

# Adaptation to Climate Change in Pakistan

Impacts on Disaster Preparedness and Resilience

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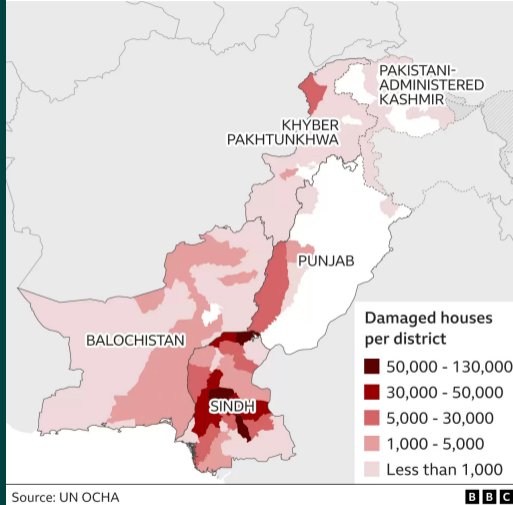
Alexandra Avdeenko & Markus Froelich

December 6, 2022



Source: BBC-Link

## Areas hit by monsoon rains



# Background

- ▶ **Extreme weather events** are becoming more common due to climate change
- ▶ **Damages** from gradual warming are projected to be very high (recurrent humanitarian disasters and estimated \$2.97 trillion in losses to the global economy over the past two decades (UN DRR 2020))
- ▶ Events **disproportionately impact lower-income communities** that cannot take steps to insure against the risk or costs of these events (esp. South Asia)

- ▶ **Setting** : Areas with highest needs of humanitarian aid after having been heavily affected by recurring disasters in the past
- ▶ **Interventions** : Support for community-level recovery with focus on protection against high risk events, such as natural disasters
- ▶ **Identification** : Cluster-randomized assignment of preparedness interventions
- ▶ **Data** : 3-wave panel data collected (2015, 2016, 2017)
- ▶ **Main result** : Disaster preparedness improves health and food-related related outcomes in the face of a large shock
- ▶ **Funding** : \$399.997 by UK's Department for International Development through the International Initiative for Impact Evaluation (3ie)

## **Empirical Evidence**

# Causally Testing Preparedness and Responses to Extreme Weather Events

## Empirical challenges

- ▶ **Selection into programs** : Probability of receiving aid is negatively correlated with wealth
- ▶ **Natural disasters are hard-to predict** : Data-collections and policy evaluations are hard to plan and implement
- ▶ Little evidence . . .
  - ▶ detailed literature

### **Mortality**

Immediate increase, but also long-term consequences due to exposure at birth  
(Netherland, Lindebook et al. 2010, JHealthE)



### **Education**

Drop in mandatory education, both in the long and medium terms; intergenerational transmission  
(e.g. Mongolia, Groppo/ Kraehnert 2017, JPopE)



### **Coping**

Poverty, borrowing, consumption  
Rising levels of poverty and borrowing;  
larger fraction of income spent on food throughout life  
(e.g. Germany, Kesternich et al. 2015, EJ)



### **Risk**

Reduced propensity to take risks;  
Fewer and change investment behavior (e.g Germany, Avdeenko Eryilmaz 2020, WP)





Mortality



Education



Coping



Risk



**Insurance**  
Less losses, less decrease in  
life satisfaction (Europe,  
Luechinger/Raschky 2009,  
JPubE 2009)



**Preparedness Interventions**  
e.g. wildfire protection of private  
homes increase construction  
(USA, Baylis/ Boomhower 2019,  
WP), flood protection on prices  
(USA, Muller/ Hopkins  
2019, NBER)



**Early Warning Systems**  
e.g. automated pollution  
monitoring and health  
improvements (China,  
Barwick et al. 2019, NBER)



**Technological Innovation**  
e.g., air conditioners reduce  
mortality (USA, Barreca et al.  
2016, JPE) and increase birth  
weight (China, Chen et al.  
2020, JPopE), subways and  
air pollution (Gendron-  
Carrier et al. forth. AEJ: AE)



Mortality



Education



Insurance



Coping



Preparedness Interventions



Risk



Technological Innovation



Early Warning Systems



**Coping**  
assets, savings,  
consumption, health,  
subjective wellbeing



**Preparedness Interventions**  
adaptation to climate  
change via improved  
sanitation, stronger  
housing, and better  
crops



Important topic, especially of interest to development economists, environmental economists, donors, and policy-makers/ -implementers

- ▶ Evidence on an adaptation policy that is largely missing in the climate change literature
- ▶ Type of intervention that is increasingly important - partly for reasons of feasibility
- ▶ High relevance in the local context given recurrent flood in 2022
- ▶ Detailed cost-effectiveness analysis

## **The Intervention**

## Natural Disaster

### Preparedness, Response and Recovery Program

DFID's Multi-Year Humanitarian Programme in Pakistan (total 100 million Pound)  
to support a decrease in needs among populations affected by natural disasters and conflict



# Natural Disasters in Pakistan

## Exposure

- ▶ Pakistan is among the most natural disaster-affected countries (floods, earthquakes, droughts, monsoons, cyclones, and landslides)

## Consequences

- ▶ Natural disasters were followed by recurrent humanitarian disasters in the past years
  - ▶ Lack of safe water, poor sanitation ; flood-related diseases, such as diarrhea and malaria
  - ▶ Food shortage (fertile crop land submerged ; livestock killed, grain washed away) ; chronic malnutrition
  - ▶ Lack of shelter ; migration
  - ▶ Loss of employment opportunities

# Local Context



The 2010 Pakistan flood was the most devastating since 1950s. One fifth of the country was flooded, over 20 million people were affected, and over 1,700 people died (WHO 2010).

In 2011, within only two months, floods deluged 27,581  $km^2$ .



## Program Implementation Strategy

Residual recovery packages and relief assistance for all those who might be affected by upcoming, future disasters

- ▶ **Coordinated** : ACTED is part of the *Natural Disaster Consortium* (together with IOM, FAO, UNICEF, HANDS)
- ▶ **Responsive** : In the event of a natural disaster all individuals in need are eligible for aid
- ▶ **Comprehensive** : Multi-sectoral, integrated response - delivery of services encompasses a set of activities
- ▶ **Supply-focused** : Physical capital injections and provision of human capital

## ACTED's Basic Humanitarian Aid Package

- ▶ **Water, Sanitation and Hygiene** [\$81,176] : Construction of own household latrines, distribution of sanitation kits
- ▶ **Shelter** [\$424,706 ; 74.72% of total] : Integration of disaster risk reduction practices into shelter construction ; conditional cash for construction work
- ▶ **Food Security and Livelihoods** [\$62,585] : Training on agriculture, water and livestock management as well as vaccination trainings (examples are disease outbreak handling, provision of seeds that resist floods or can be harvested earlier, and kitchen gardening training)

## Research Questions

- 1 Do humanitarian aid interventions make individuals more **prepared** for emergencies?  
(**Preparedness**)
- 2 Can an improvement in intermediate outcomes improve life quality, regardless of whether a disaster occurs or not? (**Greater Impact**)
- 3 Are households in fact more **resilient** once a recurrent extreme weather event strikes?  
(**Resilience**)

- ▶ **Eligible pool** : Areas that have been heavily affected by disasters in the past, have not yet fully recovered from the massive 2010 and 2011 floods
- ▶ **Targeting** : Households with children under five years of age were selected randomly
- ▶ **Waves** : Yearly panel data over three waves (2015-2017), thereof 1 baseline and 2 follow-ups
- ▶ **Clustering** : Villages, named *goath* in Sindhi, combined into clusters (n=287)
- ▶ **Interviews** : 15 households per cluster, at least one 10+ villagers Focus Group Discussion
- ▶ **Stratification** : In two districts (Badin and Kashmore)

1.7

Times affected by disaster since 2010

21

USD monthly household income



50%

Shelter destroyed in 2010 and 2011

Loss of employment opportunities



60%

Poor food consumption score

Non-educated household heads



80%

No access to latrines



40%

At least one buffalo (70% with at least one animal)

## Randomization and Intention-to-Treat Effect

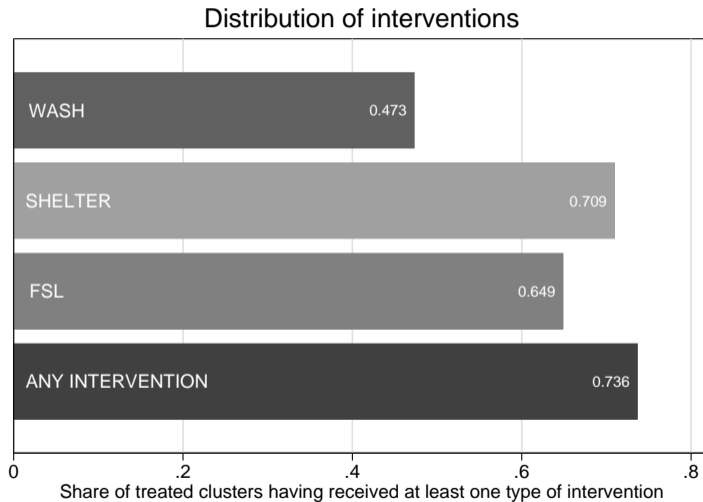
$$Y_{it} = \alpha_t + \beta D_i + \mathbf{X}_i \delta + u_{it},$$

- ▶ where  $Y_{it}$  is an outcome in *goath* cluster  $i$  ( $i = 1, \dots, 287$ ) in wave  $t$  ( $t = \textit{midline}, \textit{endline}$ ) i.e.,  $N = 574$
- ▶  $\alpha_t$  are wave fixed effects
- ▶  $D_i$  is an indicator for being assigned to the climate adaptation program,  $\beta$  identifies the intent-to-treat impact of the program on *goath* cluster  $i$
- ▶  $\mathbf{X}_i$  is the vector of baseline covariates (all variables that treatment was randomized on at baseline, i.e., at  $t=\textit{baseline}$ )
- ▶ same clusters over 3 waves of data collections, i.e., standard errors are clustered at the *goath*-cluster level
- ▶ reported statistical significance : \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ ,

## Baseline Data : Treatment vs. Control Group

	(1) <i>D</i>	(2) Control	(3) <i>Diff/SE</i>
<i>Exposure to natural disasters/extreme weather events</i>			
Number of times a village was affected by disasters since 2010	1.696	1.737	-0.041 (0.057)
Number of persons migrated out of village	187.142	178.878	8.264 (34.530)
<i>Consequences of natural disasters/need of assistance uptake</i>			
Employment opportunity loss is a reason for income loss	50.774	51.478	-0.704 (3.511)
Share of village clusters receiving assistance in the past 5 year	54.054	57.914	-3.860 (5.459)
<b>Shelters destroyed in 2010</b>	<b>49.489</b>	52.131	-2.642 (5.640)
Shelters destroyed in 2011	51.689	52.158	-0.469 (5.877)
<i>FSL</i>			
Share of HHs with poor food consumption score	61.943	64.365	-2.422 (2.920)
Share of people unable to cover their food needs	53.159	56.062	-2.904 (3.156)
Share of HHs with at least one livestock animal	71.539	70.891	0.647 (2.929)
Share of HHs with at least on buffalo	40.590	40.498	0.092 (3.294)
<i>WASH</i>			
Share of people washing hands with water only	72.989	72.570	0.419 (2.438)
Share of HHs with no access to latrines	79.968	80.427	-0.459 (2.582)
Share of HHs where at least one respondent had diarrhea	22.681	21.816	0.865 (2.098)
<i>Nutritional Status</i>			
Share moderate or severe : Weight-for-age z-score	44.080	44.705	-0.625 (1.814)
Share moderate or severe : Length/height-for-age z-score	50.088	49.507	0.581 (1.806)
<i>Household characteristics</i>			
Share of non-educated HH heads	60.809	62.519	-1.710 (2.433)
Average Poverty Score	18.677	18.598	0.079 (0.631)
Median income	2270.608	2113.129	157.479 (165.754)
Number of clusters	148	139	287

# Programme Delivery in Assigned Areas in 2016





## Results

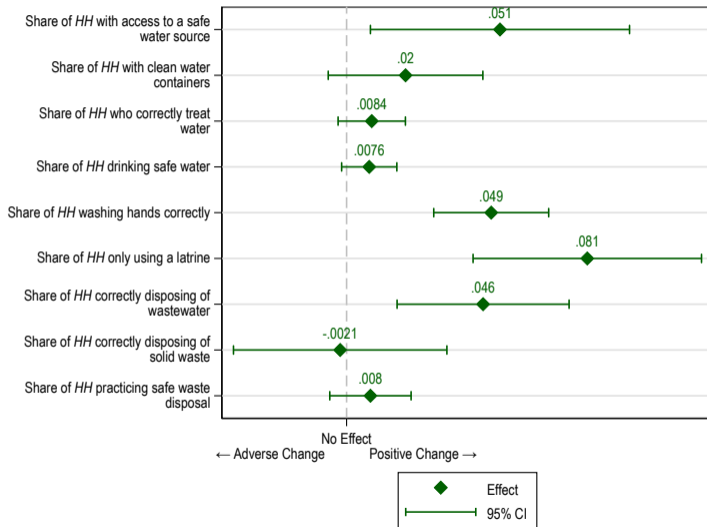


**Preparedness**

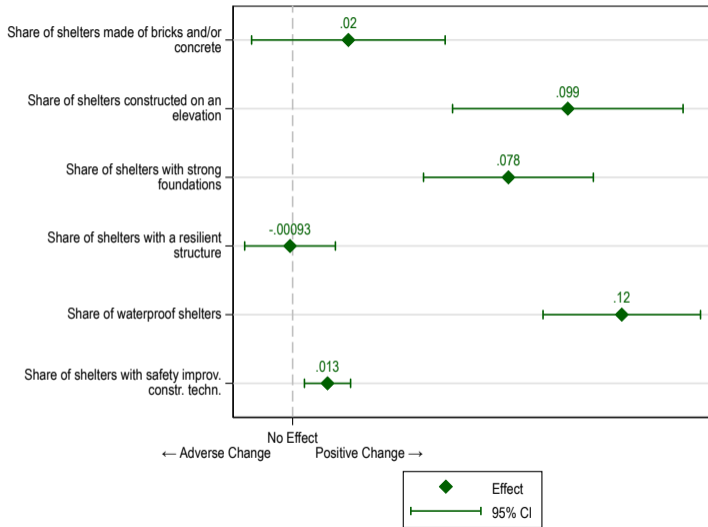
**Greater Impact**

**Resilience**

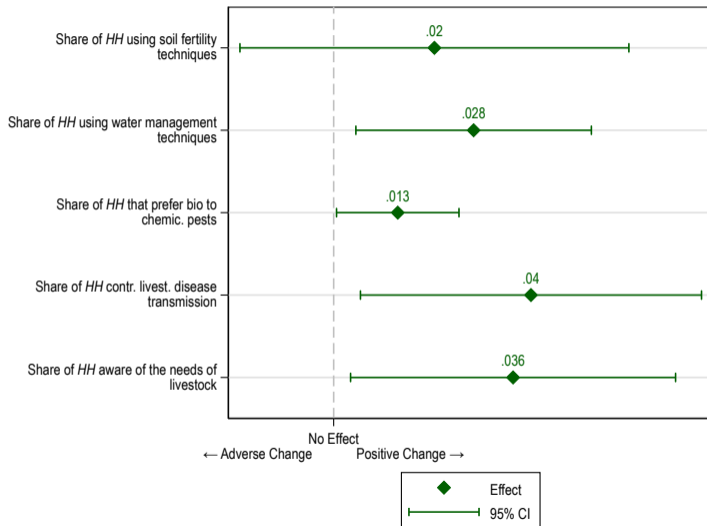
# Take-up : Climate Adaptation Water, Sanitation and Hygiene Activities



# Take-up : Climate Adaptation Shelter Activities



# Take-up : Climate Adaptation Food Security and Livelihoods Activities





Preparedness

Greater Impact

Resilience

# Direct Program Impacts

	(1) C-Mean (Control)	(2) C-SD	(3) <i>N</i>	(4) <i>D</i> ITT	(5) SE	(6) p-value	(7) q-value
<b>Panel A : Assets and Income</b>							
Share of shelters with currently observable damages	0.396	0.226	574	<b>-0.083</b>	0.019	***	***
Share of <i>HH</i> that own any livestock	0.676	0.232	574	<b>0.043</b>	0.016	***	**
Average number of buffaloes owned by <i>HH</i>	0.857	0.667	574	<b>0.086</b>	0.050	*	
Average monthly <i>HH</i> income	10580.208	3943.386	574	<b>301.766</b>	272.721		
Average outstanding <i>HH</i> debt	51107.268	36129.147	574	<b>-4360.660</b>	3265.406		
Average <i>HH</i> savings	272.699	554.965	574	<b>176.445</b>	100.858	*	
Share poor <i>HH</i>	0.672	0.191	574	<b>-0.001</b>	0.013		
Average size of irrigation land and rain-fed land (in acres)	3.625	1.490	565	<b>-0.016</b>	0.144		
<b>Panel B : Food-Security and Health</b>							
Share of <i>HH</i> with poor or borderline FCS	0.564	0.220	574	<b>-0.020</b>	0.017		
Share of <i>HH</i> with problems covering their food needs	0.332	0.225	574	<b>-0.006</b>	0.018		
Share of <i>HH</i> : at least 1 member had diarrhea last month	0.205	0.152	574	<b>0.002</b>	0.012		
Share of <i>HH</i> : at least 1 member was sick last month	0.754	0.184	574	<b>-0.001</b>	0.014		
Share of malnourished children (weight-for-age)	0.429	0.211	570	<b>0.004</b>	0.014		
<b>Panel C : Subjective Wellbeing</b>							
Share of <i>HH</i> with high life satisfaction	0.695	0.216	574	<b>0.057</b>	0.015	***	***
Share of <i>HH</i> feeling prepared for fut. disaster or <i>EWE</i>	0.266	0.203	574	<b>0.058</b>	0.016	***	***
Coping Strategy Index	4.308	4.805	574	<b>0.715</b>	0.434		*
Generalized Self-Efficacy Scale, 10/40	24.904	2.375	287	<b>0.547</b>	0.279	*	*
Generalized State-Trait Anxiety Inventory Scale, 10/40	27.806	1.966	287	<b>0.011</b>	0.213		



Preparedness

Greater Impact

Resilience

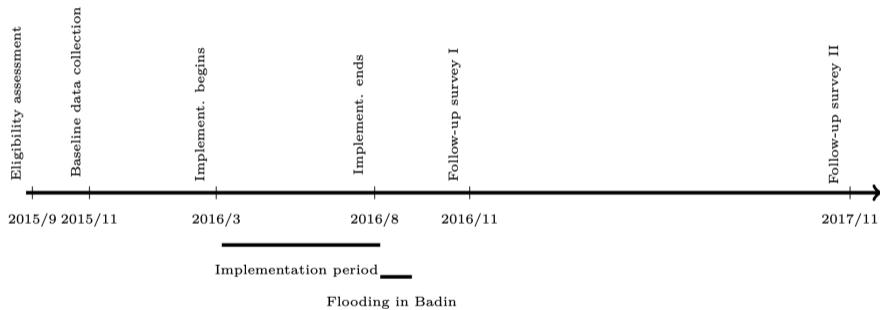


## Extreme Weather Events in Badin

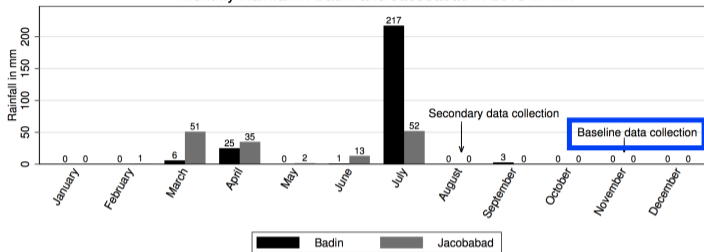


Heavy rainfalls in single months of July 2016 and August 2016, which coincides with the monsoon season.

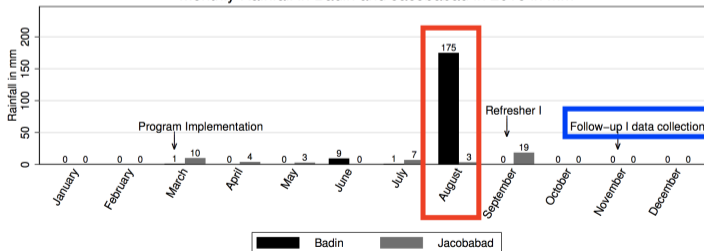
# Timeline



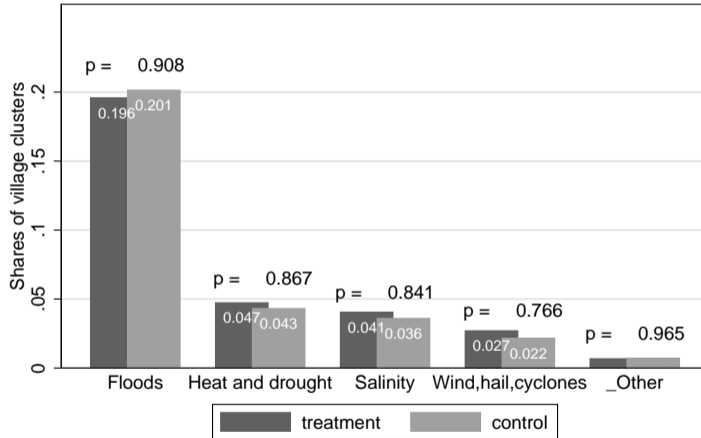
Monthly Rainfall in Badin and Jacobabad in 2015 in mm



Monthly Rainfall in Badin and Jacobabad in 2016 in mm



## Average occurrence of extreme weather events by treatment



No statistical difference in likelihood of being exposed to the extreme weather event in 2016 between treatment and control group.

## Ex-ante Preparedness and Extreme Weather Events

$$Y_{i,t} = \alpha_t + \beta_1 D_i + \beta_2 EWE_i \times D_i + \beta_3 EWE_i + \mathbf{X}_i \delta_1 + u_{it}$$

- ▶ where  $EWE_i$  is an indicator for having been affected by an extreme weather event
- ▶  $\beta_2$  resilience effect (captures the degree to which the communities recovers after the extreme weather event)
- ▶  $\beta_1 + \beta_2$  preparedness effect
- ▶ sample : Badin

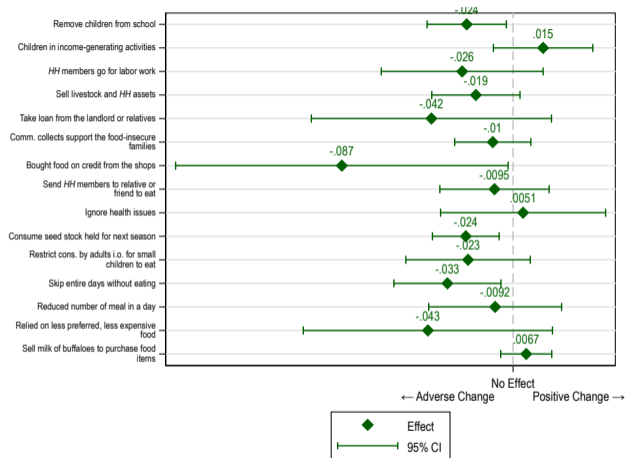
# Ex-ante Preparedness × Extreme Weather Event

	(I) Control Group		(II) Interaction Effects (incl. Resilience)				(III) Program Impacts (Adaptation, incl. Preparedness)		(IV) Targeting Heterogeneity		
	Mean	SD	D $\beta_1$	SE	D×EWE $\beta_2$	SE	EWE $\beta_3$	SE	$\beta_1 + \beta_2$	$p_{\beta_1 + \beta_2}$	$\Delta(x)$ nATE- rATE p-value (11)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
<b>Panel A : Assets and Income</b>											
Share of shelters with currently observable damages	0.413	0.207	-0.090	[0.043]**	<b>-0.064</b>	[0.06]	0.032	[0.04]	<b>-0.154</b>	***	0.166
Share of HH that own any livestock	0.571	0.234	0.007	[0.043]	<b>0.091</b>	[0.057]	-0.054	[0.038]	<b>0.099</b>	***	0.450
Average number of buffaloes owned by HH	0.474	0.399	0.000	[0.074]	<b>0.111</b>	[0.127]	-0.023	[0.083]	<b>0.111</b>		0.002 ***
Average monthly HH income	8422.735	1991.442	489.413	[427.685]	<b>-134.426</b>	[783.02]	134.854	[458.189]	<b>354.986</b>		0.016 **
Average outstanding HH debt	40159.478	26431.871	-1663.110	[6676.54]	<b>-1375.835</b>	[8294.325]	-1503.025	[6168.42]	<b>-3038.945</b>		0.327
Average HH savings	307.941	649.657	179.906	[221.548]	<b>50.106</b>	[312.09]	126.332	[214.619]	<b>230.013</b>		0.322
Share poor HH	0.588	0.179	-0.047	[0.025]*	<b>0.058</b>	[0.04]	-0.033	[0.028]	<b>0.010</b>		0.002 ***
Average size of irrigation land and rain-fed land (in acres)	3.179	1.252	0.054	[0.34]	<b>0.143</b>	[0.471]	0.317	[0.272]	<b>0.197</b>		0.09 *
<b>Panel B : Food-Security and Health</b>											
Share of HH with poor or borderline FCS	0.634	0.213	-0.049	[0.044]	<b>-0.004</b>	[0.064]	0.023	[0.041]	<b>-0.053</b>		0.640
Share of HH with problems covering their food needs	0.386	0.228	0.069	[0.037]*	<b>-0.172</b>	[0.052]***	0.107	[0.038]***	<b>-0.103</b>	***	0.543
Share of HH : at least 1 member had diarrhea last month	0.172	0.131	0.058	[0.022]**	<b>-0.118</b>	[0.031]***	0.043	[0.025]*	<b>-0.060</b>	***	0.071 *
Share of HH : at least 1 member was sick last month	0.676	0.181	0.042	[0.028]	<b>-0.136</b>	[0.044]***	0.068	[0.027]**	<b>-0.094</b>	***	0.043 **
Share of malnourished children (weight-for-age)	0.444	0.213	-0.002	[0.035]	<b>0.005</b>	[0.053]	0.061	[0.036]*	<b>0.003</b>		0.330
<b>Panel C : Subjective Wellbeing</b>											
Share of HH with high life satisfaction	0.763	0.164	0.022	[0.027]	<b>0.010</b>	[0.041]	-0.024	[0.027]	<b>0.032</b>		0.727
Share of HH feeling prepared for fut. disaster or EWE	0.262	0.165	0.055	[0.031]*	<b>0.042</b>	[0.048]	0.007	[0.032]	<b>0.097</b>	***	0.536
Coping Strategy Index	5.698	5.589	2.802	[1.149]**	<b>-3.013</b>	[1.468]**	2.717	[0.972]***	<b>-0.211</b>		0.483
Generalized Self-Efficacy Scale, 10/40	25.207	2.606	1.476	[0.7]**	<b>-1.171</b>	[0.999]	1.510	[0.728]**	<b>0.306</b>		0.327
Generalized State-Trait Anxiety Inventory Scale, 10/40	28.765	1.862	0.126	[0.422]	<b>0.055</b>	[0.602]	-0.218	[0.466]	<b>0.181</b>		0.107

The effect of the program differs, depending on whether an extreme weather event occurred or not.

► detailed coping strategies

# Coping Strategies : Preparedness × Extreme Weather Event



Notes : The figure displays on the left the indicators which are part of the coping strategy index. The figure displays the coefficients of the interaction effect of the variables  $D_i$  and  $EWE$ . Observations are measured at the household level, with standard errors being clustered at the *goath*-cluster level.

Presenting first causal estimates of the effects of climate adaptation program :

- ▶ **Preparedness** : Villagers have adapted and applied the messages and interventions delivered by the NGO
- ▶ **Greater Impact** : Households reportedly feel better prepared for natural disasters, own more livestock and have more savings
- ▶ In interaction with 2016 excessive floods, greater resilience w.r.t. food needs and diarrhea (of children)
- ▶ A **cost-effectiveness analysis** suggests solid returns to investment (benefit-cost ratio of 1.2 dollar)



For policymakers and program implementers

- ▶ **Preparedness** : Adjustment in programming (locally at ACTED ; big conference and training in Islamabad ; general openness to and implementation of RCTs)
- ▶ Presentation of the results at the British parliament
- ▶ Consideration in the revision of WFP guidelines on malnutrition prevention (as part of the 3ie window)

## Important Open Research Questions

A better understanding of the interplay between the effectiveness of adaptation strategies (including their optimal targeting) and the quickly changing climate is needed

- ▶ The exploration of the **potential to adapt** will benefit from a more refined consideration of
  - ▶ informal coping strategies and role of preparedness insurance
  - ▶ gradual changes
  - ▶ mechanisms
  - ▶ more disaggregated assessment(s) of the local risks and responses
  - ▶ interplay of adaptation strategies with ex-post disaster relief
  - ▶ sources of heterogeneity - i.e., heterogeneity driven by different responses to adaptation strategies and specific more or less effective treatment activities
- ▶ Replication in other settings

Thank you.

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## Impacts of Extreme (Weather) Events : Empirical Evidence

- ↓ **Risk** : Reduced propensity to take risks up to nine years after the disaster (Cameron and Shah 2015); fewer and less riskier investments (Binswanger et al. 1993; Dercon and Krishnan 1996)
- ↑ **Poverty** : 47-57 % (Datt and Hoogeveen 2003)
- ↓ **Education** : Herding households less likely to complete mandatory education, both in the long and medium terms (Groppo and Kraehnert 2017); intergenerational transmission (Caruso and Miller 2015)
- ↑ **Borrowing** : Del Ninno et al. (2003)
- Δ **Consumption** : Hunger [due to war] → larger fraction of income spent on food throughout life (Kesternich et al. 2015)
- ↑ **Mortality** : Exposure at birth to (weather-related) famine → boys and girls lose on average 4, respectively 2.5 years of life after age 50 (Lindeboom et al. 2010)

## Preparedness to Disasters/ Climate Change Adaptation

- ▶ Dacy and Kunreuther (1969) “The Economics of Natural Disasters” : Importance of resource allocation for recovery activities - emergency disaster plans ; early warning systems
- ▶ Barreca et al. (2016) : In the US, air conditioners reduce the mortality risk associated with high temperatures during the twentieth century
- ▶ Luechinger and Raschky (2009) find that flood disasters lower life satisfaction in regions without mandatory insurance, yet in regions with mandatory flood insurance the effect on life satisfaction was unchanged
- ▶ Von Peter et al. (2012), cross-c., uninsured disaster-related losses lead to income declines whereas there is no negative effect for insured losses (see also Noy (2009))

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# Mediation (through Preparedness) Analysis

	(I) Average Causal Mediation Effects		(II) Average Direct Effect		(III) Total Effect		
	(1)	(2)	(3)	(4)	(5)	(6)	
<b>Panel A : Subjective Wellbeing</b>							
Share of <i>HH</i> that belief that NGOs do a good job	<b>0.018</b>	0.008	**	<b>0.042</b>	0.019	<b>0.060</b>	0.019
Share of <i>HH</i> feeling prepared for future disaster/ <i>EWE</i>	<b>0.021</b>	0.011	*	<b>0.038</b>	0.027	<b>0.059</b>	0.027
Share of <i>HH</i> with high life satisfaction	<b>0.018</b>	0.009	*	<b>0.049</b>	0.022	<b>0.066</b>	0.022
Mean coping strategy index	<b>0.113</b>	0.272		<b>0.960</b>	0.691	<b>1.073</b>	0.671
<b>Panel B : Assets and Income</b>							
Share of shelters with currently observable damages	<b>-0.027</b>	0.011		<b>-0.029</b>	0.026	<b>-0.056</b>	0.025
Share of <i>HH</i> that own any livestock	<b>0.029</b>	0.010	***	<b>0.023</b>	0.023	<b>0.052</b>	0.023
Average number of buffaloes owned by <i>HH</i>	<b>0.036</b>	0.027		<b>0.011</b>	0.068	<b>0.047</b>	0.066
Average size of irrigation land and rain-fed land (in acres)	<b>0.037</b>	0.091		<b>-0.199</b>	0.222	<b>-0.162</b>	0.215
Average monthly <i>HH</i> income	<b>-171.507</b>	169.735		<b>536.820</b>	442.159	<b>365.313</b>	426.994
Average outstanding <i>HH</i> debt	<b>-785.022</b>	1610.745		<b>-3376.638</b>	4142.537	<b>-4161.661</b>	4026.651
Average <i>HH</i> savings	<b>40.179</b>	35.200		<b>166.339</b>	87.698	<b>206.518</b>	85.511
Share poor <i>HH</i>	<b>-0.012</b>	0.008		<b>0.012</b>	0.019	<b>0.000</b>	0.019
<b>Panel C : Food-Security and Health</b>							
Share of <i>HH</i> with poor or borderline <i>FCS</i>	<b>-0.020</b>	0.010		<b>-0.003</b>	0.025	<b>-0.023</b>	0.024
Share of <i>HH</i> with problems covering their food needs	<b>-0.010</b>	0.009		<b>-0.011</b>	0.023	<b>-0.021</b>	0.022
Share of <i>HH</i> : at least 1 member had diarrhea last month	<b>-0.019</b>	0.006		<b>0.038</b>	0.014	<b>0.019</b>	0.014
Share of <i>HH</i> : at least 1 member was sick last month	<b>-0.015</b>	0.008		<b>0.022</b>	0.021	<b>0.007</b>	0.020
Share moderate or severe : Weight-for-age z-score	<b>-0.006</b>	0.011		<b>-0.012</b>	0.029	<b>-0.018</b>	0.028