Remittances and Private Adaptation Strategies against Natural Disaster events?

Evidence from the Cyclone Sidr hit regions in Southern Bangladesh

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Background

Considering the increasing frequency and severity of storm events due climate change,

- Government, developing agencies and civil society organizations contribute towards funding of major storm mitigation programs.

- However, government is facing difficulty to support enough public initiatives to properly protect coastal communities (IPCC, 2014; The World Bank, 2010)

Background

- Research reveals that majority of such investments are uncoordinated (Ford et al., 2015; Ciner et al. 2018).

- Often fail to incorporate *private indigenous adaptive* capacities of the coastal communities.

Background

- Given such developments, this paper examines two key issues associated with poor coastal households:

  Issue 1: to assess the impact of increasing remittances on private investment of storm protection.

  Issue 2: to see whether publicly financed storm mitigation programs, such as embankments, cyclone shelters, etc. have the potential to partially or fully crowd out private investment in storm protection.

Background

Empirical evidence reveal **private defensive strategies against storm damages** might be influenced by,

Factor 1:
Perception on natural disaster risk – individuals seem to treat it as a low probability but high consequence event

(Kahneman & Tversky, 1979; Kunreuther et al., 2013; Botzen et al.2015)

Factor 2:
Communities access to publicly sponsored storm protection programs - might lead to partial or full crowding out effect

(Botzen & van den Bergh, 2008; Bubeck et al. 2012; Mahmud & Barbier, 2016)

Factor 3:
Role of private remittances – to reduce the magnitude of losses to properties

(**No comprehensive evidence**; *evidence showing remittances increases with a natural disaster event*; Clarke and Wallsten, 2003; Yang and Choi, 2007; Mohapatra et al., 2012)

For Low-income Coastal Households:
Bangladesh perspective

Examples of private investment on storm protection actions are,

- Converting mud-built house to brick-built house;
- Raising the height of the homestead;
- Increase in number of floors;
- Installation of tube well for safe drinking water;
- Modernization of toilet;
- Improvement of domestic animal sheds, ponds;
- Improvement of boundary of the house;
- Raising the plinths;

Research Hypothesis

Do <u>access to remittances</u> and <u>publicly sponsored storm mitigation programs</u> influence the economic behavior of the coastal households by *partially or fully crowding out* private storm-protection actions?

Methodology Adopted

Following **Mahmud and Barbier (2016)**, propose a household model of private investment in storm protection under an endogenous risk framework

Introduce a **theoretical model** combining household Production function with endogenous risk framework.

→

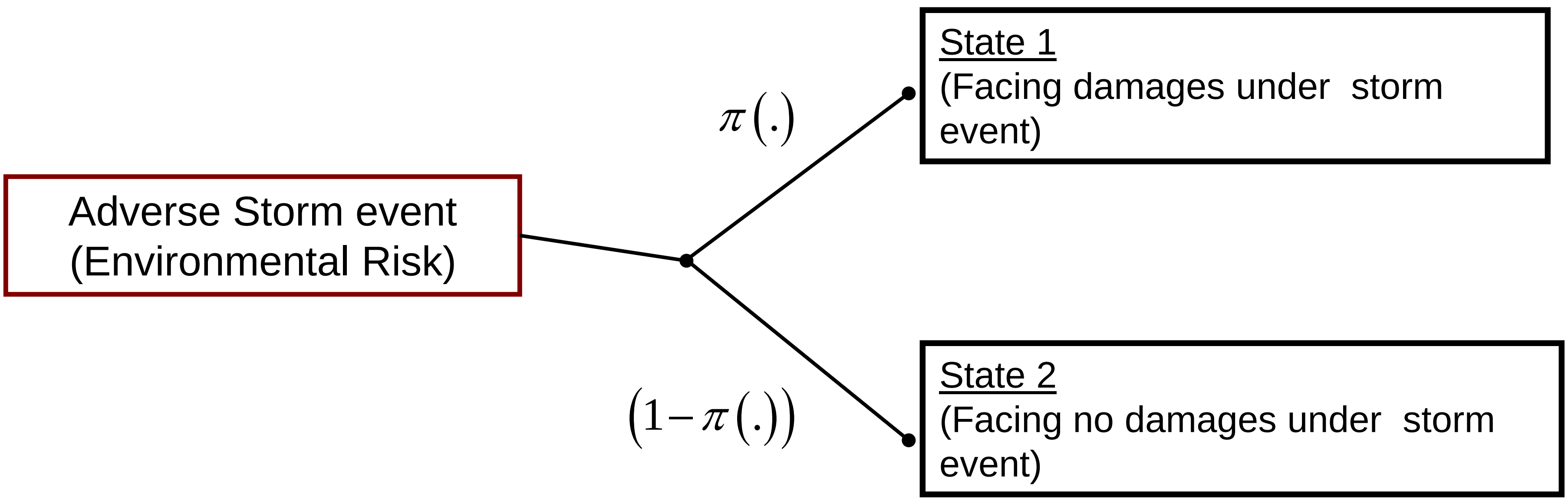
Household choose the level of private investment in storm protection against ex-post storm-inflicted property damage risk.

→

Perform **an empirical analysis** on areas most vulnerable to major storm events as a result of global climate change

Household Model of Private Investment

- Probability tree of a sequence of events:



- Assume one possible adverse storm event and two possible states of nature
- Damages are in terms of death and injury in the family, loss of assets, loss of domesticated animals, crops, and trees.

Household Model of Private Investment

- *Household Maximization Problem:*

$$\underset{S}{Max}\ E(U) = \begin{bmatrix} \pi\left(S;G\right)\cdot U^{SE}\left(I-S-L\left(S;R,G\right)\right) \\ +\left(1-\pi\left(S;G\right)\right)\cdot U^{NSE}\left(I-S\right) \end{bmatrix}$$

First-order condition, $\dfrac{\partial EU}{\partial S}$,

$$\underbrace{\pi_S \cdot \left[U\left(W_1\right)-U\left(W_2\right)\right]}_{\substack{\text{Expected marginal benefit of} \\ \text{private investment in storm protection}}} = \underbrace{\left[\pi\left(.\right)\cdot\left(1+L_S\right)U^{'}(W_1)+\left(1-\pi\left(.\right)\right)\cdot U^{'}(W_2)\right]}_{\substack{\text{Expected marginal cost of} \\ \text{private investment in storm-protection}}}$$

Comparative Static Results

Table 1: Behavioral economics of influence of foreign and domestic remittances on private investments on storm protection

Variable	Marginal Analysis Condition	Behavioral Outcome
Increasing flow of remittances	$EMB_S > EMC_S$	$\frac{dS}{dR} < 0$
	$EMB_S < EMC_S$	$\frac{dS}{dR} > 0$
Access to publicly funded storm mitigation programs	$EMB_S > EMC_S$	$\frac{dS}{dG} > 0$
	$EMB_S < EMC_S$	$\frac{dS}{dG} < 0$

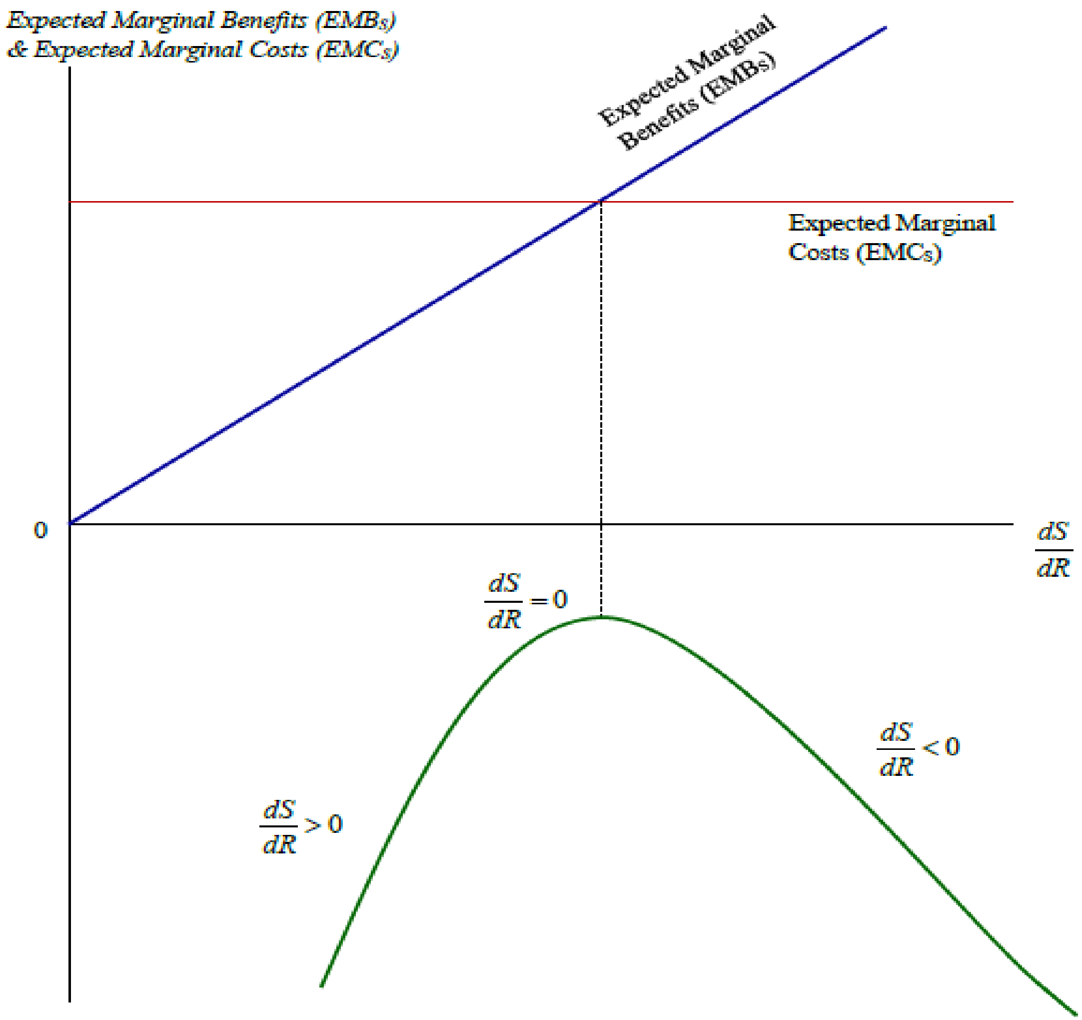
Comparative Static Results

Outcome 1: For a risk-averse coastal household, increasing flow of remittances leads to higher private investment in storm protection (increasing private storm protection actions), i.e. $\frac{dS}{dR} > 0$, if and only if expected marginal benefits of private investment in storm protection, $\pi_S\left[U(W_1) - U(W_2)\right]$, is *lower* than expected marginal costs of private investment in storm protection, $\left[\pi \cdot (1+L_S) \cdot U_S(W_1) + (1-\pi) \cdot U_S(W_2)\right]$.

Outcome 2: For a risk-averse coastal household, increasing flow of remittances leads to lower private defensive expenditures (or, decreasing private storm protection actions), i.e. $\frac{dS}{dR} < 0$, if and only if expected marginal benefits of private defensive expenditures, $\pi_S\left[U(W_1) - U(W_2)\right]$, is *higher* than expected marginal costs of private defensive expenditures, $\left[\pi \cdot (1+L_S) \cdot U_S(W_1) + (1-\pi) \cdot U_S(W_2)\right]$.

Comparative Static Results:

Behavioral Outcomes of Private Storm Protection Actions

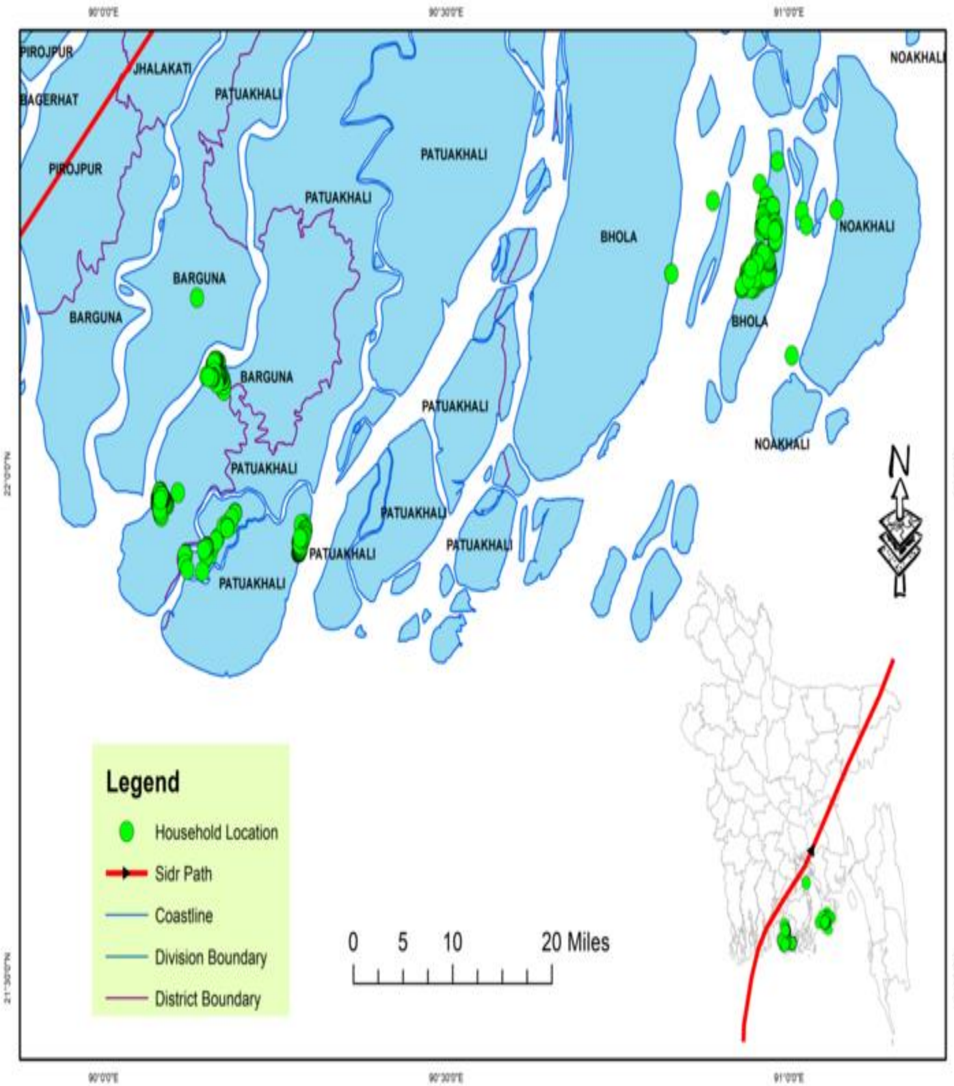


Comparative Static Results

Outcome 3: For a risk-averse coastal household, increasing access to publicly financed storm mitigation programs leads to increase in private defensive expenditures against a major storm event, i.e. $\frac{dS}{dG} > 0$, if and only if expected marginal benefits of private defensive expenditures, $\pi_S\left[U(W_1) - U(W_2)\right]$, is *higher* than the expected marginal costs of private defensive expenditures, $\left[\pi \cdot (1+L_S) \cdot U_S(W_1) + (1-\pi) \cdot U_S(W_2)\right]$.

Outcome 4: For a risk-averse coastal household, increasing access to publicly financed storm mitigation programs leads to decrease in private investment in storm protection, i.e. $\frac{dS}{dG} < 0$, if and only if expected marginal benefits of private investment in storm protection, $\pi_S\left[U(W_1) - U(W_2)\right]$, is *lower* than the expected marginal costs of private investment in storm protection, $\left[\pi \cdot (1+L_S) \cdot U_S(W_1) + (1-\pi) \cdot U_S(W_2)\right]$.

Study Area



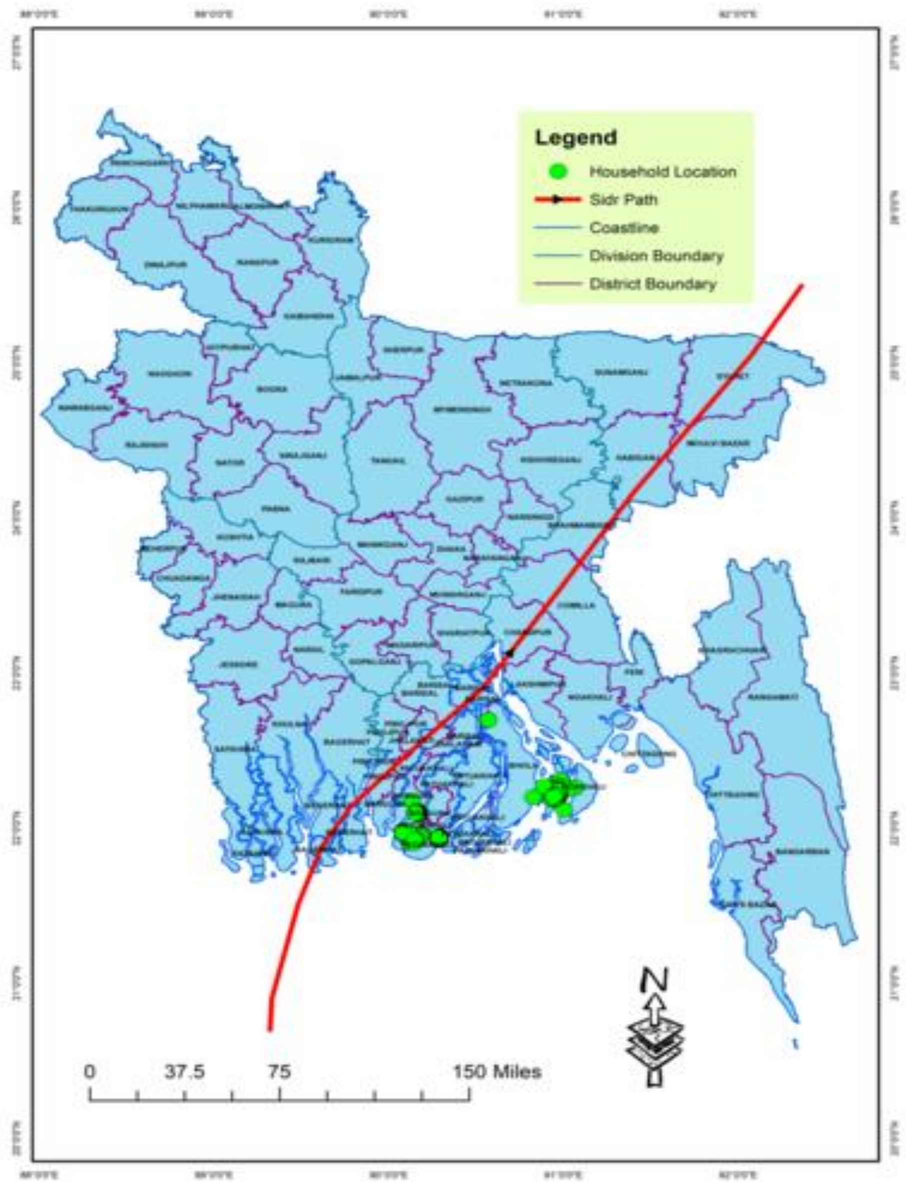
Data Set

Sampling Method: Two-stage sampling,
1st stage: Simple random sampling to pick villages
2nd stage: Systematic random sampling to pick households from the selected villages

Sample size: 610 Households
Survey conducted: November 2016

Zilla	3
Upazila	3
Union	3
Villages	23

Study Area



Questionnaire Includes

- Demographics, Occupation;
- Education levels;
- Remittance information;
- Social Status;
- Housing condition;
- Location of the house from:
    - Cyclone shelter
    - Embankment
    - Vehicular road
    - Primary school
- Tidal surge / Cyclone exposure
- Housing structure change between two major cyclones
- Damages during two cyclones
- Asset ownership; loans
- Migration
- Social network.

Key Characteristics of the Study Area

Table 3: Key Characteristics of Households based in the Survey area

Household Characteristics		Value
Respondent age (Mean)		41.49
Respondent gender (%)	Male	66.39
	Female	33.61
Respondent education (%)	No education	30.49
	Primary (Class 1-5)	42.13
	SSC	13.11
	HSC	5.74
	Diploma	0.33
	Undergraduate	0.98
	Masters	0.66
	Others	6.57
Respondent occupation (%)	Farmer	15.82
	Fisherman	9.82
	Timber Business	4.46
	Shrimp fry collector/ Shrimp fisher	23.72
	Business	7.91
	Salaried	14.16
	Professional	0.89
	Day laborer	2.68
	Others	7.02
	Housewife	9.18
	Student	4.34
Domestic migrants in family (%)		41.80
Foreign migrants in family (%)		17.21
Type of latrine (%)	Water-sealed sanitary latrine	21.66
	Sanitary latrine	7.17
	High commode latrine	18.62
	Non-sanitary latrine	8.41
	None	44.14
Sources of drinking water (%)	Tubewell	31.10
	Pondwater	4.68
	Filters for water purification	36.47
	Tap water	27.75
Sources of energy for cooking (%)	Cylinder gas	12.79
	Biogas	0.31

Key Characteristics of the Study Area

Sources of energy for cooking (%)	Cylinder gas	12.79
	Biogas	0.31
	Fuelwood	16.95
	Dung and leaves	69.95
Location of the house (%)	Within polder	31.15
	On embankment	23.45
	Lowland	33.45
	Near forest	11.94
Solar power (%)		95.41
Electricity connection (%)		0.82
Access to television (%)		7.70
Access to telephone connection (%)		19.02

Damages and Adaptation:

Post-Cyclone Sidr (2007) & Post-Cyclone Roanu (2016)

Variable name	Description	Percentages (%)
Damages during Cyclone Sidr (2007)	Death in the family (157)	7.28
	Injury in the family (8)	0.37
	Loss of assets (385)	17.85
	Loss in domestic animals (589)	27.31
	Loss in crops (569)	26.38
	Loss in trees (447)	20.72
	No loss (2)	0.09
	Total frequencies (2157)	**100**
Damages during Cyclone Roanu (2016)	Death in the family (20)	1.72
	Injury in the family (3)	0.26
	Loss of assets (114)	9.78
	Loss in domestic animals (358)	30.70
	Loss in crops (300)	25.73
	Loss in trees (203)	17.41
	No loss (168)	14.41
	Total frequencies (1166)	**100**
Adaptation post-Cyclone Sidr (2007)	Repair of walls (39)	1.85
	Increase in number of floors (519)	24.67
	Brick wall (163)	7.75
	Tube well for water (514)	24.43
	Modernization of toilet (48)	2.28
	Improvement of domestic animal sheds (45)	2.14
	Improvement of pond areas (247)	11.74
	Improvement of boundary of the house (211)	10.03
	Others	15.11
	Total frequencies (2104)	**100**
Adaptation post-Cyclone Roanu (2016)	Repair of walls (21)	2.93
	Increase in number of floors (104)	14.53
	Brick wall (36)	5.03
	Tube well for water (256)	35.75
	Modernization of toilet (7)	0.98
	Improvement of domestic animal sheds (6)	0.84
	Improvement of pond areas (92)	12.85
	Improvement of boundary of the house (52)	7.26
	Others (142)	19.83
	Total frequencies (716)	**100**

Sources of funds for Adaptation

Event name	Sources of funds	Percentage (%)
For adaptation after Cyclone Sidr (2007)	Savings (470)	35.15
	Loan (214)	16.01
	Donation (388)	29.02
	Help from friends/ relatives (87)	6.51
	Sold land / asset (178)	13.31
	Total frequencies (1334)	100
For adaptation after Cyclone Roanu (2016)	Savings (262)	46.70
	Loan (72)	12.83
	Donation (119)	21.21
	Help from friends/ relatives (4)	0.71
	Sold land/ asset	18.54
	Total frequencies (561)	100

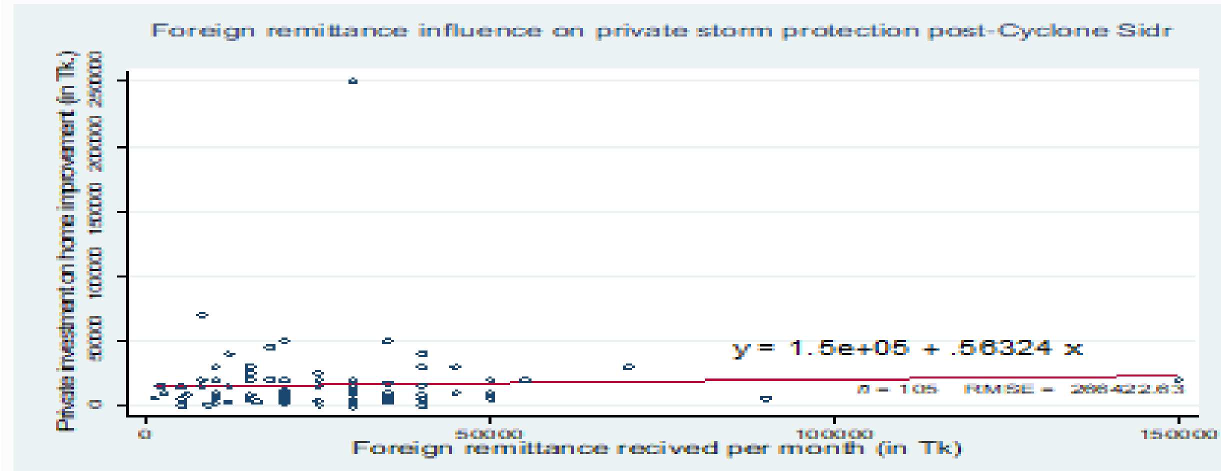
Household Perception:

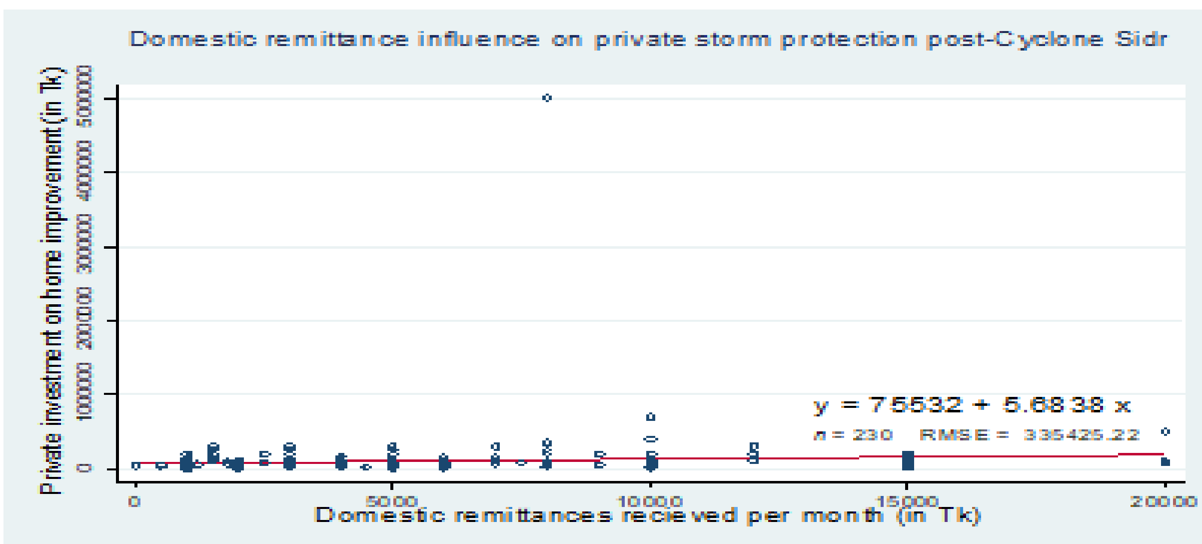
Flooding/ water logging from major cyclone events

	Total 'Yes' responses	Percentages
Entire Study Area	570 (610)	93.44
Patuakhali	191 (201)	95.02
Borguna	206 (207)	99.52
Bhola	173 (202)	85.64

Foreign and Domestic Remittance:

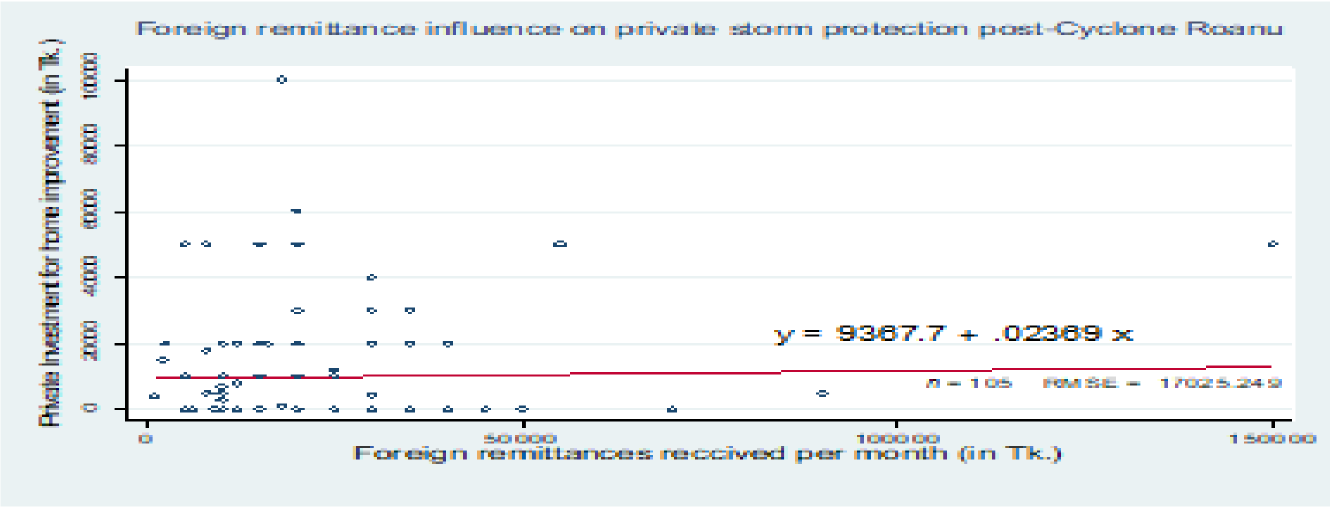
Influence on private storm protection post-Cyclone Sidr

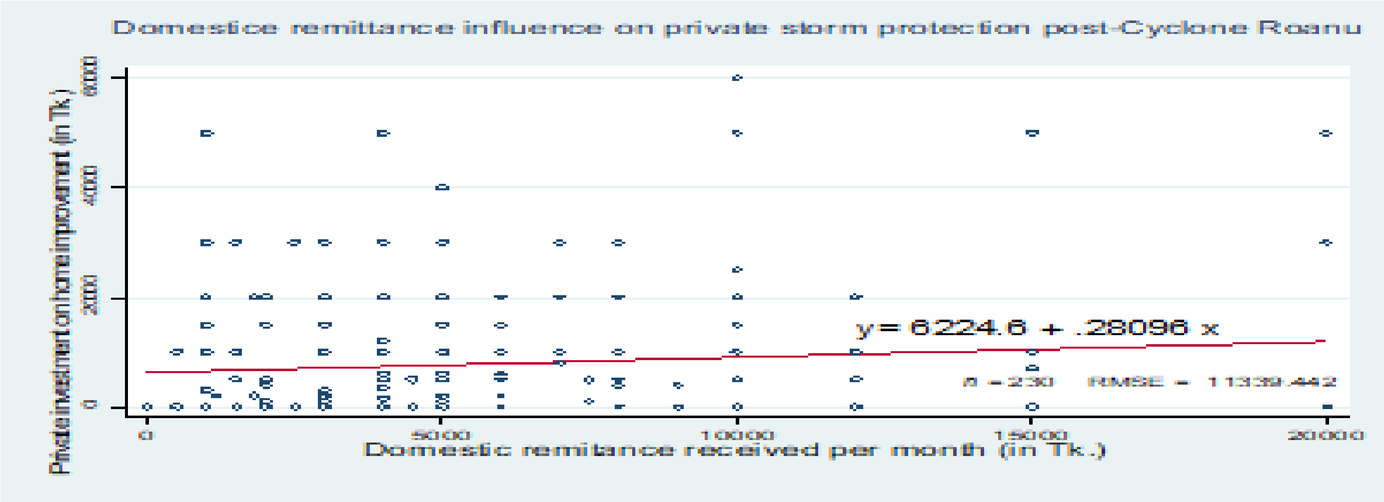




Foreign and Domestic Remittance:

Influence on private storm protection post-Cyclone Roanu





Damages and Adaptation:

Post-Cyclone Sidr (2007) & Post-Cyclone Roanu (2016)

Variable	*Definition*	*No. of Obs.*	*Mean*	*Standard Deviation*
Dependent Variables				
PRIHOMECS	Household spending on home improvement after Cyclone Sidr (in Tk.)	610	114293.4	257082.0
PRIHOMECR	Household spending on home improvement after Cyclone Raono (in Tk.)	610	9321.166	18344.22
Independent Variables				
REMITFOR	Foreign remittance received per month (in Tk.)	105	25690.50	19285.60
REMITDOM	Domestic remittance received per month (in Tk.)	230	6187.39	4036.48
AGE	Age of the respondent (in years)	610	41.485	13.975
AGE2	Age squared of the respondent (in years)	610	1916.02	1246.36
MEMBER	Total members living in the house	610	5.761	2.289
FORMEM	Total members of the household living and working in foreign countries	105	1.133	0.369
FEMMEM	Total female members living in the house	610	2.7777	1.4574
FEWMEM	Total female workers in the house	610	0.1639	0.4319
FSTU	Total female students in the house	610	0.6754	0.8041
CSCH	School going children below 7-years age	610	0.3377	0.5562
FAMINC	Family Income per month (in TK.)	610	16894.75	14656.47
MEDEXP	Medical expenditures per month (in Tk.)	610	1648.77	1318.40
EDUEXP	Education expenditures per month (in Tk.)	610	1922.95	2196.35
HOMEST	Area of the homestead (in Decimals)	610	34.41	80.23
AGLAND	Area of agricultural land (in Decimals)	323	187.675	317.596
DISEMB	Distance from nearest embankment (in km.)	610	0.696	0.736
DISCYSH	Distance from nearest cyclone shelter (in km.)	610	1.345	0.840
DISPS	Distance from nearest primary school (in km.)	610	1.149	0.837
DISVR	Distance from nearest vehicular road (in km.)	610	1.192	1.227

Empirical Analysis:
Hypotheses

Hypothesis 1. A household receiving either foreign remittances in the aftermath of a crisis from the migrant member(s) invests more in private storm protection activities to reduce the severity of future storm-inflicted damages.

Hypothesis 2. A household's access to publicly financed storm mitigation programs, such as, cyclone shelters, embankments, dams, etc. lead to less investment in private storm protection actions.

Econometric Strategy

- Our survey questions allowed us to capture the strategies that households' privately adopted to avert the likelihood and reduce the severity of storm-inflicted damages to properties covering almost a 10-year timeframe (Nov. 2007 to Dec. 2016).

- We identified households of two (2) types:
  - (**Type 1**) Households that have *migrant family member(s)* and hence, have access to monthly or yearly remittances; and,
  - (**Type 2**) Households that have *no migrant family member* and hence, do not have access to remittances.

Econometric Strategy

- Our baseline model of analysis is:

$$y_{ij} = \alpha_{ij} + \gamma \times R_{ij} + \boldsymbol{X}_{ij} \times \theta + u_{ij} \qquad (1)$$

Where, *y* is the expenditure on home improvement Post-Cyclone Sidr for household *i* in village *j*, *R* is the receipt of foreign remittances, **X** is vector of household characteristics.

- Makes sense to assume a-priori that $E(u|R) \neq 0$.

- Also, the p-value of the omitted variable test is slightly above .05 which means we cannot reject the null (no OVB) at 5%.

- Our survey, in fact, shows that majority of the households migration decision is influenced by their preference for storm-inflicted damage avoidance.

- Therefore, the instrumental-variables (IV) estimator would be the choice of our preferred estimators.

Econometric Strategy

- **Using natural experiment** as an identification strategy, we estimate a remittances equation in the **first stage** using,

Two instruments:

i) the distance of the household from the nearest vehicular road (Z_1) and,

ii) the distance of the household from the nearest primary school (Z_2).

Here, variables **Z** correlated with remittances that satisfy the exclusion restrictions, i.e. $E(u|\boldsymbol{Z}) = 0$.

Econometric Strategy

- **An indicator variable**:
  Regarding whether the households' homes suffered damage by Cyclone Roano (the treatment group) controlling for several variables including village fixed effects.

  Modified baseline regression becomes:

$$y_{ij} = \alpha_{ij} + \gamma \times R_{ij} + \boldsymbol{X}_{ij} \times \theta + F_j + u_{ij} \qquad (2)$$

  Where, F_j is the village fixed effects.

- In the **second stage** regression, where the dependent variable is private adaptive expenditure undertaken after Cyclone Sidr, the coefficient on remittances measures the "average treatment effect" for the treatment group.

Findings from Econometric Analysis

Why considering households' homes affected by Cyclone Roano as indicator variable?

- This is to meet the exclusion criterion under a natural experiment.
- The randomized instrument (Z_3) affect the dependent variable, private investment in storm protection, ONLY through the treatment variable, amount of foreign remittances received.
- The *exclusion criteria* excludes any possibility of the randomised instrument to affect the dependent variable directly.
- It is achieved because damages incurred due to Cyclone Roanu cannot affect private expenditure on home improvement after Cyclone Sidr.

Findings from Econometric Analysis

- Using this identification method, we find that a Tk. 1000 increase in foreign remittances lead to an increase in private adaptive expenditures of Tk. 18.06.

- The effect of remittances is found to be significant at 5% level.

- The first stage F-statistic on excluded instrument is found to be 17.81 which is greater than the rule-of-thumb value of 10 implying instruments are valid.

- The p-value for the Basman F – statistic 0.04 which means over identification condition may not be valid.

Findings from Econometric Analysis

- To overcome the problem of *overidentification*,

  We constructed another instrument, i.e. Z_3 which is formed by taking the distance to nearest vehicular road (Z_1) interacted with an indicator variable for whether the households' homes suffered damage by Cyclone Roano.

- The use of a single instrument helps us to get around the problem of identification because it leads to the *exact identification* of the equation.

Findings from Econometric Analysis

- Using this strategy, we report that a Tk. 1000 increase in foreign remittances lead to an increase in private adaptive expenditures of Tk. 20.95.

- The resulting estimation coefficient, measuring the “average treatment effect” for the treatment group (remittances recipient household affected by Cyclone Roanu) is significant at 1% level.

- The first-stage F-statistic is 9.13, which is just higher than 15% of relative bias.

Regression Analysis:

IV-LIML estimator Post-Cyclone Sidr

Table 8: Instrumental Variable Limited Information Maximum Likelihood (IV-LIML) Model to capture Foreign Remittance Influence on Private Storm Protection Expenditures after Cyclone Sidr

Regressand	Private spending on home improvement after Cyclone Sidr	
Instrumented	Foreign remittance received per month (in Tk).	
Instrumental variables	***DISPS, DISVR, DMROANU***	***DISVR*DMROANU***
CONSTANT	85090.12 (0.53)	92714.96 (0.52)
REMITFOR	18.066 (2.49)***	20.951 (6.09)***
AGE	5081.261 (1.06)	6304.07 (1.84)**
AGE2	-61.388 (-0.76)	-82.499 (-1.46)*
MEMBER	13273.64 (0.47)	16769.42 (0.63)
FEMMEM	-845505.31 (-1.99)**	-93206.47 (-2.60)***
FEWMEM	146857.6 (2.05)**	169639.4 (6.38)***
FSTU	119180.1 (2.51)***	128710.9 (2.89)***
CSCH	54676.18 (1.35)*	52014.02 (1.23)
FORMEM	112832.7 (1.48)	136906.1 (1.86)**
MEDEXP	32.429 (1.65)*	35.799 (1.58)*
EDUEXP	-47.277 (-4.29)***	-48.338 (-3.83)***
FAMINC	-12.559 (-2.12)**	-14.897 (-4.04)***
HOMEST	1909.98 (1.35)*	2116.51 (1.26)
AGLAND	76.273 (0.88)	85.297 (0.94)
DISEMB	4388.68 (0.21)	419.69 (0.02)
DISCYSH	69384.41 (2.67)***	65396.61 (2.52)***
No. of observations	50	50
Prob. > χ^2	0.000	0.000
R-squared	0.7088	0.6492
Wald χ^2	231.11	433.55
1st stage summary statistics	R^2=0.9910; Adj. R^2 = 0.9370; Prob>F = 0.0000 Robust F-Stat = 17.8153 (3, 18)	R^2=0.9741; Adj. R^2 = 0.8605; Prob>F = 0.0073; Robust F-Stat = 9.1379 (1, 18)

Z-tests are shown in parentheses beneath coefficient estimates. Significance levels: ***1%, **5%, *10%.

Regression Analysis:

IV-LIML estimator Post-Cyclone Sidr

Table 9: Results of external validity test

Treatment Group (Group 1): *Remittance recipient affected by Cyclone Roanu* **Non-treatment Group** (Group 0): *Remittance recipients not affected by Cyclone Roanu*			
Confounding Variables	**Mean difference**	**t-test**	**p-value** *(Mean differences being zero)*
REMIFOR***	-23089.29	-3.0574	0.0034
AGE	1.464	0.1580	0.8750
AGE SQAURED	140.083	0.1779	0.8594
MEMBER**	2.577	1.9308	0.059
FEMMEM	1.024	1.321	0.1919
FEWMEM	0.3393	1.062	0.2925
FSTU	0.1548	0.3803	0.7051
CSCH*	0.4286	1.474	0.1459
FORMEM	0.1250	0.6435	0.5225
MEDEXP	-625.00	-0.5519	0.5832
FAMINC	-22821.43	-2.3739	0.0210
HOMEST	13.506	0.5994	0.5513
AGLAND	117.439	0.5535	0.5825
DISEMB	0.5	0.8956	0.3796
DISCY	0.4125	0.9173	0.3628
R1	-0.0714	-0.4722	0.6386
FARMER	-0.2262	-0.4722	0.2452
FISHER	0.0536	0.4050	0.6870
PRIMARY	0.1488	0.4953	0.6223
SECONDARY	-0.4345	-1.696	0.0953
HIGHER SECONDARY	0.1250	0.6435	0.5225
UNDERGRAD	0.0357	0.3276	0.7444
Degrees of Freedom	**57**		

Regression Analysis:
Summary of the key findings

- Both foreign and domestic remittances lead to increase in private investment in storm protection after a major storm event.

Thus, **Hypothesis 1** and **Outcome 1** are empirically supported.

- Influence of public sponsored storm mitigation programs, such as embankments and cyclone shelters, on private investment in storm protection actions are ambiguous

Cannot reach a conclusion for **Hypothesis 2** and **Outcome 4**

Contributions to Literature

- Theoretical model of household private investment in storm protection could be generalized to all coastal communities, especially in developing countries, affected by climate change.

- Empirical findings reveal households with migrant members (both domestic and foreign) are more climate resilient as they undertake a range of *effective private indigenous* storm-protection actions in the countries with poor coastal-based communities.

Policy Implications

- To support climate adaptation in the vulnerable coastal-based communities,

  First, public-partnerships of key stakeholders of the migrant countries should be encouraged to create development funds targeted to strengthen **long-term adaptive capacities** and hence, strengthening **community resiliency** against major storm events.

Policy Implications

- Second, donor countries along with government organizations, non-government organizations, and civil society organizations should integrate private indigenous adaptive capacities / storm-protection actions in their programs to avoid "coordination failure."

  Combinations of improved capacities and better budgeting should allow the stakeholders to reach "poverty reduction" goals of climate vulnerable communities in developing countries.

Thank You

Questions & suggestions