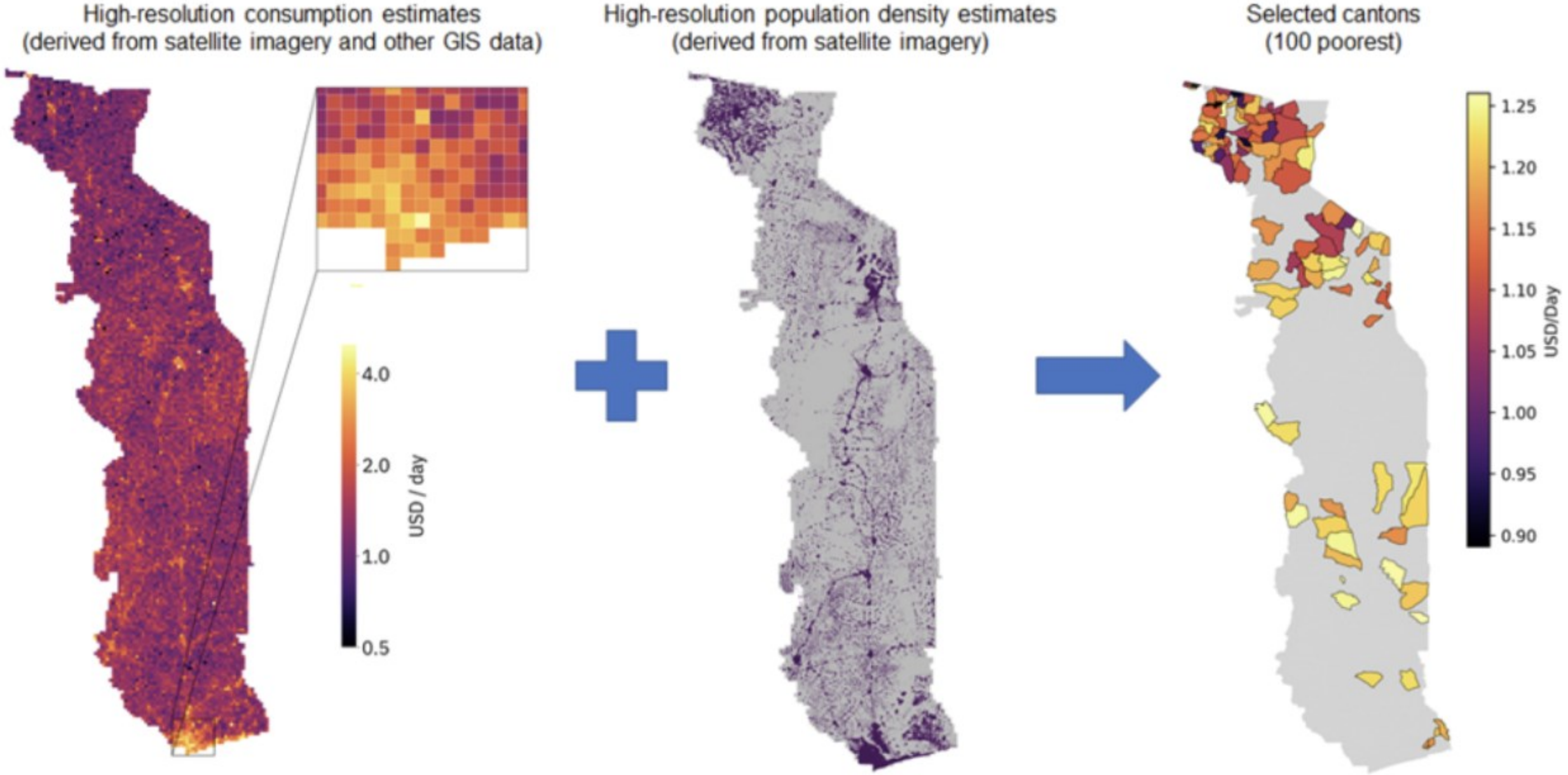
5. Social Protection



- Ultimately, governments will need to be ready to adapt to climate change by supporting households that face shocks
- Cash transfers
  - Plenty of evidence of good use of cash transfer in general
  - Success in COVID years in targeting & Logistics though mobile money etc (TOGO)
  - Some evidence of positive impact of cash transfers during COVID (though limited in the US)
- Anticipatory cash transfers: Take advantage of improvement in prediction of where disaster may occur

Social protection and cash transfers

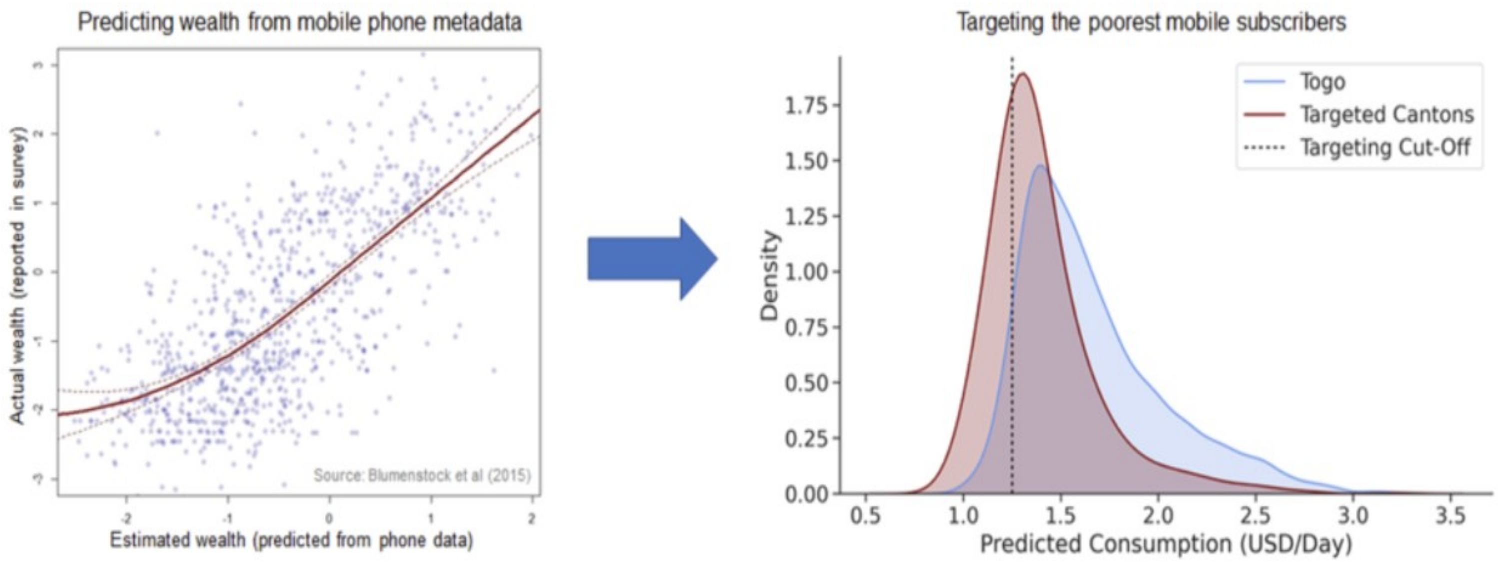
Figure 1: Prioritizing the Poorest Villages and Neighborhoods



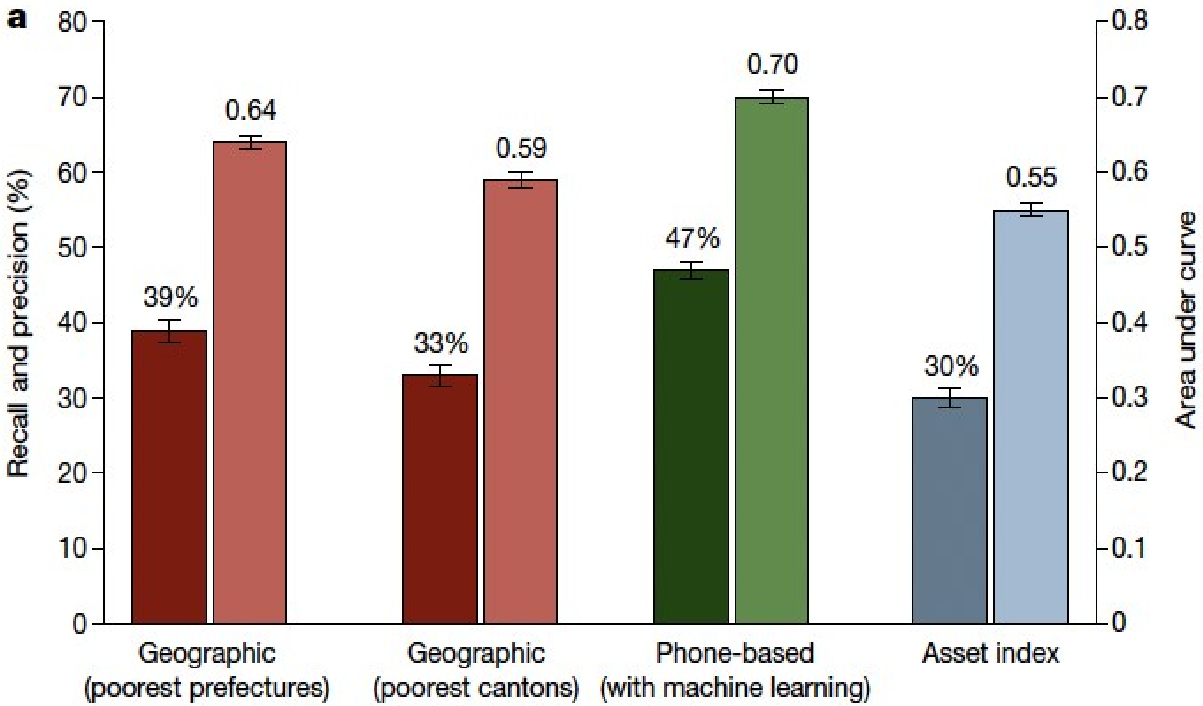
Togo's Novisi: Geographic targetting

Cell phone meta data predict well who is the poorest.

Figure 2: Prioritizing the Poorest Mobile Subscribers



Using cell phone meta-data



Dark bar: 1-exclusion error, lighter bar, measure of overall performance

Algorithm predict better than purely geographic targeting of PMT

- In July 2020, the World Food Programme (WFP) sent BDT 4,500 (approximately $53) using mobile money accounts to 23,434 households along the Jamuna River that were about to experience severe Flooding, based on data-driven forecasts of river levels.
- Many households that shoud have been reached could not be reached due to logistical challenges during the COVID pandemic.

Anticipatory transfer (Pople et al, 2023)

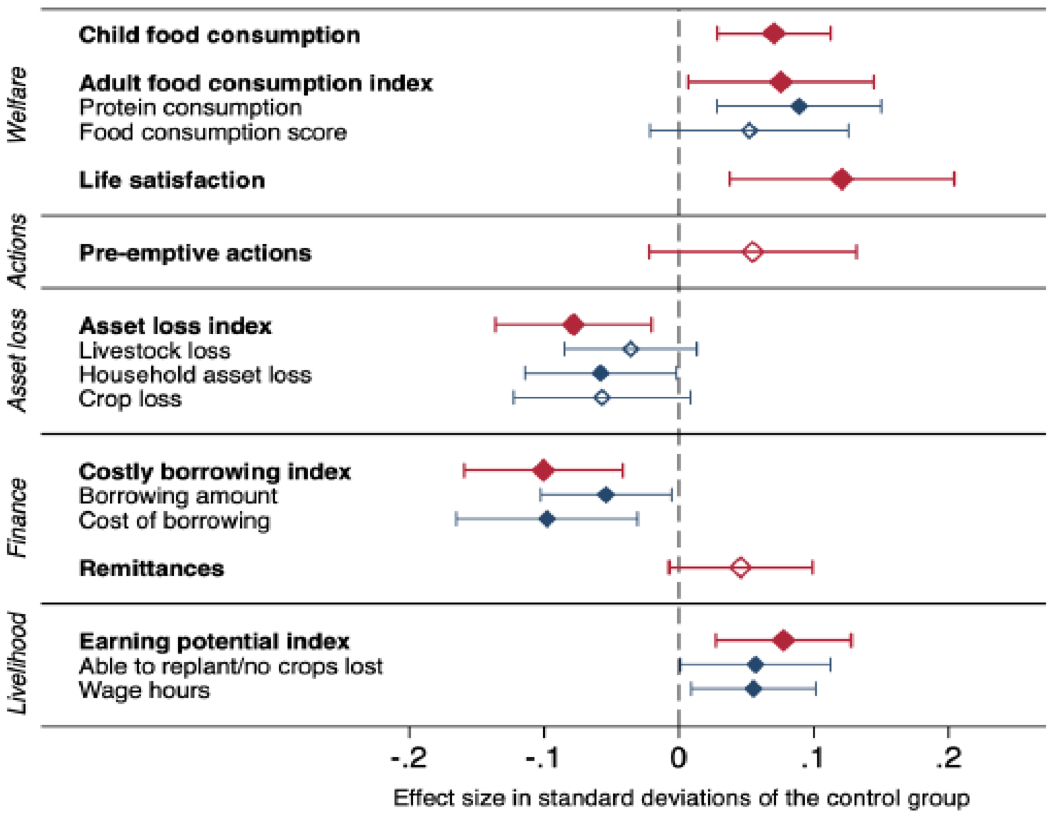
Table 2: Balance and summary statistics

	Control mean	Treatment mean	Δ	Norm. Diff.	*p*-value
Individual characteristics					
Age	37.47	38.79	1.32	0.10	0.108
Female respondent	0.97	0.97	0.00	0.00	0.426
Household head	0.18	0.22	0.03	0.08	0.705
Completed primary school	0.34	0.30	-0.04	-0.08	0.576
Household characteristics					
Household size	4.68	4.73	0.05	0.03	0.872
Dependency ratio	0.75	0.76	0.01	0.02	0.282
Raw material house	0.26	0.27	0.01	0.02	0.183
Distance to large water body (m)	1332.73	1249.13	-83.60	-0.06	0.394
Protected mainland	0.43	0.33	-0.09	-0.19	0.470
Unprotected mainland	0.27	0.27	0.00	0.00	0.100
Char land	0.30	0.40	0.09	0.20	0.018
Anticipatory action					
Received WFP cash transfer	0.00	1.00	1.00	.	.
Received dignity kit from UNFPA	0.06	0.14	0.09	0.29	0.000
Received feed or storage from FAO	0.04	0.07	0.03	0.15	0.011
Technology					
Used digital wallet in last six months	0.50	0.47	-0.03	-0.05	0.417
Own mobile	0.82	0.80	-0.02	-0.06	0.633
Uses someone else's mobile	0.16	0.18	0.03	0.07	0.482
Uses mobile at least once a week	0.97	0.96	-0.01	-0.03	0.609
Observations	2388	6566			

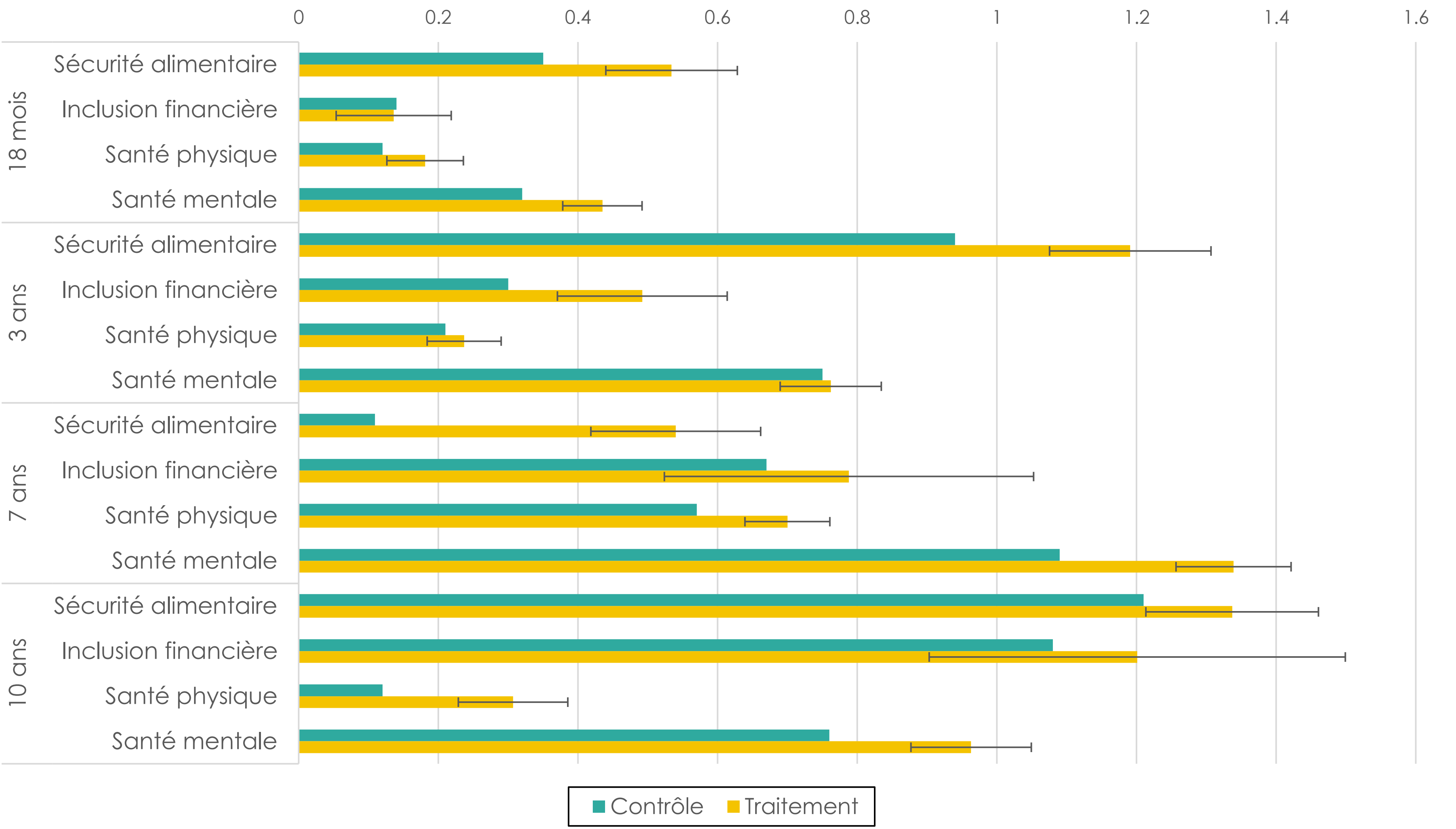
Notes: Δ reports the treatment mean minus the control mean. Norm. Diff. reports the normalised difference between the treatment and control group means, following Imbens and Rubin (2015). The last column reports the *p*-value from ordinary least squares regressions of each variable on the treatment dummy to test equivalence of means, controlling for union fixed effects and clustering standard errors at union level as in our main specification.

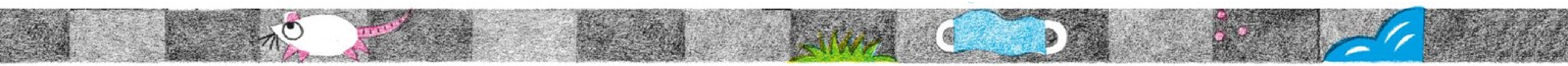
Households that were reached and not look similar

Figure 3: Effect of receiving a cash transfer



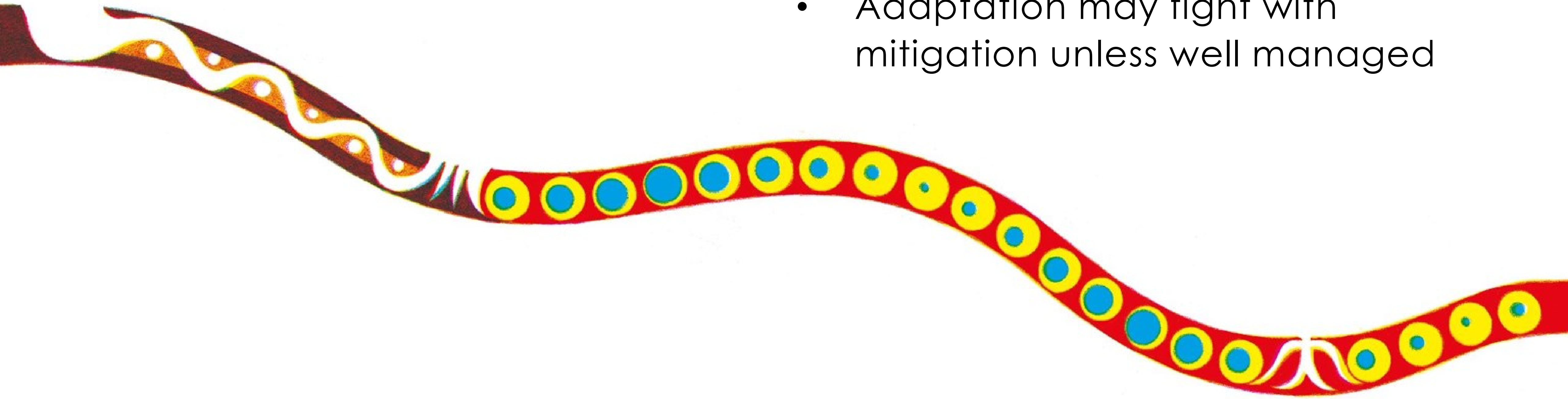
Positive impacts





Don’t let any one fall in extreme Poverty: Ultra poor programs

- Adaptation will take money
- Without help, countries will look to the shortest way possible to adapt
- Adaptation may fight with mitigation unless well managed



Conclusion