Public Programs and Remittances Influence on Private Storm-Protection Actions: Is Crowding Out Effect Most Likely Outcome?

Dr. Sakib Mahmud
School of Business & Economics
University of Wisconsin, Superior, USA
&
Dr. Gazi Hassan
Department of Economics
University of Waikato, Hamilton, New Zealand

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 even*t; 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 access to remittances and publicly sponsored storm mitigation programs 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

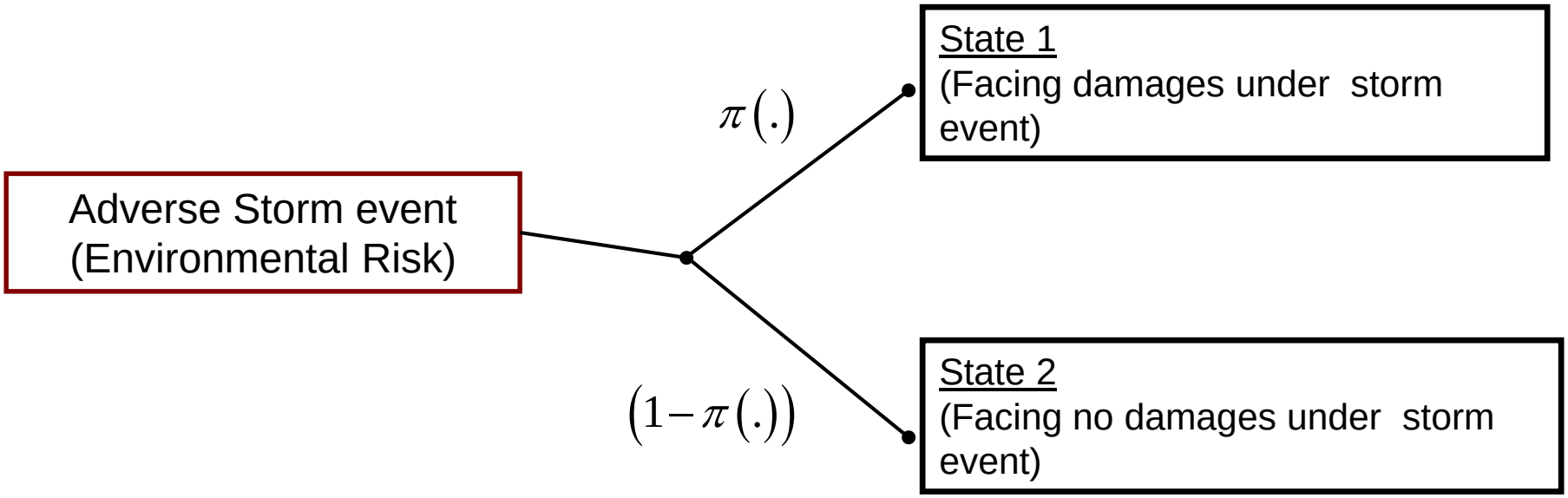
Introduce a **theoretical model** combining household Production function with endogenous risk framework.

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:*

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

First-order conditions,

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

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, $\left[\pi \cdot (1+L_S) \cdot U_S(W_1) + (1-\pi) \cdot U_S(W_2)\right]$.

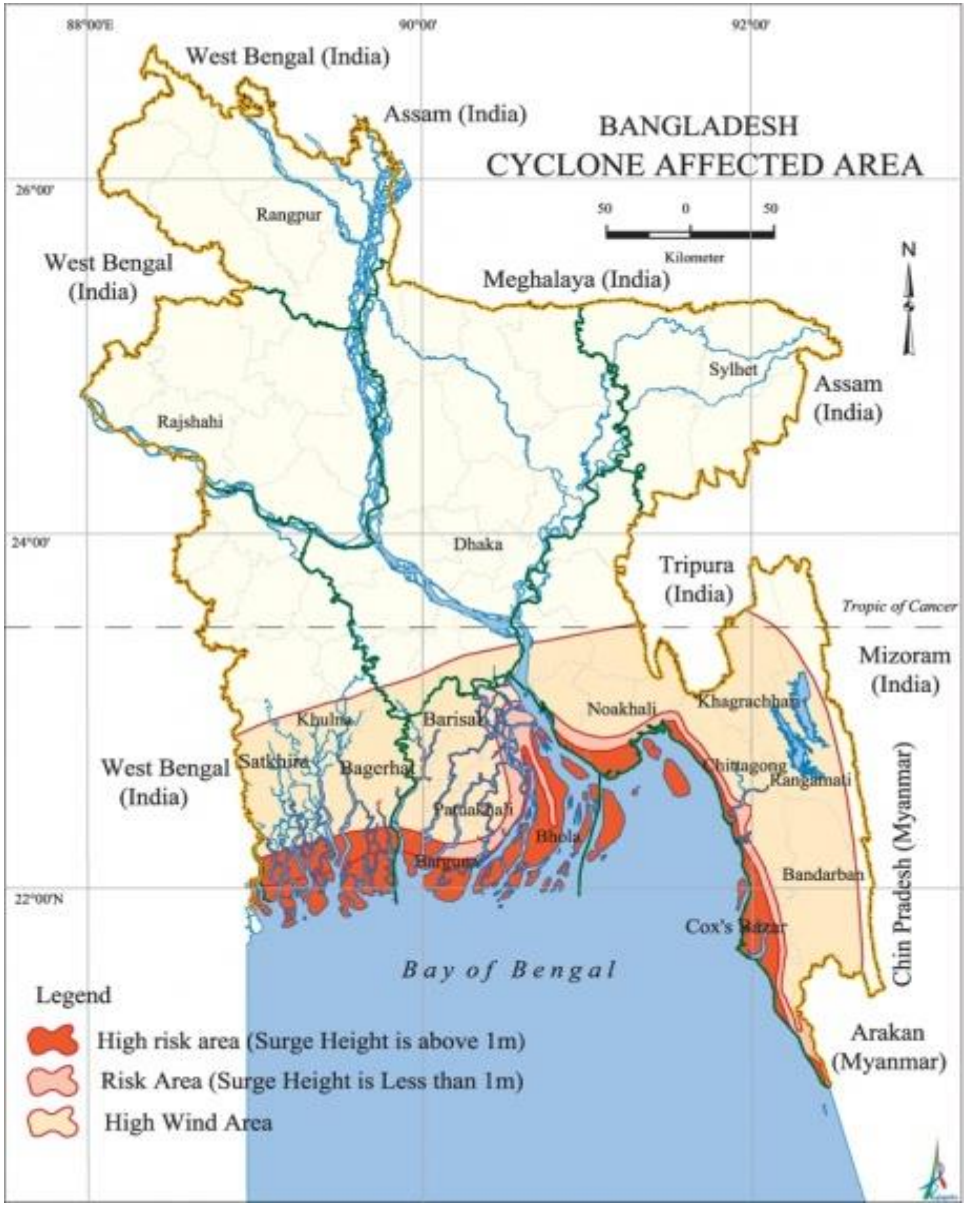
Outcome 2: For a risk-averse coastal household, increasing flow of remittances leads to lower private defensive expenditures (or, decreasing private storm protection actions), i.e. $\frac{dS}{dR} < 0$, if and only if expected marginal benefits of private defensive expenditures, $\pi_S\left[U(W_1) - U(W_2)\right]$,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

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



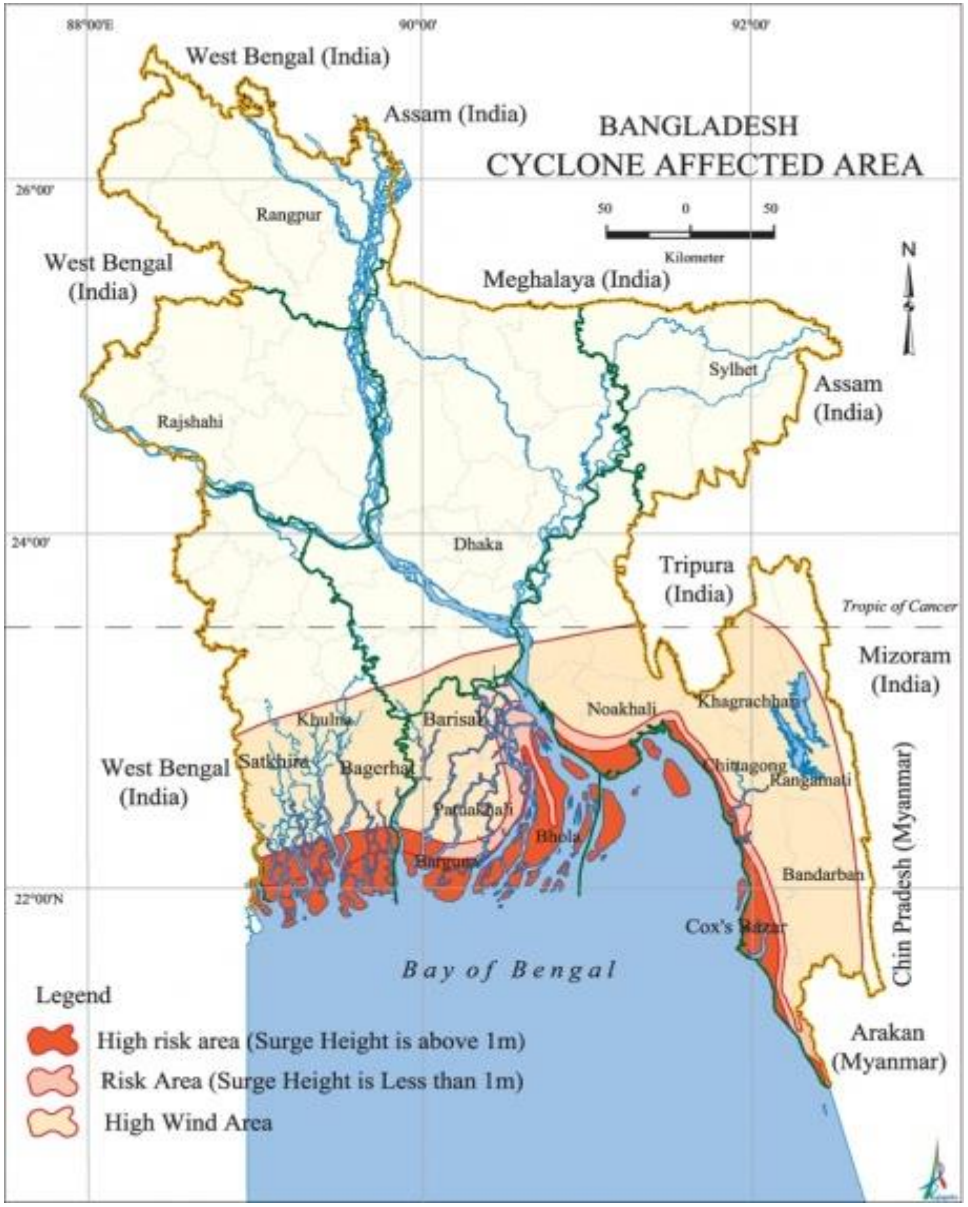
Data Set

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)	Income / 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)	Income/ 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**

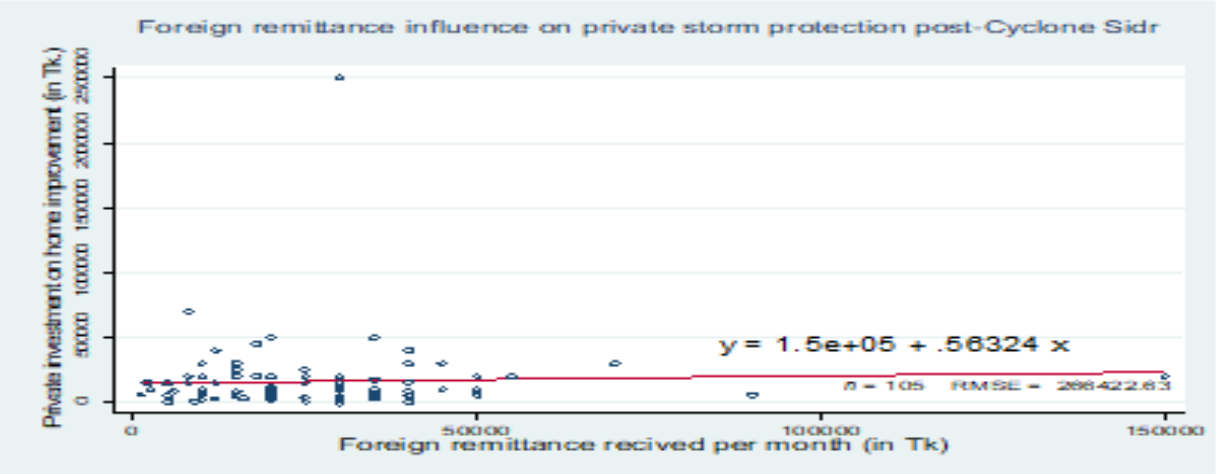
Household Perception:

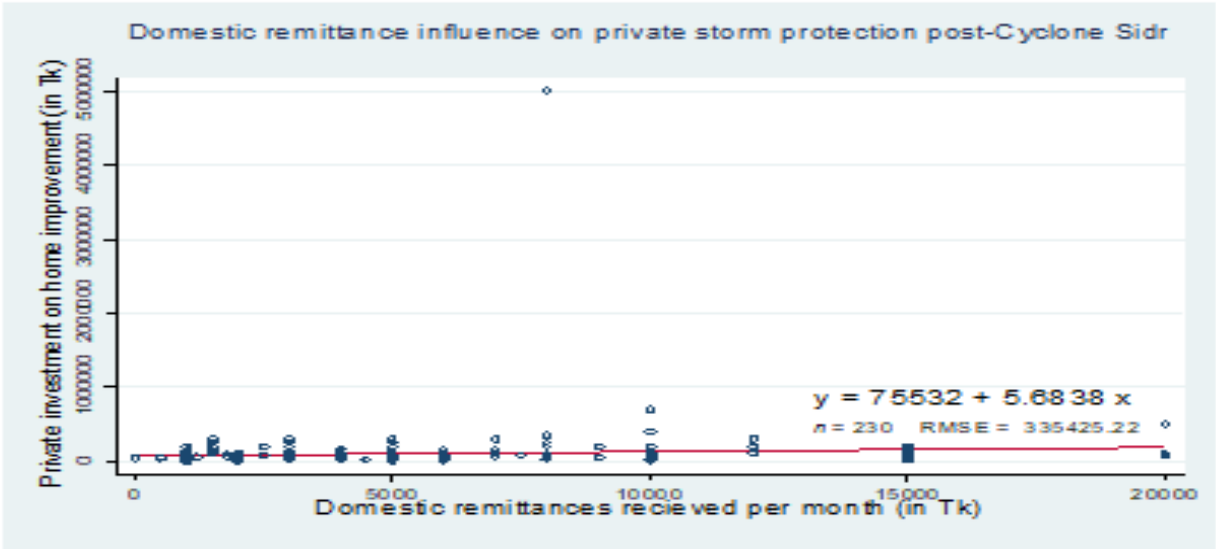
Flooding/ water logging from major cyclone events

	Total 'Yes' responses	Percentages
Entire Study Area	570	93.44
Patuakhali	191	33.51
Borguna	206	36.14
Bhola	173	30.35

Foreign and Domestic Remittance:

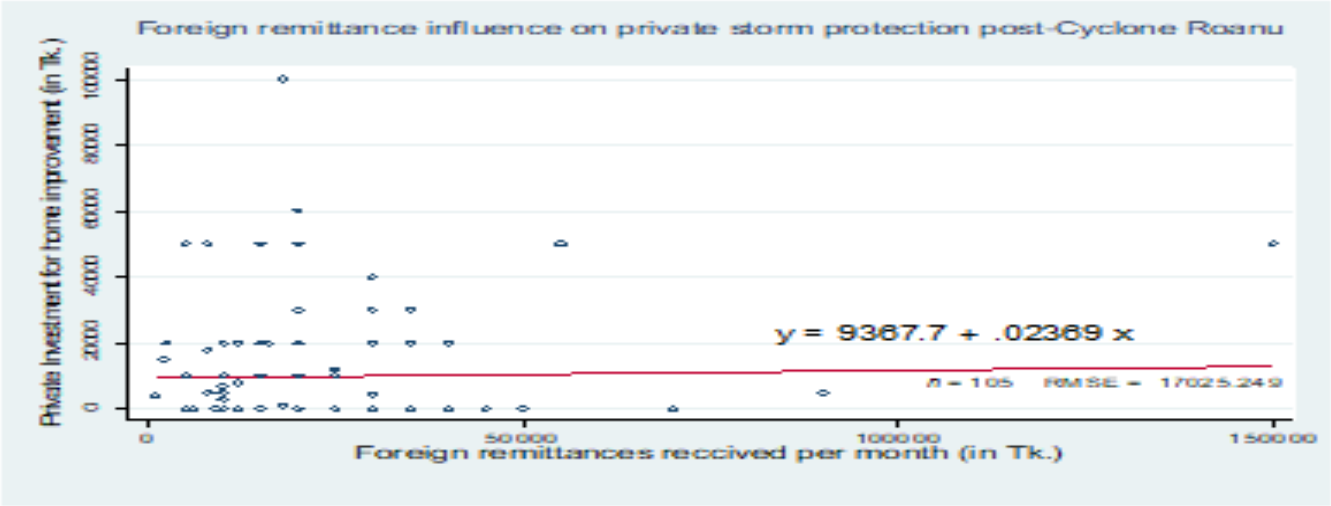
Influence on private storm protection post-Cyclone Sidr

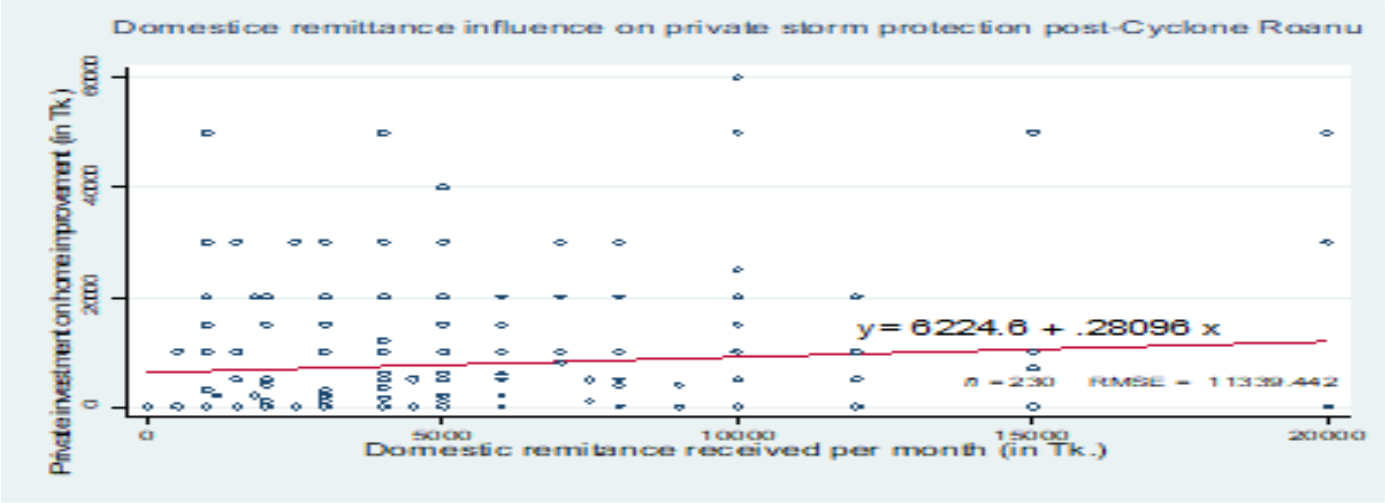




Foreign and Domestic Remittance:

Influence on private storm protection post-Cyclone Roanu





Regression Analysis:

Hypotheses

Hypothesis 1. A household receiving either foreign or domestic 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.

Regression Analysis:

Summary Statistics of the Key variables

Variable	Definition	No. of Observations	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
DOMMEM	Total members of the household living outside home but working within Bangladesh	255	1.314	1.063
FAMINC	Family Income per month (in TK.)	610	16894.75	14656.47
MEDEXP	Medical expenditures per month (in Tk.)	610	1648.77	1318.40
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

Regression Analysis:

IV-2SLS estimator Post-Cyclone Sidr

Regressand	Private spending on home improvement after Cyclone Sidr			
Instrumented	Foreign remittance received per month (in Tk.)		Domestic remittance received per month (in Tk.)	
Regressors	*Parsimonious Model under foreign remittance (1)*	*Add access to the publicly funded storm protection programs (2)*	*Parsimonious Model under domestic remittance (3)*	*Add access to the publicly funded storm protection programs (4)*
CONSTANT	-657293.8 (-1.24)	-486319.2 (-1.26)	-822164.8 (-1.31)*	-428756.9 (-1.11)
REMITFOR	37.9772 (1.68)**	30.4425 (1.77)**		
REMITDOM			67.0387 (1.70)**	39.163 (1.66)**
AGE	18899.3 (1.16)	16628.5 (1.33)*	13655.28 (0.86)	6688.88 (0.60)
AGE2	-267.3058 (-1.26)	-236.963 (-1.43)*	-164.165 (-0.89)	-86.530 (-0.68)
MEMBER	21476.08 (0.65)	15424.9 (0.62)	46579.19 (1.09)	25183.54 (0.74)
FORMEM	414685 (2.20)**	340760.2 (2.21)**		
DOMMEM			24756.25 (0.50)	18839.81 (0.47)
MEDEXP	16.443 (0.72)	17.620 (0.96)	6.6020 (0.09)	20.8331 (0.29)
FAMINC	-36.8708 (-1.73)**	-29.9988 (-1.81)**	-6.1739 (-0.49)	-5.4784 (-0.46)
HOMEST	1763.62 (1.59)*	1590.58 (1.61)*	-54.279 (-0.08)	-239.71 (-0.45)
AGLAND	408.323 (1.90)**	349.271 (2.07)**	46.288 (0.20)	103.838 (0.54)
DISEMB		-50186.27 (-1.40)*		-7633.11 (-0.22)
DISCYSH		10689.29 (0.30)		32631.99 (0.74)
No. of observations	75	75	123	123
Under identification test (P-value)	3.306 (0.1914)	4.088 (0.1295)	4.024 (0.1337)	6.408 (0.0406)
Weak identification F-test	1.201	1.657	2.080	2.760
Hansen J-stat (P-value)	0.831 (0.3621)	1.464 (0.2262)	1.948 (0.1628)	3.359 (0.0668)

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

Regression Analysis:

IV-Tobit estimator Post-Cyclone Roanu

Regressand	Private spending on home improvement after Cyclone Roanu			
Instrumented	Foreign remittance received per month (in Tk.)		Domestic remittance received per month (in Tk.)	
Regressors	*Parsimonious Model under foreign remittance (1)*	*Add access to the publicly funded storm protection programs (2)*	*Parsimonious Model under domestic remittance (3)*	*Add access to the publicly funded storm protection programs (4)*
CONSTANT	-245663.3 (-1.25)	-168264.1 (-1.29)*	-87467.97 (-1.19)	-71675.06 (-1.16)
REMITFOR	14.8180 (1.55)*	10.3519 (1.65)*		
REMITDOM			8.7307 (1.58)*	7.291 (1.65)**
AGE	4850.31 (0.80)	3494.93 (0.79)	1181.54 (0.55)	1077.971 (0.57)
AGE2	-69.6359 (-0.86)	-49.451 (-0.85)	-13.9784 (-0.59)	-12.677 (-0.60)
MEMBER	13487.25 (1.21)	9458.86 (1.20)	4769.31 (1.84)**	4259.38 (1.87)**
FORMEM	111144 (1.41)*	83311.86 (1.53)*		
DOMMEM			2996.229 (0.58)	3518.92 (0.75)
MEDEXP	1.2909 (0.14)	-0.4403 (-0.07)	-2.7421 (-0.45)	-3.462 (-0.64)
FAMINC	-14.1295 (-1.53)*	-9.9484 (-1.63)*	-1.492 (-1.11)	-1.089 (-0.97)
HOMEST	555.6463 (1.11)	481.638 (1.29)*	62.1641 (0.58)	25.01 (0.23)
AGLAND	86.8618 (1.04)	56.8938 (1.01)	-12.949 (-0.55)	-17.949 (-0.82)
DISEMB		-19449.58 (-1.47)*		-4823.32 (-1.00)
DISCYSH		2926.027 (0.22)		-1373.51 (-0.23)
No. of observations	75	75	123	123
Wald χ^2 (P-value)	4.30 (0.8904)	6.21 (0.8592)	10.78 (0.2914)	14.19 (0.2229)
Wald test of exogeneity χ^2 (P-value)	12.42 (0.0004)	8.20 (0.0042)	6.77 (0.0093)	6.77 (0.0093)

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

Regression Analysis:

IV-Probit estimator Post-Cyclone Sidr and Post-Cyclone Roanu

Regressands	Private spending on home improvement after 2007 Cyclone Sidr (binary)		Private spending on home improvement after 2016 Cyclone Roanu (binary)	
Instrumented	Foreign remittance received per month (in Tk.)	Domestic remittance received per month (in Tk.)	Foreign remittance received per month (in Tk.)	Domestic remittance received per month (in Tk.)
Regressors	**Model 1**	**Model 2**	**Model 3**	**Model 4**
CONSTANT	-2.7618 (-1.12)	-2.3054 (-0.00)	-1.3928 (-1.47)*	-2.6656 (-2.70)***
REMITFOR	0.00013 (3.81)***		0.00015 (10.56)***	
REMITDOM		0.00025 (0.00)		0.00024 (8.56)***
AGE	0.15099 (1.10)	0.05381 (0.00)	0.0547 (1.24)	0.0438 (0.57)
AGE2	-0.002 (-1.27)	-0.0007 (-0.00)	-0.00087 (-1.63)*	-0.00046 (-0.95)
MEMBER	0.3240 (1.39)*	0.1626 (0.00)	0.2079 (3.29)***	0.1356 (2.69)***
MEDEXP	-000004 (-0.03)	0.0004 (0.00)	0.000004 (0.05)	-0.000003 (-0.02)
FAMINC	-0.00013 (-3.92)***	-0.00007 (-0.00)	-0.00015 (-9.70)***	-0.00005 (-2.74)***
HOMEST	0.00622 (0.78)	0.00269 (0.00)	0.00289 (0.77)	0.00069 (0.28)
AGLAND	-2.762 (-1.12)	-0.00002 (-0.00)	0.00118 (2.69)***	0.00004 (0.07)
No. of observations	75	123	123	123
Log-Likelihood	-772.922	-1187.677	-796.127	-1254.968
Wald χ^2 (P-value)	28.99, df = 8 (0.0003)	0.00, df = 8 (1.0000)	118.00, df = 8 (0.0000)	130.63, df = 8 (0.0000)
Wald test of exogeneity: χ^2 (P-value)	2.60, df = 1 (0.1072)	0.00, df = 1 (0.9916)	10.22, df = 1 (0.0014)	9.12, df = 1 (0.0025)

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

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, donor countries can bolster the household private storm-protection actions by adopting a simpler and more open immigration policies for climate refugees rather funding capital for public programs in developing countries.

Policy Implications

- Second, 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.

Thank You

Questions & suggestions